Stormwater Management Measures
Maintenance Plan & Field Manuals

Development Name: Bristol Myers Squibb

Address: Princeton Pike

Block(s) / Lot(s): Block 5001, Lot 1.01

Township, County: Lawrence Township, Mercer County

Party Responsible for Maintenance:

Prepared by: Van Note Harvey Associates, Inc. Date: February 27, 2024
Last Revised:
VNHA #: BRMYS23006

van note-harvey
division of pennoni

This plan is recorded in

Deed Book # _______ Page # ____ with _________ County Clerk on Date _______

Table of Contents

Part I- Maintenance

Part II- Field Manuals and Maintenance Records

Part III – Attachments

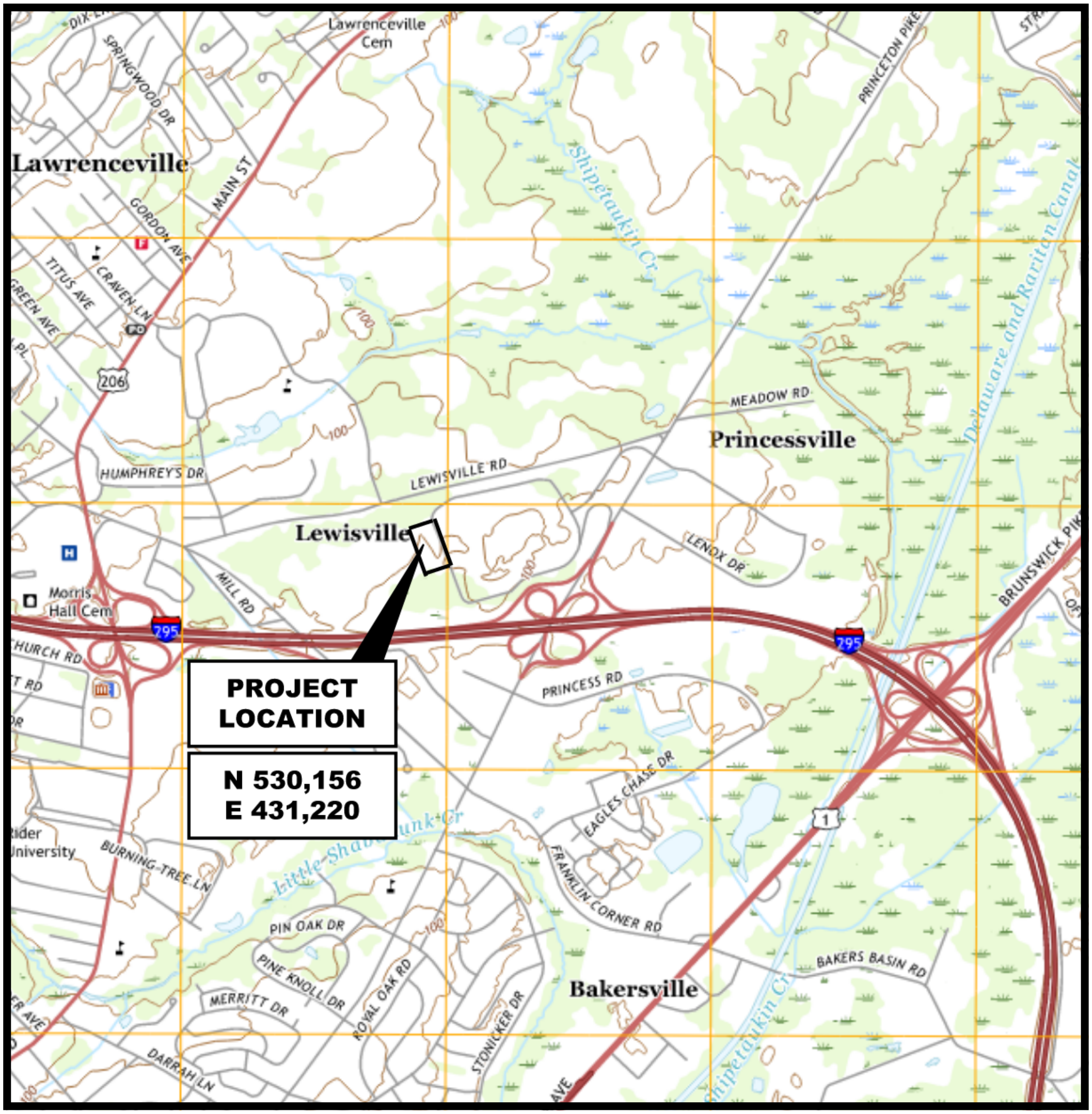
Part I- Maintenance Plan

List of Stormwater Management Measures

The stormwater management measures incorporated into this development are listed below. The corresponding Field Manuals for the stormwater management measures are located in Part II of the Maintenance Plan.

STORMWATER MANAGEMENT MEASURE	BMP No.	Description	Northing / Easting
Porous Asphalt	1	Parking Area	N: 530,131 E: 431,260
Underground Infiltration/Extended Detention System	2	Located on the southwesterly side of parking area	N: 530,103 E: 431,190

Location Map



No.	Type of Stormwater Management Measure
1	Permeable Pavement
2	Underground Infiltration/Extended Detention Basin

Description of Stormwater Management Measures

Design storm: 100 Year (Current Precipitation)

- Design Purposes:
  - Water quality, water quantity, groundwater recharge
  - 1.25 inches in 2 hours
  - 2-year storm (3.34 inches);
  - 10-year storm (5.11 inches);
  - 100-year storm (8.67 inches)

Design storm: 100 Year (Projected Precipitation)

- Design Purposes:
  - Water quality, water quantity, groundwater recharge
  - 1.25 inches in 2 hours
  - 2-year storm (3.8 inches);
  - 10-year storm (5.9 inches);
  - 100-year storm (11.3 inches)

Preventative and Corrective Maintenance Action Plan

Overview

Effective stormwater management system performance requires regular and effective maintenance. This manual establishes a basic Operation and Maintenance (O&M) program based primarily on systematic inspections by appointees of the Owner. During each inspection, checklists (Field Manuals in Part II of this Manual) must be used. The completed checklist must be dated and signed by the "Inspector" and incorporated into this manual.

This manual is intended as a guide for the Owner and outlines the proper procedures for conducting routine O&M. The Owner shall appoint a key site person, from within their organization (Inspector), which will perform inspections for the year. This manual will then be transferred yearly to the appointed "Inspector." A continuous record of the O&M must be maintained. The Designated Inspectors List will be identified by the Owner. This section must be updated periodically pending a change in the Officials, the Inspector, the Engineer, or the Contractor.

At least two (2) copies of this manual shall be kept by the Owner at all times. All correspondence and maintenance checklists shall be reproduced in triplicate and distributed for inclusion into the manuals.

Lawrence Township's Tier A Municipal Stormwater Coordinator should receive the previous year's maintenance records and inspection logs no later than April 1st. This section of the manual has been prepared to provide the Inspector with a simple and systematic method for inspecting, operating and maintaining the systems. For the most part, the O&M involves observation rather than evaluation.

Maintenance records and/or certifications are required to be submitted annually to Lawrence Township for their records.

Schedules

Maintenance should be completed on a routine basis along with required inspections as outlined later in this manual. Specific tasks have been outlined in the following sections and should be closely followed to ensure the effectiveness and longevity of the stormwater management system and avoid costly repairs. Standard maintenance forms are provided in Part II.

Access

All of the stormwater management facilities must be accessible for inspection and maintenance. Access routes are provided in the form of the roadways throughout the site. These areas need to be kept clear and free of obstructions so that equipment and personnel can complete work in a timely fashion. Any trees, shrubs, and underbrush must be pruned or trimmed as necessary to maintain a clear route to all stormwater management systems.

In the event the stormwater management facility becomes a danger to public safety or public health, the municipality shall so notify the responsible party in writing. Upon receipt of that notice, the responsible party shall have 14 days to effect maintenance and repair of the facility in a manner that is approved by the municipal engineer or his designee. The municipality, in its discretion, may extend the time allowed for effecting maintenance and repair for good cause. If the responsible party fails or refuses to perform such maintenance and repair, the municipality or County may immediately proceed to do so and shall bill the cost thereof to the responsible party.

Safety

Standard safety precautions should be taken when maintaining the stormwater management facilities. The primary concern for the wet pond is related to standing water (above the normal water surface elevation) remaining in the systems for more than 72 hours. Extreme caution should be used when entering any areas of standing water.

All personnel should receive proper training prior to commencing work. Maintenance training begins with a basic description of the purpose and function of the overall wet pons structure and of its major components. Such understanding will enable maintenance personnel to provide more effective component maintenance and more readily detect maintenance-related problems.

Cleaning of Inlet, Cleanout and Manhole Structures

Regular removal of sediment and debris accumulated in outlet, inlet, cleanout and manhole structures is the best method to preventing clogging and failure of the storm sewer system and avoid costly repairs (i.e. no standing water). Sediment removal should take place when the sewer is completely dry. Disposal of debris and trash should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations. Outlet structures, inlets, cleanouts, and manhole structures should be inspected and maintained on a biannual basis.

Basins

All structural components of the basins, including but not limited to the outlet structure, spillways, outlet protection, and out fall must be cleaned of all debris at least twice annually and after major storm events. Sediment and debris removal shall only occur when the basins are completely dry. Disposal of debris, trash, sediment and other waste material must be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations. Refer to manual for specific maintenance requirements.

Landscape Care

If any bare spots or eroded areas are observed within the planted areas, they should be replanted and/or stabilized at once. Planted areas should be inspected on a semiannual basis. All trash and other litter that is observed during these inspections should be removed.

Preventative Maintenance Actions

The frequency of the preventative maintenance actions listed here is adopted from Chapter 9, BMP Manual of Structural Stormwater Management Measures. Design engineer and responsible party should adjust the frequency of preventative maintenance actions according to the situations of the stormwater management measures in the development.

Preventative Maintenance Actions

Frequency	Preventative Maintenance Actions
Quarterly	Basins should be inspected for clogging and excessive debris and sediment accumulation, including outlet structure and riprap apron.
Monthly (or as required)	All storm structures and cleanouts (where applicable) within or draining to the porous pavement should be checked for sediment and standing water.
Annual	General maintenance considerations include watering thoroughly the first year, and inspecting shrubs closely to discover and control pests and diseases in their early stages. General maintenance is the same as General Shrub Care above, with the additional maintenance measure of staking.
Unscheduled	Fertilizer should be applied with care to keep fertilizer off parking and driveway areas where it can wash into the storm drain system. Pesticides should be used with care and only applied to address specific problems.
Biennial (or as required)	Regular removal of sediment and debris from storm structures (including inlets, cleanouts, outlet structures and manholes) accumulated should be done when the sewer is completely dry. Herbaceous vegetation is planted to achieve between 80-100% coverage within a two-year period.

Inspection and Logs of All Preventative and Corrective Maintenance

Inspection Checklists in the Field Manual for the stormwater management measures on this site include:

- Pervious Paving System Field Manual
- Infiltration Basin Field Manual

The logs of all inspections, and both preventative and corrective maintenance performed should be attached in the "**Maintenance Logs and Inspection Records**" section. See Part II of this Maintenance Plan.

Maintenance Personnel, Equipment, Tools, and Supplies

No specialized equipment, tools, or supplies are needed to maintain the stormwater management facilities; however, the following is a list of recommended materials and equipment to accompany any inspector:

Stormwater Management Recommended Inspection Equipment/Materials	Quantity	Required for:
Stormwater Facilities (SWF)-Specific Information		
Blank inspection checklists	multiple	All SWFs
Site plans/as-built drawings	per facility	All SWFs
Facility type and outfall pipe size	per facility	All SWFs
Previous inspection results (Reports, redlines and photos)	per facility	All SWFs
Confined Space Entry permit (as required)	per facility	Underground/Confined Space Entry (CSE)
Inspection Equipment		
Clipboard w/Forms, Pencil and Compass	1	All SWFs
Area Map	1	All SWFs
Mobile Telephone	1	All SWFs
Two-Way Radio w/charged batteries	2	All SWFs
100' Measuring Tape	1	All SWFs
25' Retractable Tape Measure	1	All SWFs
Bolt Cutters	1	All SWFs
Cans of Orange Spray Paint	2	All SWFs
Crow Bar	1	All SWFs
Digital Camera	1	All SWFs
First Aid Kit	1	All SWFs
Flashlight w/charged batteries	1	All SWFs
Goggles or Safety Glasses	2	All SWFs
Hardhats	2	All SWFs

Leather Gloves	2	All SWFs
Manhole Cover Tool / Puller	1	All SWFs
Pair of Hard Sole Boots (wear)	2	All SWFs
Pair of Rubber Boots (as-needed)	2	All SWFs
Roll of Orange Tie-off Tape	1	All SWFs
Std. Size Bolt Locks and Keys (for pond gates)	2	All SWFs
Waterproof Carrying Bag	1	All SWFs
Machete or Pruning Sheers	1	Above ground
Monkey Wrench	1	Above ground
Standard Shovel	1	Above ground
Observation Well Cap Wrenches	1/Size	Infiltration facilities only
Small Size Bolt Lock and Key (for well caps)	1	Infiltration facilities only

Disposal Plan

Disposal/Recycling Procedures

Disposal plan shall be prepared by the Owner. Any permits that may be required shall be obtained and this manual shall be updated accordingly.

Permits for the Proposed Onsite Disposal Field (if required)

Local/State permits ☐ not required
☐ required

Permit Number	Government Entity	Issuance Date	Expiration Date

Disposal Field – Offsite

Description of the Offsite Disposal:

____

____

____

Safety Measures and Procedures

Prior to maintaining or inspecting the on-site stormwater facilities/structures, personnel should review this manual and the field manuals to understand the systems and be aware of any safety precautions that may be required.

Training Plan and Records

- Refer to the following applicable sections of the New Jersey Best Management Practices Manual
- Chapter 9.6 Pervious Pavement

  Maintenance

  Regular and effective maintenance is crucial to ensure effective porous asphalt performance; in addition, maintenance plans are required for all stormwater management facilities on a major development. There are a number of required elements in all maintenance plans, pursuant to N.J.A.C. 7:8-5.8; these are discussed in more detail in Chapter 8: Maintenance of Stormwater Management Measures. Furthermore, maintenance activities are required through various regulations, including the New Jersey Pollutant Discharge Elimination System (NJPDES) rules, N.J.A.C. 7:14A. Specific maintenance requirements for porous asphalt systems are presented below; these requirements must be included in the maintenance plan.

  Maintenance Objectives

  The primary goal of porous pavement maintenance is to prevent the pavement surface and/or underlying infiltration bed from being clogged with fine sediments. To keep the system clean throughout the year and prolong its life-span, the porous pavement surface, as well as standard pavement surface that contribute to the surface runoff, should be vacuumed at least four (4) times per year with a commercial cleaning unit. Pavements washing systems or compressed air units are generally not recommended as fines may be unintentionally embedded further into the voids of the pavement. All cleanout structures within these areas should be inspected and maintained on a biannual basis. All inlet structures within or draining to the infiltration beds should also be cleaned out on a biannual basis.

  Superficial dirt does not necessarily clog the pavement voids. However, dirt that is ground in repeatedly by tires, etc. can lead to clogging. Therefore, trucks or other heavy vehicles should be prevented from tracking or spilling dirt onto the pavement. Furthermore, all construction or hazardous materials carriers should be prohibited from entering a porous pavement lot.

  Descriptive signage is recommended to maintain institutional memory/awareness of porous pavement.

  Special Maintenance Considerations:

  1. Prevent Clogging of Pavement Surface with Sediment
     - Vacuum pavement followed by low pressure hosing at least 4 times per year
     - Maintain planted/vegetated areas adjacent to pavement
     - Immediately clean any soil deposited on pavement

- Do not allow construction staging, soil/mulch storage, etc. on unprotected pavement surface

2. Snow/Ice Removal
   - Do not apply abrasives such as sand or cinders on or adjacent to porous pavement
   - Snow plowing is permitted but should be done carefully (i.e. set the blade slightly higher than usual)
   - Salt application is acceptable, although more environmentally-benign deicers are preferable (e.g. chloride/brine solutions)
   - Limit the use of salt applications for the first several months following construction to allow for adequate curing of the surface.
   - Any snow stockpiles shall not be kept on porous pavement areas.
3. Oil/Fuel Spill
   - Check for oil sheen on surface of pavement. Determine whether residue/first flush or further investigation is required.
   - In the case of an extreme event (vehicle fire, large-rapid oil deposit from vehicle, etc.) adhere to the State (New Jersey Department of Environmental Protection) and Federal (Environmental Protection Agency) guidelines. Report events to NJDEP immediately.
4. Repairs
   - Pavement surface should never be seal-coated.
   - Damaged areas should be patched with an approved asphalt mix (to match damaged area); read on further for specific repair instructions.
   - If cleanouts or catch basins within parking lot area indicate standing water 72 hours after a rainfall event, it could mean the bottom stratum is clogged and infiltration/discharge is not occurring. Pumps can be used to drain the system and a professional engineer should be contacted to determine any problems occurring within the system and to provide the next steps that should be taken to correct the issue(s) for the system to function properly.
5. Site Maintenance/Construction
   - Any construction staging to be done on-site shall be kept off of porous pavement areas.

Vacuuming

Vacuuming is recommended for porous pavement with a vacuum sweeper on a quarterly basis. Acceptable types of vacuum sweepers include the Elgin Whirlwind and the Allianz Model 650. Though much less effective than "pure" vacuum sweepers, regenerative air sweepers, such as the Tymco Model 210, Victory, and others are sometimes used. These units contain a blower system that generates a high velocity air column, which forces the air against the pavement at an angle, creating a 'peeling' or 'knifing' effect. The high volume air blast loosens the debris from the pavement surface, then transports it across the width of the sweeping head and lifts it into the containment hopper via a suction tube. Thus, sediment and debris are loosened from the pavement and sucked into the unit. (Note: Simple broom sweepers are limited in their ability to remove sediment and are therefore, not recommended for porous pavement maintenance.)

If the pavement surface has become significantly clogged such that routine vacuum sweeping does not restore permeability, then a more intensive level of treatment may be required. Recent studies have revealed the usefulness of washing porous pavements with clean, low pressure water, followed by immediate vacuuming. Combinations of washing and vacuuming techniques have proved effective in cleaning both organic clogging as well as sandy clogging. (Note: If the pressure of the washing nozzle is too great, clogging materials/contaminants may be driven further into the porous surface.) Maintenance crews are encouraged to determine the most effective strategy of cleaning their porous installations.

Winter Maintenance

Winter maintenance for porous pavement may be necessary but is usually less intensive than that required for a standard pavement. By its very nature, a porous pavement system with 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 porous 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 porous pavement. Snow plowing is acceptable, provided it is done carefully (i.e. by setting the blade slightly higher than usual, about an inch). Although salting is acceptable for use as a deicer on the porous pavement, nontoxic, organic deicers, applied either as blended, magnesium chloride-based liquid products (Refer to Attachment 5 for a sample supplier). or as pretreated salt, are preferred.

Restoration/Repairs

Potholes in the porous pavement are extremely unlikely, though 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 porous mix. If an area greater than 50 SF is in need of repair, approval of patch type must be sought from either the engineer or 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.

With minimal maintenance, porous bituminous asphalt can function effectively for well over 20 years. However, in the event that maintenance of the porous pavement is neglected and it becomes clogged over time, the Owner shall vacuum the lot until the original permeability is restored. (If the original permeability of the lot cannot be restored, the pavement should be removed and replaced with a new porous mix or a portion of the surface can be milled and overlaid depending on the severity of the clogged surface.) Recent research has shown that one of the most effective ways of restoring porous pavement is applying a pressurized dose of a non-toxic detergent cleaning solution, allowing adequate soak time, and then vacuuming with a high performance unit (Elgin Whirlwind or others). Once again, it is important to note that high pressure washing may drive contaminants further into the porous surface and even into the underlying aggregate. It is therefore recommended that, prior to vacuum sweeping, a low performance pressure washer be used to get the solution to break the surface tension and reach into the pores.

More training information is available at NJ Stormwater.org
(http://www.nj.gov/dep/stormwater/training.htm)

- Chapter 9.8 Small Scale Infiltration Basin (Subsurface)

  Maintenance

  Regular and effective maintenance is crucial to ensure effective small scale infiltration basin performance; in addition, maintenance plans are required for all stormwater management facilities on a major development. There are a number of required elements in all maintenance plans, pursuant to N.J.A.C. 7:8-5.8; these are discussed in more detail in Chapter 8: Maintenance of Stormwater Management Measures. Furthermore, maintenance activities are required through various regulations, including the New Jersey Pollutant Discharge Elimination System (NJPDES) rules, N.J.A.C. 7:14A. Specific maintenance requirements for infiltration basin systems are presented below; these requirements must be included in the maintenance plan.

  Definition

  The underground detention system is comprised of an arch shaped chamber system.

  All underground detention systems must be cleaned and maintained. Underground systems may be maintained more cost effectively if these simple guidelines are followed. Inspection should be performed at a minimum of once per year. While maintenance can generally be performed year-round, it should be scheduled during a relatively dry season.

  Maintenance

  - Removal and Disposal of Accumulated Debris and Trash

    - All underground detention basin components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment at least four times annually as well as after every storm exceeding 1 inch of rainfall. All debris and trash should be removed from the underground basin.

  - Sediment Removal and Disposal

    - Accumulated sediment should be removed before it threatens the operation or storage volume of the basin. Sediment volume should be monitored on a quarterly basis to assure that the storage capacity of the basin is not adversely affected.
    - If maintenance to the arch rows is required, a JetVac truck utilizing a high pressure nozzle (sledge dredging tool) with rear facing jets will be required. Insert the nozzle from the distribution manifold into the arch row through the opening. Turn the water feed hose

on and feed the supply hose until the nozzle has reached the end of the arch row. Withdraw the nozzle slowly.

  - The tool will backflush the arch row forcing debris into the distribution manifold. Use the stringer vacuum hose to remove the sediments and debris from the distribution manifold. Multiple passes may be required to fully cleanout the arch row.
  - Use caution to minimize movement of stone bedding at the arch invert while performing this task; relevel stone as needed. Vacuum out the distribution manifold and remove all debris that may be clogging the outlet pipe.
  - Sediment removal should take place during the dry season. Disposal of debris, trash and sediment or other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste disposal regulations.

- Structural Components
  - All structural components must be inspected for cracking, subsidence spalling, erosion and deterioration at least annually.
- Inspection
  - The following is the recommended procedure to inspect system in service:
  - Inspection can be done through manhole access and visually inspecting the distribution manifold. When the depth of sediment accumulates over 4 inches, cleanout is recommended.

Annual Evaluation of the Effectiveness of the Plan

The responsible party should evaluate the effectiveness of the current maintenance plan by comparing the maintenance plan with the actual performance of the maintenance. The items to evaluate may include, but not limited to,

- Whether the inspections have been performed as scheduled;
- Whether the preventive maintenance has been performed as scheduled;
- Whether the frequency of preventative maintenance needs to increase or decrease;
- Whether the planned resources were enough to perform the maintenance;
- Whether the repairs were completed on time;
- Whether the actual cost was consistent with the estimated cost;
- Whether the inspection, maintenance, and repair records have been kept.

If actual performance of those items has been deviated from the maintenance plan, the responsible party should find the causes and implement solutions in a revised maintenance plan and documents below.

Annual Evaluation Records

Evaluator(s)	Date of Evaluation	Decision
		__Maintain current version OR __Revise current version Revision date __________ (also update the last revision date on the cover page) __Requires a new deed recording (also update the last recording information on the cover page)
		__Maintain current version OR __Revise current version Revision date __________ (also update the last revision date on the cover page) __Requires a new deed recording (also update the last recording information on the cover page)
		__Maintain current version OR __Revise current version Revision date __________ (also update the last revision date on the cover page) __Requires a new deed recording (also update the last recording information on the cover page)

Part II- Field Manuals

Attachment of Field Manuals for Stormwater Management Measures on this Site

As per N.J.A.C. 7:8-5.8(b)&(e), preventative and corrective maintenance shall be performed to maintain the function of stormwater management measures, including repair or replacement of the structure; removal of sediment, debris or trash; restoration of eroded areas; snow and ice removal; fence repair or replacement; restoration of vegetation; repair or replacement of non-vegetated linings, and removal of rodent/wildlife and repair/restoration to damaged affected areas caused by them.

The Field Manual attached to this Maintenance Plan is a separate document pertaining to one specific type of stormwater management measure, and should be used by inspections and maintenance crews in order to carry out the maintenance work required by N.J.A.C. 7:8-5.8(e) for each stormwater management measure. Design engineers should prepare the field manuals in accordance with the design of each measure and the specific requirements of the site. See the sample field manual for further guidance.

Maintenance Logs and Inspection Records

As per N.J.A.C. 7:8-5.8(e), preventative and corrective maintenance shall be performed to maintain the function of the stormwater management measure(s), including repairs or replacement to the structure; removal of sediment, debris, or trash; restoration of eroded areas; snow and ice removal; fence repair or replacement; restoration of vegetation; and repair or replacement of non-vegetated linings.

As per N.J.A.C. 7:8-5.8(f), the person responsible for maintenance shall maintain a detailed log of all preventative and corrective maintenance for the structural stormwater management measures incorporated into the design of the development, including a record of all inspections and copies of all maintenance-related work orders.

The responsible party shall maintain a record of all maintenance actions performed, including:

1. Inspection checklists from each performed inspection
2. Preventative maintenance logs
3. Corrective maintenance logs, including work orders
4. Other maintenance records

ENGINEER'S ESTIMATE OF
INSPECTION AND MAINTENANCE COSTS
BRISTOL MYERS SQUIBB
TOWNSHIP OF LAWRENCE
MERCER COUNTY, NEW JERSEY

Pennoni

Item #	Description	Rate	Unit	Total Units	Frequency Per Year	Item Total
1	Jet Cleaning of Underground Stormwater System	$ 1,000.00	1	1	1	$1,000.00
2	General Maintenance	$ 500.00	LS	1	2	$1,000.00
3	Visual Inspection	$ 250.00	1	2	As Needed	$500.00
4	Trash and Debris Removal	$ 300.00	LS	4	1	$1,200.00
5	Preventive Maintenance	$ 350.00	LS	1	1	$350.00
6	Vacuum Clean Subsurface Pipes	$ 750.00	LS	1	1	$750.00
7	Jet Cleaning/Vacuum of Porous Asphalt	$ 1,000.00	1	1	1	$1,000.00

TOTAL ANNUAL	$5,800.00

Part II- Field Manuals

Pervious Paving System
Measure #1 on the Location Map

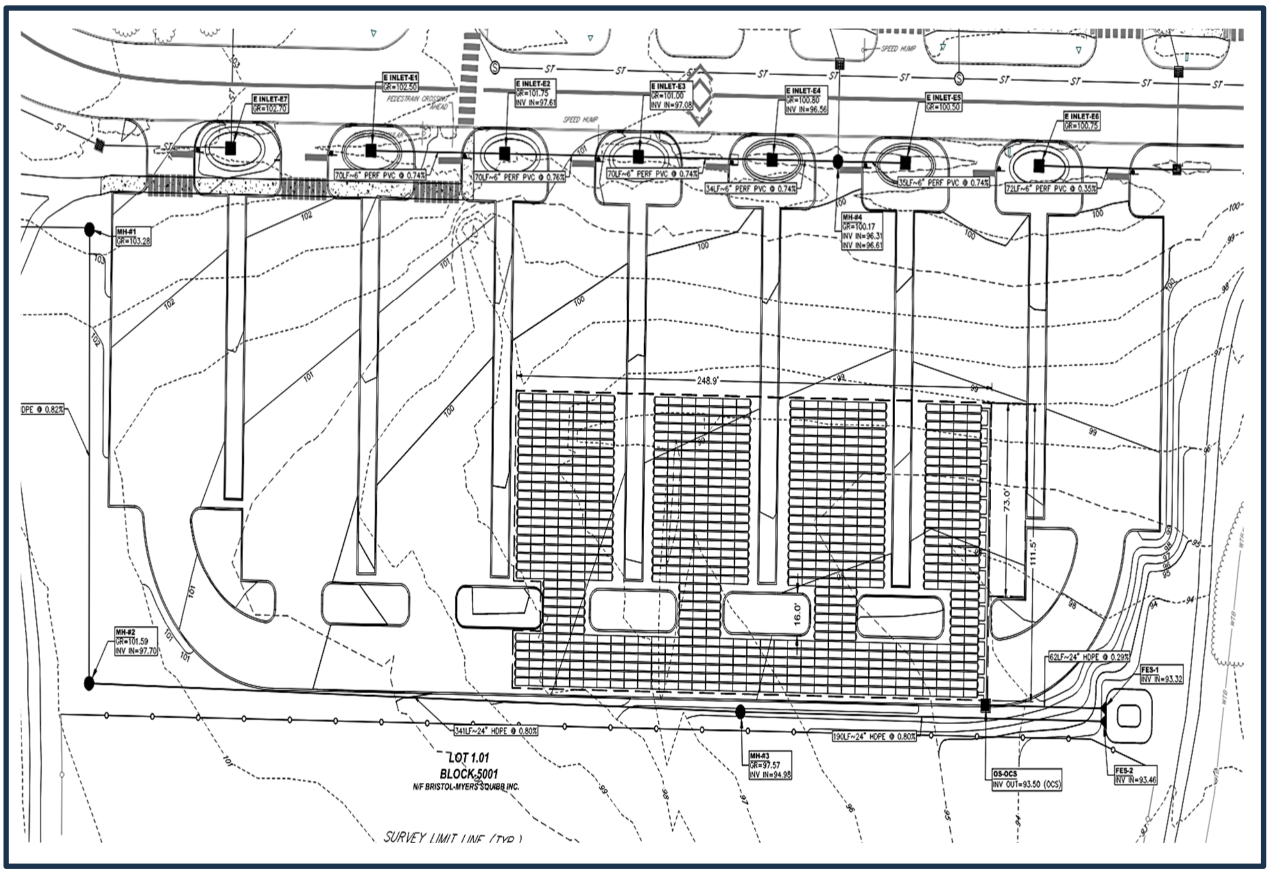
Development Name: Bristol Myers Squibb Additional Parking

Township, County: Lawrence Township, Mercer County

Location of System: N: 530,157; E :431,192

Location Description: 244 Parking Spaces

Location Map



Example Map: Use aerial photo, site plan, or other graphics showing the locations of BMPs

NOTE

This Field Manual is intended to be editable and adjustable in accordance with the design of stormwater management measures, the site conditions, and the special needs of responsible party. The Engineer should supplement information and best management practice to assist the responsible party to perform maintenance.

Blue text indicates information may be deleted and or replaced as necessary.

Table of Contents

Pervious Pavement System Overview

Functionality

Pervious paving systems are paved areas that produce less stormwater runoff than areas paved with conventional paving. This reduction is achieved primarily through the infiltration of a greater portion of the rain falling on the area than would occur with conventional paving. This increased infiltration occurs either through the paving material itself or through void spaces between individual paving blocks known as pavers.

Pervious paving systems are divided into two general types. Each type depends primarily upon the nature of the pervious paving surface course and the presence or absence of a runoff storage bed beneath the surface course. Porous paving and permeable paver with storage bed systems treat the stormwater quality design storm runoff through storage and infiltration. Therefore, these systems have adopted TSS removal rates similar to infiltration structures. The adopted TSS removal rate for each type of pervious paving system is from 80%.

Pervious paving systems are used to reduce runoff rates and volumes from paved, on-grade surfaces such as patios, walkways, driveways, fire lanes, and parking spaces. Pervious paving systems with runoff storage beds achieve these reductions through storage of runoff and eventual infiltration into the subgrade soils. Through this infiltration process, these types of pervious paving systems also achieve stormwater quality requirements.

Proper care and attention in the long-term maintenance of the stormwater management measure is critically important to the safety and health of the public.

Type of BMP – Dry Stormwater Management Measure

The pervious pavement system shall fully drain within 72 hours of the most recent rainfall. Standing water in excess of 72 hours is a sign of the porous pavement failure. It may also contribute to mosquito breeding and other health and safety issues. At no time shall there be ponding on the surface of the pavement.

Basic Design Information

This section shall be filled out by the design engineer.

Hydrology Design Targets

1. The system is porous pavement with storage chambers and stone bed.
2. This system is designed with a soil permeability rate of 2.3 inches/hour (pre-construction) and 1.15inches/hour (post-construction - tested on 02 / 09 / 2024 .
3. The design drain time is 4.8 hours.
4. The elevation of the seasonal high-water table of this pavement area was observed on 02 / 09 / 2024 and it was not encountered below the pavement bottom surface, at EL. 84.8 feet.
5. The TSS removal rate is 80%.

Hydraulic Design Targets

1. This system is designed to infiltrate the runoff from the Water Quality Design Storm, which generates 8,093 cubic feet of runoff. The peak flow entering the system is 30.9 cubic feet per second.
   Larger storms are stored in the chambers and stone bed and routed through the outlet control structure.
2. The invert elevation of the 6" diameter outlet is at EL.93.50, 1.25' weir El. 94.00.

System Configuration Targets

1. The system has no pretreatment.
2. The minimum depth of uniformly graded coarse aggregate in the storage bed is 6 inches.
3. The top of the system is not vegetated.

Critical Maintenance Features

1. Avoid sand or silt onto the porous pavement area.
2. Sweep and vacuum the porous pavement area often to prevent clog.
3. Do not apply sealant to cracks or entire surface.
4. (Others to be added by the design engineer, if necessary)

Attach the following Disturbance Notices, if applicable to the site:

Wetland Disturbance Notice:

Maintenance of this BMP may disturb a wetland area. Contact NJDEP Division of Land Use Regulation for guidance and any required permit(s) before performing maintenance.

Wildlife Disturbance Notice:

Maintenance of this BMP may disturb or remove vegetation in an area designated to endangered and/or threatened species. Contact NJDEP Division of Fishing and Wildlife for guidance and any required permit(s) before performing maintenance.

Visual Aid for Pervious Paving System Inspection

Currently, no photos are available. Photos will be updated upon availability.

Reference Documents

Documents to be placed in this field manual should include the following:

- As-built Drawings with Drainage Plans
- Manufacturer's Operation and Maintenance Manual
- Soil Boring Logs
- Permeability Test (Pre-construction)
- Permeability Test (Post-construction)
- Landscaping Plan
- Groundwater Mounding Analysis

Inspection Checklist / Maintenance Actions
Porous Asphalt Paving System

Checklist (circle one): Quarterly / Annual / Monthly / Special Event Inspection

Checklist No. _______________ **Inspection Date:** ________________

Date of most recent rain event: ___________

Rain Condition (circle one):
Drizzle / Shower / Downpour / Other ______________

Ground Condition (circle one):
Dry / Moist / Ponding / Submerged / Snow accumulation

The inspection items and preventative/corrective maintenance actions listed below represent general requirements. The design engineer and/or responsible party shall adjust the items and actions to better meet the conditions of the site, the specific design targets, and the requirements of regulatory authorities.

	For Inspector			For Maintenance Crew
Component No. Component Name	Inspection Item and Inspection Item No.		Result	Preventative / Corrective Maintenance Actions
A Pretreatment (Vegetative Filter Strip)	1	Poor quality vegetation, erosion, sedimentation, or debris	Y__ N__	(See Vegetative Filter Strip Field Manual)
B1 Pavement Surface (Porous Pavement)	1	Standing water is present after the design drain time The observed drain time is approximately __________ hours. Excessive sediment or mud accumulation on top of the pavement	Y__ N__	Recheck to determine if there is standing water after 72 hours If standing water is present longer than 5 days, report to mosquito commission. If excessive sediment is present, the system may be clogged - Sweep the surface - Power wash (at 45 degree angle to the top) - Vacuum the surface - Excavate to inspect the storage bed for clogging, replace the storage bed material if it is severely clogged - Check the permeability rate of the subsoil Work Order # ________________
B 1 Pavement Surface (Porous Pavement)	2	Cracking, subsidence, spalling, or other damage to the pavement	Y__ N__	Repair according to the manufacturer's procedures and material. See Reference Documents section. Work Order # ________________
	3	Weeds or other vegetation on the porous pavement	Y__ N__	Remove the vegetation
Note:				

	For Inspector			For Maintenance Crew
Component No. Component Name	Inspection Item and Inspection Item No.		Result	Preventative / Corrective Maintenance Actions
B 2 Pavement Surface (Permeable Paver)	1	Standing water is present after the design drain time The observed drain time is approximately __________ hours..	Y__ N__	Recheck to determine if there is standing water after 72 hours If standing water is present longer than 5 days, report to mosquito commission. If excessive sediment is present, the system may be clogged - Sweep the surface - Vacuum the surface - Excavate to inspect the storage bed for clogging, replace the storage bed material if it is severely clogged - Check the permeability rate of the subsoil Work Order # ________________ (Note: Do not power wash a permeable paver system)
	2	Excessive sediment or mud accumulation on the system	Y__ N__	Sweep and/or vacuum surface Replenish aggregate in joints Work Order # ________________
	3	Cracking, subsidence, spalling, deformation, uneven settlement, broken unit(s), or other damage to the pavers	Y__ N__	Repair according to the manufacturer's procedures and material. See Reference Documents section. Work Order # ________________
	4	Loss of aggregate between joints	Y__ N__	Replenish aggregate in joint Work Order # ________________
Note:				

	For Inspector			For Maintenance Crew
Component No. Component Name	Inspection Item and Inspection Item No.		Result	Preventative / Corrective Maintenance Actions
C Vegetation (for permeable pavers with vegetation)	1	Vegetation is overgrown	Y__ N__	Remove the vegetation according to the permeable paver manufacturer's instruction Work Order # ________
D Outlet	1	Clogged overflow outlet	Y__ N__	Clear and remove sediment
	2	Discharge pipe apron is eroded or scoured	Y__ N__	Restabilize the discharge riprap apron Work Order #___________
Note:				

Follow Up Items (Component No. / Inspection Item No.):
_(e.g., B/1, C/2)____

Associated Work Orders: # _______, # _______, # _______, # ______, # ______

______________________________ ___________________________ ___________________

Inspector Name Signature Date

Report issues to the local authority and mosquito commission as required by local ordinances and regulatory authorities.

File this checklist in the Maintenance Log after performing maintenance.

Preventative Maintenance Record

Corresponding Checklist No. _________
Component No.________, Inspection Item No._________

Work Logs

Activities	Components	Date Completed
Sediment/debris removal	A – Pretreament (Vegetative Filter Strip)	
	B1 – Pavement Surface (Porous Pavement)	
	B2 – Pavement Surface (Permeable Paver)	
	D – Outlet	
Vegetation removal	A – Pretreament (Vegetative Filter Strip)	
	B2 – Pavement Surface (Permeable Paver)	
	C – Vegetation	
(List additional tasks, if applicable)		

Debris, sediment, and trash are handled (onsite / by _____________ (contractor name) to disposal site __________________). (See Part I: Maintenance Plan – Disposal Plan Section)

Crew member:_____________________/___________________ Date: _______________
(name/ signature)

Supervisor:______________________/____________________ Date: _______________
(name/ signature)

File this Preventative Maintenance Record in the Maintenance Log after performing maintenance.

Corrective Maintenance Record

1. Work Order # ______________________ Date Issued _____________

2. Issue to be resolved:
(e.g., clogged surface)

3. The issue was from **Corresponding Checklist No.** ________, **Component No.** ________________________, **Inspection Item No.** ____________.

4. Required Actions

Actions	Planned Date	Date Completed

5. Responsible person(s):
____

6. Special requirements
   - Time of the season or weather condition:_________________________
   - Tools/equipment:____
   - Subcontractor (name or specific type):__________________________

Approved by ___________________/_______________ Date _____________
(name/signature)

Verification of completion by ____________/________ Date _____________
(name/signature)

File this Corrective Maintenance Record in the Maintenance Log after performing maintenance.

Subsurface Infiltration/Extended Detention System
Measure #2 on the Location Map

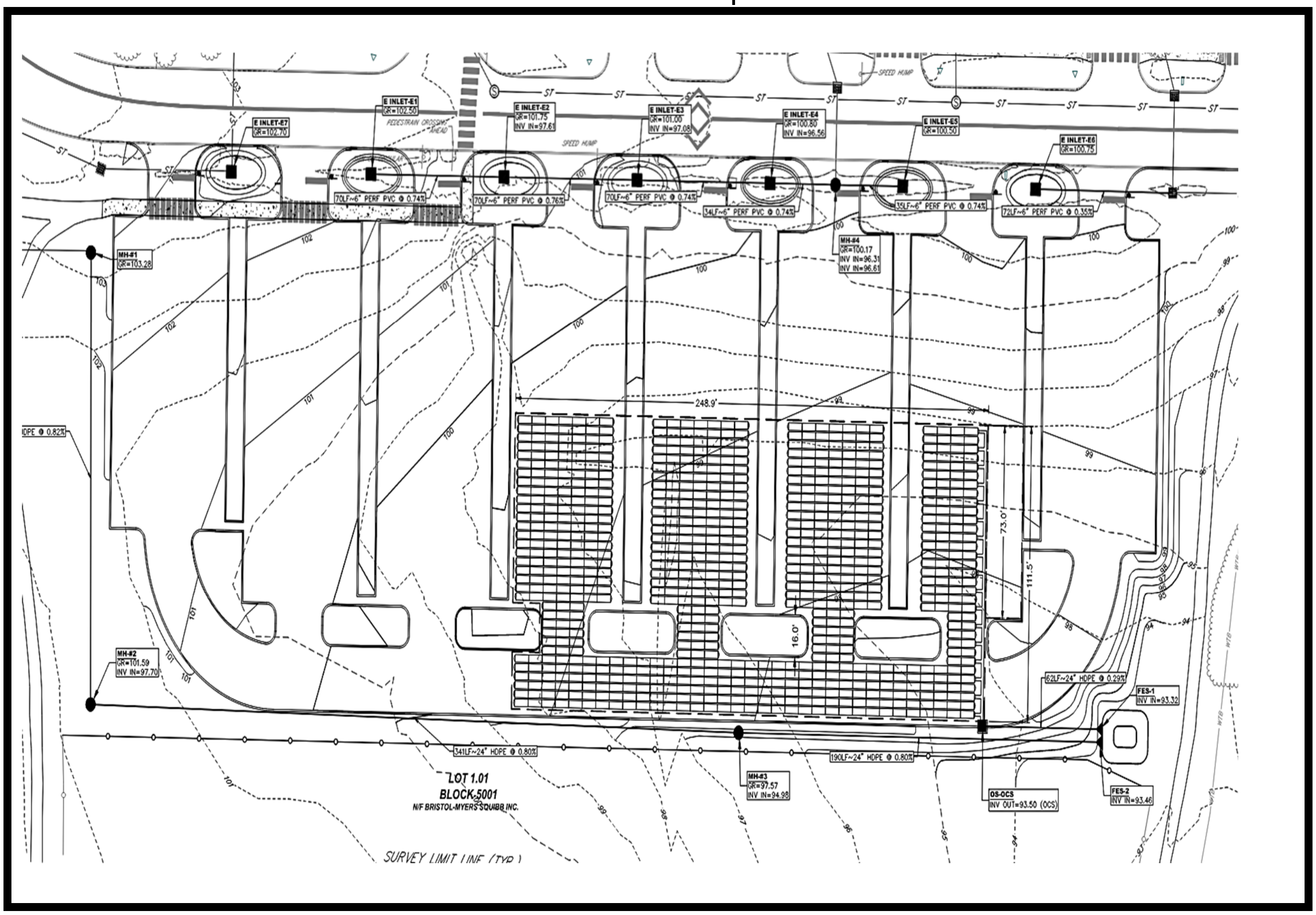
Development Name: Bristol Myers Squibb Additional Parking

Township, County: Lawrence Township, Mercer County

Location of Infiltration System: N: 530,109; E :431,205

Location Description: beneath 244 space parking area

Location Map



Example Map: Use aerial photo, site plan, or other graphics showing the locations of BMPs

NOTE

This Field Manual is intended to be editable and adjustable in accordance with the design of stormwater management measures, the site conditions, and the special needs of responsible party. The Engineer should supplement information and best management practice to assist the responsible party to perform maintenance.

Blue text indicates information may be deleted and or replaced as necessary.

Table of Contents

Subsurface Infiltration/Extended Detention Basin Overview

Functionality

A subsurface infiltration/extended detention basin receives and temporarily stores stormwater runoff. Discharge of this stored runoff is infiltration into the surrounding soils with larger storm events routed through the facility. A subsurface basin may be either a structural chamber, an excavated pit filled with aggregate or a combination of both.

Subsurface infiltration/extended detention basins can be used to reduce the increased volume of stormwater runoff. Subsurface infiltration/extended detention basins can also be used to meet the groundwater recharge requirements of the NJDEP Stormwater Management Rules.

Proper care and attention in the long-term maintenance of the stormwater management measure is critically important to the safety and health of the public.

Type of BMP – Dry Stormwater Management Measure / Infiltration Only

A subsurface infiltration/extended detention basin is a type of **dry** stormwater management measure. Dry stormwater management measures must fully drain within 72 hours of the most recent rainfall. Standing water in excess of 72 hours is a sign of failure. It may also contribute to mosquito breeding and other health and safety issues. The design drain time shall be closely monitored to ensure that potential failure is recognized early.

All underground detention basin components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment at least four times annually as well as after every storm exceeding 1 inch of rainfall. All debris and trash should be removed from the underground basin. While maintenance can generally be performed year-round, it should be scheduled during a relatively dry season.

See attached Manufacturer’s maintenance recommendations.

Basic Design Information

This section shall be filled out by the design engineer.

Hydrology Design Targets

1. This subsurface basin is designed with a subsoil permeability rate of 2.3 inches/hour (pre-construction) and 1.15 inches/hour (post-construction - tested on 02 / 29 / 2024 .
2. The design drain time is 2.09 hours.
3. The elevation of the seasonal high water table of this subsurface basin was observed on 02 / 29 / 2024 and it was not encountered below the subsurface basin bottom surface, at EL.93.00 feet.

Hydraulic Design Targets

1. This subsurface basin is designed to infiltrate the runoff from the Water Quality Design Storm which generates 8,107 cubic feet of runoff.

Subsurface basin Configuration Targets

1. The dimensions of the subsurface basin are 249' L x 112'W (width, length (or diameter), depth).
2. The chamber size is 16 inches high by 34 inches wide . The chambers are arranged 40 inches center to center.
3. The stone fill uses clean, crushed angular stone.

Critical Maintenance Features

1. Check parking area and remove leaves and other debris immediately.
2. Check inspection port for excessive sediment.
3. Check overflow inlet

Attach the following Disturbance Notices, if applicable to the site:

Wetland Disturbance Notice:

Maintenance of this BMP may disturb a wetland area. Contact NJDEP Division of Land Use Regulation for guidance and any required permit(s) before performing maintenance.

Visual Aid for Subsurface Basin Inspection

No photos are currently available. Photos will be updated upon availability.

Reference Documents

Documents to be placed in this field manual should include the following:

- As-built Drawings (or specifications if a manufactured subsurface basin is used) with Drainage Plans
- Operation and Maintenance Manual, if a manufactured subsurface basin is used
- Permeability Test (Pre-construction)
- Permeability Test (Post-construction)
- Fabric Specifications and Maintenance Information
- Groundwater Mounding Analysis

Attach Reference Documents Here

Inspection Checklist / Maintenance Actions
Subsurface Infiltration/Extended Detention Basin

Checklist (circle one): Quarterly / Annual / Monthly / Special Event Inspection

Checklist No. _______________ **Inspection Date:** ________________

Date of most recent rain event: ___________

Rain Condition (circle one):
Drizzle / Shower / Downpour / Other ______________

Ground Condition (circle one):
Dry / Moist / Ponding / Submerged / Snow accumulation

The inspection items and preventative/corrective maintenance actions listed below represent general requirements. The design engineer and/or responsible party shall adjust the items and actions to better meet the conditions of the site, the specific design targets, and the requirements of regulatory authorities.

	For Inspector			For Maintenance Crew
Component No. Component Name	Inspection Item and Inspection Item No.		Result	Preventative / Corrective Maintenance Actions
A Subsurface Basin	1	The cap of the inspection port is loose, damaged, or missing.	Y__ N__	Fix, repair, or replace the cap Work Order #___________
	2	Standing water is present after the design drain time The observed drain time is approximately __________ hours.	Y__ N__	Recheck to determine if there is standing water after 72 hours If standing water is present longer than 5 days, report to mosquito commission. Remove any sediment buildup and replace the stone fill if necessary Check the chambers for clogging and clean it if necessary Check the chambers for damage and repair it if necessary Check subsoil permeability and replace subsoil if necessary Work Order #___________
	3	Excessive sediment or debris present in the inspection port	Y__ N__	Clear and remove sediment or debris
Note:				

	For Inspector			For Maintenance Crew
Component No. Component Name	Inspection Item and Inspection Item No.		Result	Preventative / Corrective Maintenance Actions
A Subsurface Basin	4	Little or no flow into the subsurface basin	Y__ N__	Check whether the gutter, inlet pipe, downspout, or flow diverter is clogged Clear and remove debris
	5	Overflow pipe is clogged	Y__ N__	Clear the clog
	6	Odor present	Y__ N__	Clear and remove sediment and debris Investigate the inflow and outflow pipes
	7	Overflow from the inlet	Y__ N__	Clear and remove sediment and debris Check the outlet control structure and bypass pipe if any clog Remove any sediment buildup and replace the stone fill if necessary Check the chambers for clogging and clean it if necessary Check the chambers for damage and repair it if necessary Check subsoil permeability and replace subsoil if necessary
Note:				

Follow Up Items: (Component No. / Inspection Item No.):

_(e.g., A/1, A/2)____

Associated Work Orders: # _______, # _______, # _______, # _______, # ______

______________________________ ______________________ ____________________

Inspector Name Signature Date

Report issues to the local authority and mosquito commission as required by local ordinances and regulatory authorities.

File this checklist in the Maintenance Log after performing maintenance.

Preventative Maintenance Record

Corresponding Checklist No. _________
Component No.________, Inspection Item No.________

Work Logs

Activities	Components	Date Completed
Sediment/debris removal **Sediment removal should take place when the subsurface basin is thoroughly dry.**	A- Subsurface basin	
(List additional tasks, if applicable)		

Debris, sediment, and trash are handled (onsite / by _____________ (contractor name) to disposal site __________________). (See Part I: Maintenance Plan – Disposal Plan Section)

Crew member:____________________/_____________ Date: ______________
(name/ signature)

Supervisor:______________________/_____________ Date: ______________
(name/ signature)

File this Preventative Maintenance Record in the Maintenance Log after performing maintenance.

Corrective Maintenance Record

1. Work Order # ______________________ Date Issued _____________

2. Issue to be resolved:
(e.g., damaged cap)

3. The issue was from Corresponding Checklist No. ________, Component No. ____________________, Inspection Item No.______________.

4. Required Actions

Actions	Planned Date	Date Completed
Repair cap		
Repair chambers		
Repair fabric		
Repair bypass pipe		
Repair downspout		
(If there are additional tasks, list them here.)		

5. Responsible person(s):
____

6. Special requirements
   - Time of the season or weather condition:_________________________
   - Tools/equipment:____
   - Subcontractor (name or specific type):___________________________

Approved by ___________________/_______________ Date _____________
(name/signature)

Verification of completion by ____________/________ Date _____________
(name/signature)

File this Corrective Maintenance Record in the Maintenance Log after performing maintenance.

12.0 Inspection and Maintenance

12.1 Isolator Row Plus Inspection

Regular inspection and maintenance are essential to assure a properly functioning stormwater system. Inspection is easily accomplished through the manhole or optional inspection ports of an Isolator Row PLUS. Please follow local and OSHA rules for a confined space entry.

Inspection ports can allow inspection to be accomplished completely from the surface without the need for a confined space entry. Inspection ports provide visual access to the system with the use of a flashlight. A stadia rod may be inserted to determine the depth of sediment. If upon visual inspection it is found that sediment has accumulated to an average depth exceeding 3 (76 mm), cleanout is required.

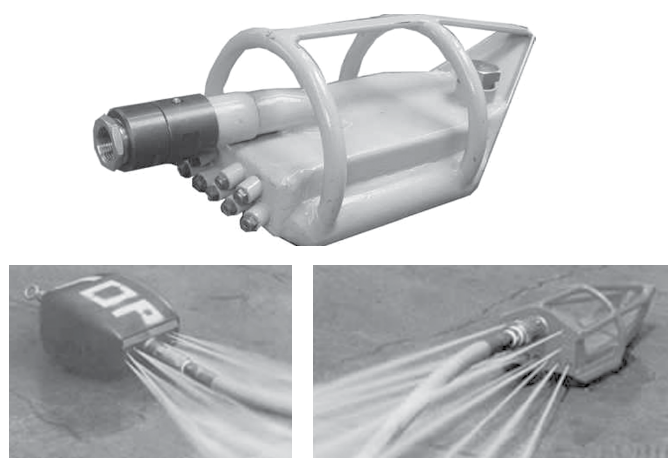
A StormTech Isolator Row PLUS should initially be inspected immediately after completion of the site's construction. While every effort should be made to prevent sediment from entering the system during construction, it is during this time that excess amounts of sediments are most likely to enter any stormwater system. Inspection and maintenance, if necessary, should be performed prior to passing responsibility over to the site's owner. Once in normal service, a StormTech Isolator Row PLUS should be inspected bi-annually until an understanding of the sites characteristics is developed. The site's maintenance manager can then revise the inspection schedule based on experience or local requirements.

12.2 Isolator Row Plus Maintenance

JetVac maintenance is recommended if sediment has been collected to an average depth of 3 (76 mm) inside the Isolator Row PLUS. More frequent maintenance may be required to maintain minimum flow rates through the Isolator Row PLUS. The JetVac process utilizes a high pressure water nozzle to propel itself down the Isolator Row PLUS while scouring and suspending sediments. As the nozzle is retrieved, a wave of suspended sediments is flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/ JetVac combination vehicles. Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear facing jets with an effective spread of at least 45 (1143 mm) are best. StormTech recommends a maximum nozzle pressure of 2000 psi be utilized during cleaning. The JetVac process shall only be performed on StormTech Rows that have ADS PLUS fabric over the foundation stone.

Looking down the Isolator Row PLUS

A typical JetVac truck (This is not a StormTech product.)



Examples of culvert cleaning nozzles appropriate for Isolator Row PLUS maintenance. (These are not StormTech products).

12.0 Inspection & Maintenance

StormTech Isolator Row Plus - Step-by-Step Maintenance Procedures

Step 1: Inspect Isolator Row PLUS for sediment

A) Inspection ports (if present)
   i. Remove lid from floor box frame
   ii. Remove cap from inspection riser
   iii. Using a flashlight and stadia rod, measure depth of sediment
   iv. If sediment is at, or above, 3" (76 mm) depth proceed to Step 2. If not proceed to Step 3.

B) All Isolator Plus Rows
   i. Remove cover from manhole at upstream end of Isolator Row PLUS
   ii. Using a flashlight, inspect down Isolator Row PLUS through outlet pipe
      1. Follow OSHA regulations for confined space entry if entering manhole
      2. Mirrors on poles or cameras may be used to avoid a confined space entry
   iii. If sediment is at or above the lower row of sidewall holes [approximately 3" (76 mm)]proceed to Step 2. If not proceed to Step 3.

Step 2: Clean out Isolator Row PLUS using the JetVac process

A) A fixed floor cleaning nozzle with rear facing nozzle spread of 45 (1143 mm) or more is preferable

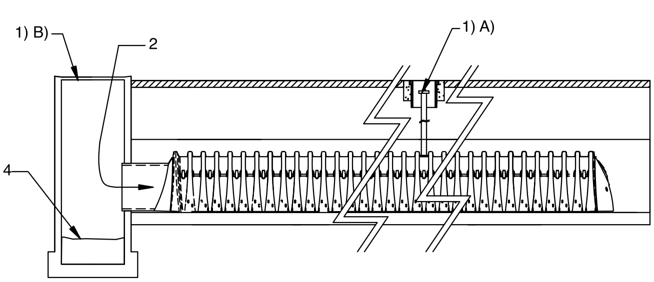
B) Apply multiple passes of JetVac until backflush water is clean

C) Vacuum manhole sump as required during jetting

Step 3: Replace all caps, lids and covers

Step 4: Inspect and clean catch basins and manholes upstream of the StormTech system following local guidelines.

Figure 20 – StormTech Isolator Row Plus (not to scale)



12.3 Eccentric Pipe Header Inspection

Theses guidelines do not supercede a pipe manufacturer's recommended I&M procedures. Consult with the manufacturer of the pipe header system for specific I&M procedures. Inspection of the header system should be carried out quarterly. On sites which generate higher levels of sediment more frequent inspections may be necessary. Headers may be accessed through risers, access ports or manholes. Measurement of sediment may be taken with a stadia rod or similar device. Cleanout of sediment should occur when the sediment volume has reduced the storage area by 25% or the depth of sediment has reached approximately 25% of the diameter of the structure.

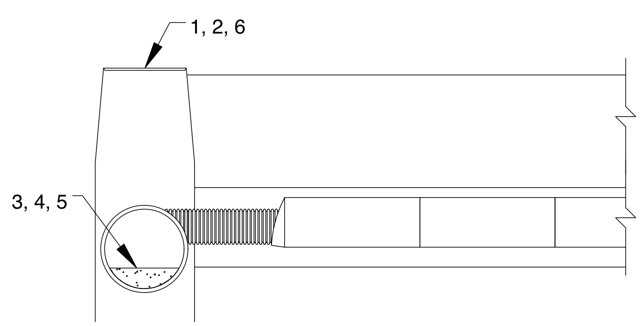
12.4 Eccentric Pipe Manifold Maintenance

Cleanout of accumulated material should be accomplished by vacuum pumping the material from the header. Cleanout should be accomplished during dry weather. Care should be taken to avoid flushing sediments out through the outlet pipes and into the chamber rows.

Eccentric Header Step-by-Step Maintenance Procedures

1. Locate manholes connected to the manifold system
2. Remove grates or covers
3. Using a stadia rod, measure the depth of sediment
4. If sediment is at a depth of about 25% pipe volume or 25% pipe diameter proceed to step 5. If not proceed to step 6.
5. Vacuum pump the sediment. Do not flush sediment out inlet pipes.
6. Replace grates and covers
7. Record depth and date and schedule next inspection

Figure 21 – Eccentric Manifold Maintenance



Please contact StormTech's Technical Services Department at 888-892-2894 for a spreadsheet to estimate cleaning intervals.

13.0 General Notes

1. StormTech requires installing contractors to use and understand StormTech's latest Installation Instructions prior to beginning system installation.

2. Our Technical Services Department offers installation consultations to installing contractors. Contact our Technical Service Representatives at least 30 days prior to system installation to arrange a preinstallation consultation. Our representatives can then answer questions or address comments on the StormTech chamber system and inform the Installing contractor of the minimum installation requirements before beginning the system's construction. Call **860-529-8188** to speak to a Technical Service Representative or visit **www.stormtech.com** to receive a copy of our Installation Instructions.

3. StormTech's requirements for systems with pavement design (asphalt, concrete pavers, etc.): Minimum cover for the SC-740, DC-780 and SC-310 chambers is 18" (457 mm) not including pavement; Minimum cover for the SC-160LP chamber is 14 (350 mm); Maximum cover for the SC-740 and SC-310 chambers is 96" (2.4 m) including pavement design; Maximum cover for the SC-160LP chamber is 10' (3.0 m); Maximum cover for the DC-780 chamber is 12' (3.6 m) including pavement design. For installations that do not include pavement, where rutting from vehicles may occur, minimum required cover is 24" (610 mm), maximum cover is as stated above.

4. The contractor must report any discrepancies with the bearing capacity of the chamber foundation materials to the design engineer.

5. AASHTO M288 Class 2 non-woven geotextile (filter fabric) must be used as indicated in the project plans.

6. Stone placement between chamber rows and around perimeter must follow instructions as indicated in the most current version of StormTech's Installation Instructions.

7. Backfilling over the chambers must follow requirements as indicated in the most current version of StormTech's Installation Instructions.

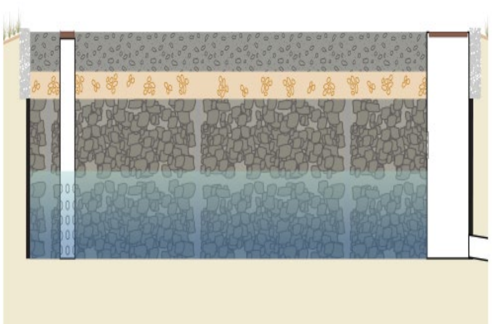
8. The contractor must refer to StormTech's Installation Instructions for a Table of Acceptable Vehicle Loads at various depths of cover. This information is also available at StormTech's website:
   www.stormtech.com. The contractor is responsible for preventing vehicles that exceed StormTech's requirements from traveling across or parking over the stormwater system. Temporary fencing, warning tape and appropriately located signs are commonly used to prevent unauthorized vehicles from entering sensitive construction areas.

9. The contractor must apply erosion and sediment control measures to protect the stormwater system during all phases of site construction per local codes and design engineer's specifications.

10. STORMTECH PRODUCT WARRANTY IS LIMITED. Contact StormTech for warranty information.

Part III- Attachments

9.6 PERVIOUS PAVING SYSTEMS



A pervious paving system is a stormwater management facility used to address the impacts of land development. The system consists of a durable, permeable surface course, which allows stormwater runoff to move through it; this surface course is placed over a transition layer and a storage bed of open-graded, i.e., devoid of fine particles, aggregate. There are two types: underdrained systems and systems designed to infiltrate into the subsoil. When designed in accordance with this chapter, the total suspended solid (TSS) removal rate is 80%.

N.J.A.C. 7:8 Stormwater Management Rules – Applicable Design and Performance Standards		
	Green Infrastructure	Yes
	Stormwater Runoff Quantity	Yes
GR	Groundwater Recharge	Yes, for systems designed to infiltrate into the subsoil
%	Stormwater Runoff Quality	80% TSS Removal

Stormwater Runoff Quality Mechanisms and Corresponding Criteria	
Filtering	
Maximum Area of Additional Inflow	≤ 3 x the Area of Pervious Paving System
Maximum Drain Time	72 hours, Using Slowest Design Permeability Rate
Porous Asphalt, Pervious Concrete and Permeable Interlocking Paver Units	6.4 inches/hour Minimum Infiltration Rate

Introduction

A pervious paving system is a stormwater management facility that filters stormwater runoff as it moves vertically through the system by either infiltrating through the void spaces in the surface course or infiltrating through the joints in paver units. The system consists of a surface course, a transition layer and a storage bed of open-graded aggregate, where runoff is temporarily stored. Discharge of runoff from pervious paving systems is either through an underdrain or through infiltration into the subsoil. In order to receive a TSS removal rate for compliance with the stormwater runoff quality design standard, these systems must be designed to treat the entire Water Quality Design Storm (WQDS) volume without overflow; the adopted total suspended solids (TSS) removal rate is 80%.

Permeable surface courses have many benefits, including improved traction, reduced noise and reduced surface ponding. Additionally, there is a biofilm micro-ecosystem in the system that can filter and biodegrade a wide variety of pollutants, including hydrocarbons. Finally, the moist environment in the sub-layers results in a higher temperature in the system that makes it more resistant to frost and may significantly reduce the area that needs to be de-iced.

Due to the potential for groundwater contamination, the use of pervious paving systems designed to infiltrate into the subsoil, and all stormwater infiltration best management practices (BMPs), is prohibited in areas where high pollutant or sediment loading is anticipated. For more information regarding stormwater runoff that may not be infiltrated, refer to N.J.A.C. 7:8-5.4(b)3. However, this prohibition is limited only to areas onsite where this type of loading is expected. Additionally, pervious paving systems may only be used on these types of sites provided the location of the infiltration practice is not inconsistent with an NJDEP-approved remedial action work plan or landfill closure plan.

Systems designed to infiltrate into the subsoil may not be used where their installation would create a significant risk of adverse hydraulic impacts. These impacts may include exacerbating a naturally or seasonally high water table that results in surficial ponding, flooding of basements, or interference with the proper operation of a subsurface sewage disposal system or other subsurface structure or where their construction will compact the subsoil. Hydraulic impacts on the groundwater table must be assessed. For more information on groundwater mounding analysis, refer to the *USGS Paper on Assessment of Impacts* link available on the *Additional Guidance Documents* page at www.njstormwater.org and *Chapter 13: Groundwater Table Hydraulic Impact Assessments for Infiltration BMPs*.

Pervious paving systems may have additional contributory drainage areas such as an impervious drive aisle where stormwater runoff flows onto pervious paving parking spaces. If these areas result in the pervious paving areas receiving excessive stormwater runoff, achieving the goals of maintaining natural hydrology and managing stormwater runoff close to its source can be negatively impacted. Currently, a pervious paving system is limited to a maximum ratio of contributory drainage area to pervious system surface area of 3:1. Systems designed in accordance with the design and performance standards published herein have been successful in maintaining natural hydrology and managing stormwater runoff close to its source.

Finally, a pervious paving system must have a maintenance plan and must be reflected in a deed notice recorded in the county clerk's office to prevent alteration or removal.

Applications

Pursuant to N.J.A.C. 7:8-5.2(a)(2), the minimum design and performance standards for groundwater recharge, stormwater runoff quality and stormwater runoff quantity at N.J.A.C. 7:8- 5.4, 5.5 and 5.6 shall be met by incorporating green infrastructure in accordance with N.J.A.C. 7:8-5.3.

Pervious paving systems may be designed to convey storm events larger than the Water Quality Design Storm (WQDS); however, regardless of the design storm chosen, all pervious paving systems must be designed for stability and in accordance with the *Standards for Soil Erosion and Sediment Control in New Jersey*.

Only pervious paving systems designed to infiltrate into the subsoil may be used to meet the groundwater recharge requirements at N.J.A.C. 7:8-5.4. If designed with an underdrain, pervious paving systems cannot be used to meet these requirements. For more information on computing groundwater recharge, see *Chapter 6: Groundwater Recharge*.

To merit the approved TSS removal rate of 80%, pervious paving systems must be designed to treat the WQDS and in accordance with all of the design criteria provided in this chapter.

Design Criteria

Basic Requirements

The following design criteria apply to all pervious paving systems. Additional design criteria may be found, beginning on Page 11, for a system with an underdrain and Page 13, for a system designed to infiltrate into the subsoil.

Contributory Drainage Area

- The maximum ratio of additional inflow contributory drainage area to surface area of the pervious paving system is 3:1. This contributory drainage area limitation is included at N.J.A.C. 7:8-5.3(b).
- The entire contributory drainage area must be completely stabilized prior to use of the pervious paving system.

Inflow and Pretreatment

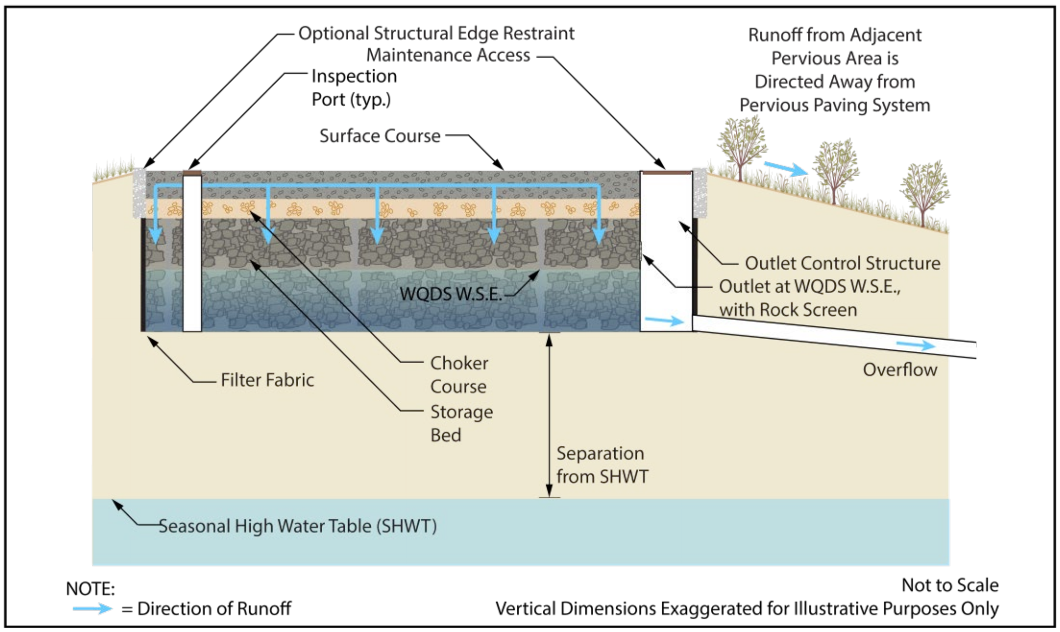
- All inflow must be stable, non-erosive and designed in accordance with the *Standards for Soil Erosion and Sediment Control in New Jersey*.
- Roof runoff may bypass the surface course and directly discharge into the storage bed.

☐ However, any roof runoff that does bypass the surface course must be pretreated by leaf screens, first flush diverters or roof washers. For details of these pretreatment measures, see Pages 5 and 6 of *Chapter 9.1: Cisterns.*

☐ This pretreatment requirement can be waived by the review agency if the building in question has no potential for debris and other vegetative material to be present in the roof runoff. For example, a building that is significantly taller than any surrounding trees and does not have vegetative roof should not need the pretreatment. However, in making this determination, the review agency must consider the mature height of any surrounding trees.

The graphic below illustrates the basic internal elements of pervious pavement systems and are discussed immediately thereafter. These elements are common to a variety of pervious pavement systems and direct the flow of runoff through the system. The illustrations show possible configurations and flow paths and are not intended to limit the design. The acronym WQDS is the abbreviation for the Water Quality Design Storm.

Profile View – Porous Pavement Basics



Surface Course

- The surface course must be designed to support, without lateral movement of the components, the anticipated traffic and other design loads, including additional stresses that may be anticipated at the edges of the installation.

- For a system designed to provide treatment for the WQDS, the minimum tested infiltration rate of the surface course is 6.4 inches per hour. Systems designed to address the stormwater runoff quantity control design standard must have a minimum tested infiltration rate of the surface course of 20 inches per hour. Appropriate testing methods are outlined in the section of this chapter entitled *Types of Surface Courses for Pervious Paving Systems*, beginning on Page 16. While it is likely that the surface course of a pervious paving system will have much higher tested infiltration rate, this is the minimum rate required to prevent surface ponding and meet the requirements of the Stormwater Management rules.

- Sealant, prime coat and other treatments that could reduce the rate of infiltration may not be applied to the surface course.
- The maximum surface course slope is 5%.
- After installation, measures must be taken to ensure the surface course does not become clogged until all aspects of the project are completed.

Choker Course

- The choker course must consist of clean, washed broken stone whose thickness is appropriate for the surface course desired and design load conditions.
- The choker course must consist of clean, washed AASHTO No. 57 broken stone.

Storage Bed

- Storage bed aggregate must be clean, open-graded broken stone with a size designation appropriate for the desired surface course and design load conditions. The stone must be washed, prior to placement, to minimize the amount of stone dust and other fine particles.
- Storage bed aggregate must be placed in lifts and compacted using plate compactors. The maximum recommended loose lift thickness is 6 inches.
- The system must have sufficient volume to fully contain the volume of stormwater runoff produced by the WQDS, in the storage bed and without overflow, including any additional runoff that enters the storage bed through a piping system.
- A system designed to provide stormwater runoff quantity control must include additional storage volume in the storage bed, above the water surface elevation (W.S.E.) of the WQDS, in order to provide detention of stormwater runoff. Refer to the detail illustration found on Page 7 for clarification.
- No standing water may remain in the storage bed 72 hours after a rain event in order to allow for sufficient storage for the next rain event. Storage times in excess of 72 hours may render the system ineffective and may result in anaerobic conditions, odor and both water quality and mosquito breeding issues.

Safety

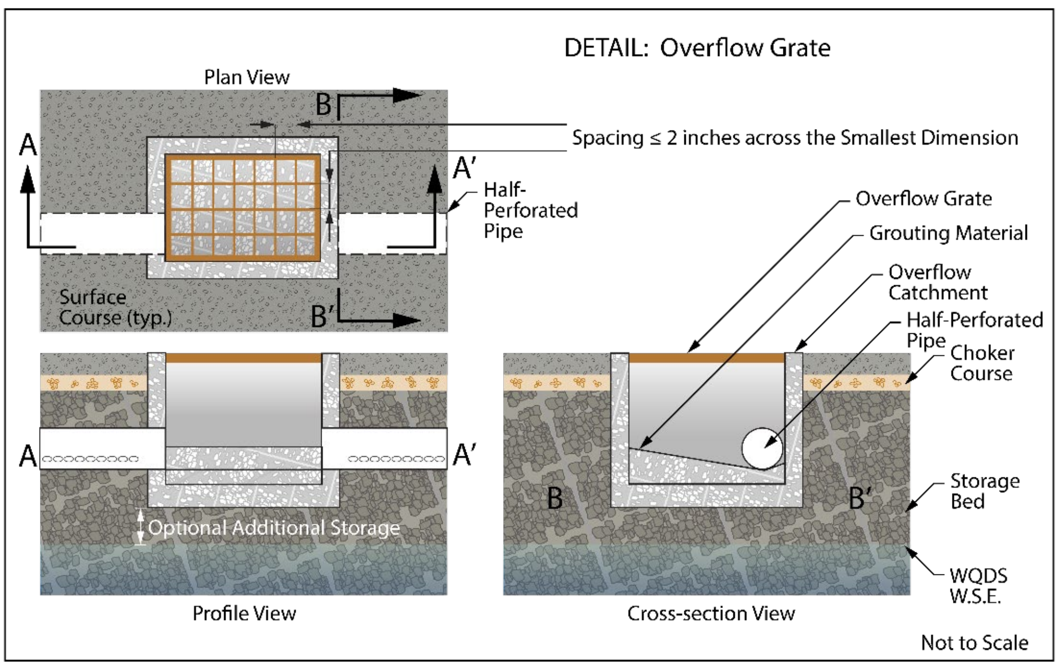
- All pervious paving systems must be designed to safely convey overflows to downstream drainage systems. The design of any overflow structure must be sufficient to provide safe, stable discharge of stormwater runoff in the event of an overflow. Safe and stable discharge minimizes the possibility of adverse impacts, including erosion and flooding in down-gradient areas. Therefore, discharge in the event of an overflow must be consistent with the *Standards for Off-Site Stability* found in the *Standards for Soil Erosion and Sediment Control in New Jersey*.
- For systems designed to provide stormwater runoff quantity control, emergency overflow catchments must be provided to direct surface runoff in excess of that generated by the maximum design storm into the storage bed. Calculations to determine location, elevation, size and efficiency of these structures must assume the surface course is completely impervious (i.e. CN = 98; C = .99) and be in accordance with applicable Federal, State, county and local requirements. The following criteria apply to overflow catchments:

□ Overflow grates are required at each overflow catchment and are illustrated in the detail provided on the following page. They must comply with the following requirements:

1. The overflow grate must be secured to the outlet structure but removable for emergencies and maintenance;
2. The overflow grate spacing must be no greater than 2 inches across the smallest dimension; and
3. The overflow grate must be constructed of rigid, durable and corrosion resistant material and designed to withstand traffic loads.

□ Excess stormwater runoff diverted into the overflow catchments must be distributed over the area of the storage bed through half-perforated pipes, which are solid on top, subject to the following requirements.

1. The lateral pipe network must be designed for positive drainage,
2. The pipes must be of sufficient strength and installed at adequate depth to withstand the anticipated loads,
3. The pipe laterals may connect to the inspection ports, which are discussed on Page 11 for a system designed with an underdrain and on Page 14, for systems designed to infiltrate into the subsoil, and
4. Grouting material such as concrete, a mixture of sand and cement or similar must fill the space below the invert of the discharge pipe so that water will not pond in the outlet structure. This material must be sloped towards the discharge pipe to facilitate drainage as shown in the detail below. Take note the optional additional storage shown below is for pervious paving systems designed for stormwater runoff quantity control.

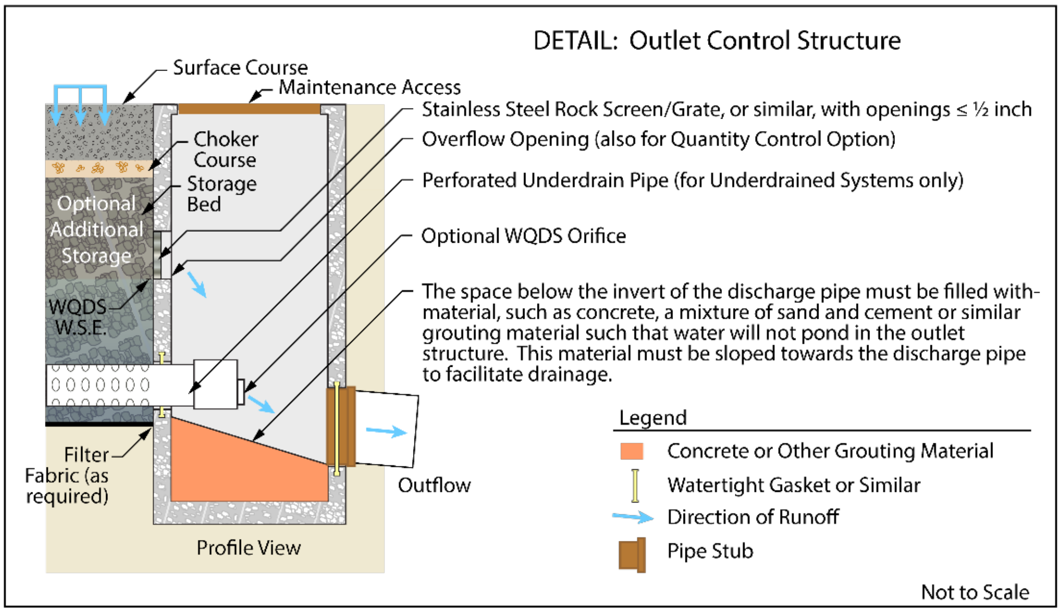


Outlet Structure

Pervious paving systems designed to provide stormwater runoff quantity control or designed with underdrains must also be designed with an outlet structure.

- The outlet structure must be designed to safely control the discharge of stormwater runoff in excess of the maximum design storm.
- All access points must conform to all Federal, State, County and municipal safety standards such as those for confined space entry.
- Any maintenance access hatch or cover must be watertight to ensure that stormwater runoff does not bypass the surface course.
- The space below the invert of the discharge pipe must be filled with material, such as concrete, a mixture of sand and cement, or similar grouting material, such that water will not pond in the outlet structure. This material must be sloped towards the discharge pipe to facilitate drainage, as shown below.
- Any opening for discharge of stormwater runoff from the storage bed must be covered with a stainless steel or equivalently durable grate or rock screen which has openings less than or equal to one-half inch in size.
- When modeling a pervious paving system with an outlet structure, the effective opening of the outlet structure must be calculated as if it is partially obstructed by the rock screen and the stone of the storage bed. The calculated effective opening size must then be used in the model.
- Under no circumstances may a drain-down valve or other dewatering measure be included in the design of a pervious paving system, even if it was intended to remain open or unused during normal operation.

The detail shown below illustrates the requirements for the outlet control structure; the optional elements are solely for illustrative purposes and are not intended to limit the design.



- Blind connections to downstream facilities are prohibited. Any connection to downstream stormwater management facilities must include access points such as inspections ports and manholes, for visual inspection and maintenance, as appropriate, to prevent blockage of flow and ensure operation as intended. All entrance points must adhere to all Federal, State, County and municipal safety standards such as those for confined space entry.

- The effects of tailwater on the hydraulic design of the underdrain and overflow systems, as well as any stormwater quantity control outlets, must be analyzed in instances where the lowest invert in the outlet or overflow structure is below the flood hazard area design flood or tide elevation in a downstream waterway or stormwater collection system. Two methods to analyze tailwater are:
  - A simple method entails inputting flood elevations for the 2-, 10- and 100-year events as static tailwater during routing calculations for each storm event. These flood elevations are obtained from either a Department flood hazard area delineation or a FEMA flood hazard area delineation that includes the 100-year flood elevation or derived using a combination of NRCS hydrologic methodology and a standard step backwater analysis or level pool routing, where applicable. In areas where the 2- or 10-year flood elevation does not exist in a FEMA or Department delineation, it may be interpolated or extrapolated from the existing data. If this method demonstrates that the requirements of the regulations are met with the tailwater effect, then the design is acceptable. If the analysis shows that the requirements are not met with the tailwater effects, the detailed method below may be used or the BMP must be redesigned.
  - A detailed method entails the calculation of hydrographs for the watercourse during the 2-, 10- and 100-year events using NRCS hydrologic methodology. These hydrographs are input into a computer program to calculate rating curves for each event. Those rating curves are then input as a dynamic tailwater during the routing calculations for each of the 2-, 10- and 100-year events. This method may be used in all circumstances; however, it may require more advanced computer programs. If this method demonstrates that the requirements of the regulations are met with the tailwater effect, then the design is acceptable. If the analysis shows that the requirements are not met with the tailwater effects, the BMP must be redesigned.

Construction Requirements

- Construction may not take place during rain or snow, nor when the subsoil is frozen. Frozen aggregate materials may not be installed.

- The proposed area of the pervious pavement system must be kept free from sediment during the entire construction process. Construction materials contaminated by sediments must be removed and replaced with clean materials.

- The location of the proposed pervious paving system should not be used to provide sediment control during construction; however, when unavoidable, the bottom of the sediment control basin must be at least 2 feet above the final design elevation of the bottom of the storage bed in the pervious paving system.

- The excavation to the final design elevation of the storage bed may only occur after all construction within its contributory drainage area is completed and the drainage area is stabilized.

If construction of the pervious paving system cannot be delayed, during all phases of construction all flows must be diverted away from the pervious paving system. The diversions may not be removed until all construction within the contributory drainage area is completed and the area is stabilized.

- The contributory drainage area must be completely stabilized prior to pervious paving system use.

Cold Weather Requirements

- Snow and ice, especially from areas treated with sand, cinders or de-icing materials, may not be stockpiled on a pervious paving system.
- A grade-separated area must be designated on the plan for stockpiling snow and ice separate from the pervious paving system.

Types of Pervious Paving Systems

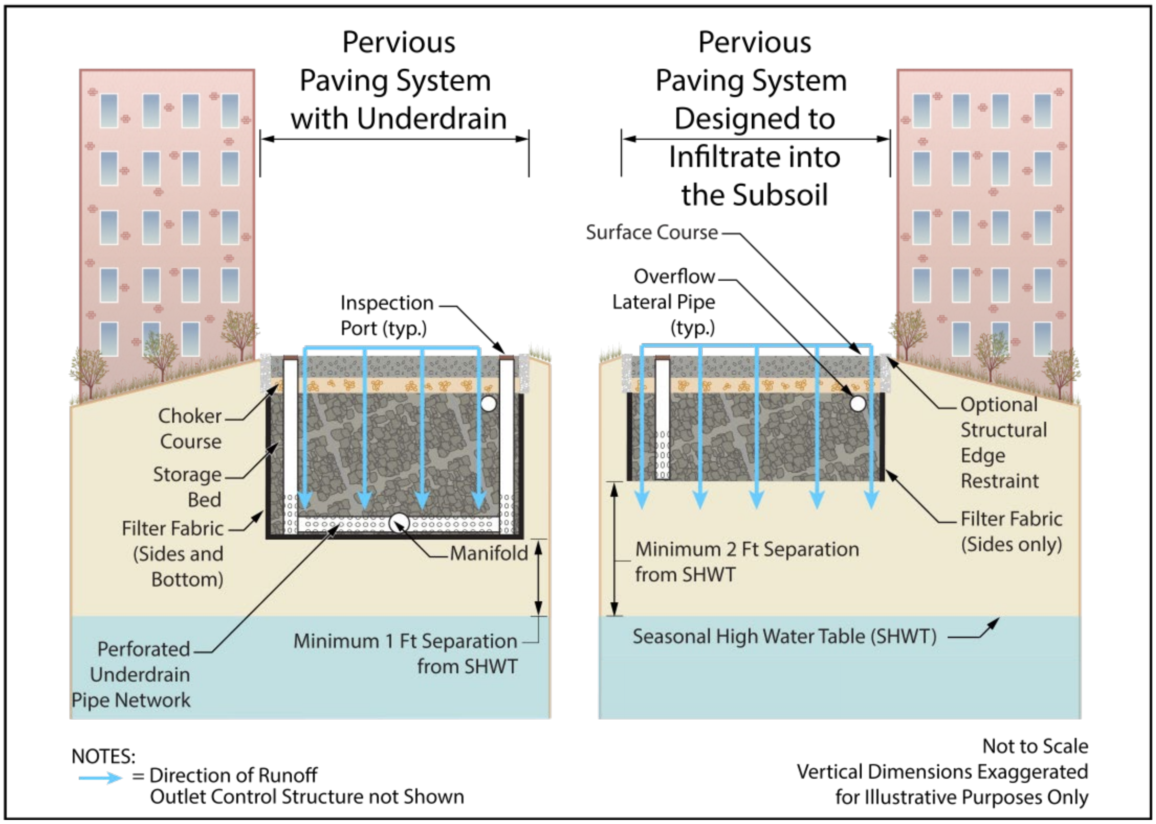
There are two types of pervious paving systems:

1. Pervious Paving Systems with Underdrains
2. Pervious Paving Systems Designed to Infiltrate into the Subsoil

Individual Types of Pervious Paving Systems

The following section provides detailed design criteria for each type of pervious paving system. The illustrations show possible configurations and flow paths and are not intended to limit the design. The illustration below is a side-by-side comparison of the two types of pervious paving systems. Details for the elements depicted below are included in the respective design criteria.

Cross Section Views – A Comparison of the Two Types of Pervious Paving Systems

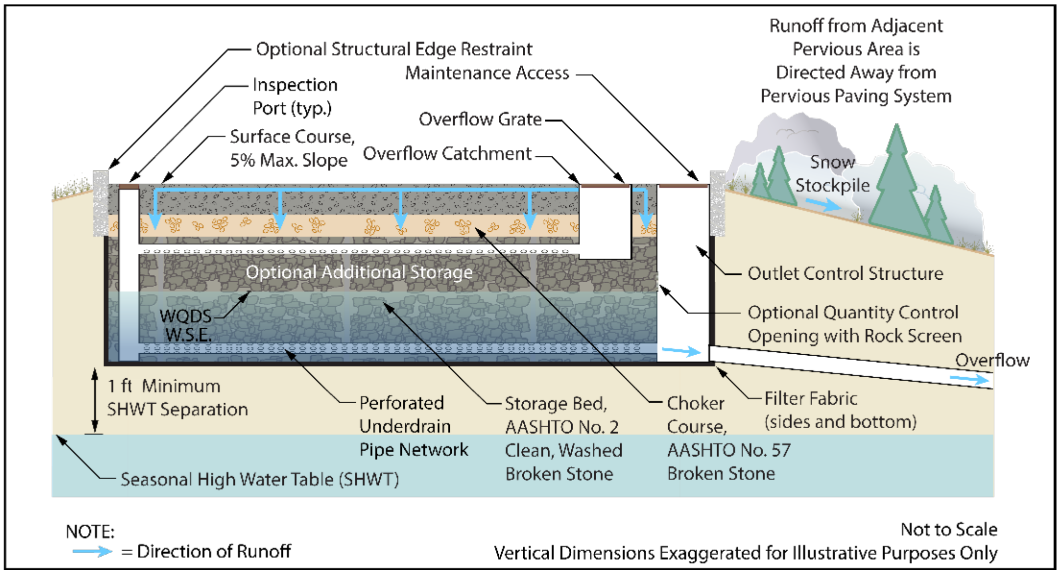


Pervious Paving Systems with Underdrains

- Filter fabric is required along the sides and the bottom of the system to prevent migration of fines from the surrounding soil.
- The storage bed in this type of system consists of an aggregate layer and an underdrain, which is a network of pipes that collect runoff and transport it to the outflow section of the system.
  - The aggregate layer must have sufficient depth to provide at least 3 inches of aggregate above and below the pipe network. It must consist of clean, washed, open-graded AASHTO No. 2 broken stone.
  - Within the aggregate layer, the network of pipes must be able to withstand the design loads.
  - The manifold or other mechanisms used to collect flow from the pervious paving system must be non-perforated.
  - All joints must be secure and watertight.
  - The capacity of the underdrain must be sufficient to allow the system to drain within 72 hours.
- The seasonal high water table (SHWT) or bedrock must be at least 1 foot below the bottom of the storage bed if designed with underdrains or 2 feet below the bottom of the storage bed if designed to infiltrate into the subsoil.
- **Under no circumstances may exfiltration (infiltration into the soil below the system) be used in the routings for stormwater runoff quantity control for any pervious paving system with an underdrain. Exfiltration is defined as the discharge of stormwater into the subsoils and is sometimes referred to as infiltration.**
- At least one inspection port, with a removable cap, must be provided at the upstream and downstream ends of the perforated section of the network of pipes and be flush with the surface of the surface layer and each location denoted in the maintenance plan. Each inspection port must be placed at least 3 feet from any edge. The size of the inspection port must be large enough to allow for maintenance activities. Additionally, each inspection port must extend down to the underdrain pipe network.

The illustration on the following page shows an underdrained pervious paving system; it is only one possible configuration and flow path and is not intended to limit the design. Details of the overflow catchment and outlet control structure are provided on Pages 6 through 8.

Profile View – Pervious Paving System with Underdrain



Pervious Paving Systems Designed to Infiltrate into the Subsoil

- The bottom of the storage bed must be as level as possible in order to allow runoff to uniformly infiltrate into the subsoil.

- The seasonal high water table (SHWT) or bedrock must be at least 2 feet below the bottom of the storage bed.

- The following subsoil permeability requirements apply:

  - The permeability of the subsoil must be sufficient to allow the system to drain within 72 hours.
  - Soil tests are required at the exact location of the proposed system in order to confirm its ability to function as designed. Take note that permits may be required for soil testing in regulated areas, such as areas regulated under the Flood Hazard Area Control Act Rules (N.J.A.C. 7:13), the Freshwater Wetlands Protection Act Rules (N.J.A.C. 7:7A), the Coastal Zone Management Rules (N.J.A.C. 7:7) and the Highlands Water Protection and Planning Rules (N.J.A.C. 7:38).
  - The testing of all permeability rates must be consistent with *Chapter 12: Soil Testing Criteria* in this manual, including the required information to be included in the soil logs, which can be found in section *2.b Soil Logs*. In accordance with *Chapter 12*, the slowest tested hydraulic conductivity must be used for design purposes.
  - Since the actual permeability rate may vary from soil testing results and may decrease over time, a factor of safety of 2 must be applied to the slowest tested permeability rate to determine the design permeability rate. The design rate would then be used to compute the system's drain time for the maximum design volume. The drain time is defined as the time it takes to fully infiltrate the maximum design storm runoff volume through the most hydraulically restrictive layer.
  - The maximum design permeability rate is 10 inches/hour for any tested permeability rate of 20 inches/hour or more.
  - The minimum design permeability rate of the subsoil is 0.5 inches/hour, which equates to a minimum tested permeability rate of 1.0 inch/hour.

- Routing calculations using the design permeability rate (i.e., one-half the tested hydraulic conductivity) of the most restrictive soil layer below the bottom of the system, must be included in the stormwater management report and the drain down time recorded in the maintenance plan as an indicator of a reduction in performance.

- Exfiltration can be used in the design of a pervious pavement system designed to infiltrate, provided all of the conditions regarding the use of exfiltration in stormwater runoff calculations, as published in *Chapter 5* are met. This information is published in the section beginning on Page 7 of *Chapter 5*. The pretreatment requirements outlined under *Inflow and Pretreatment*, which begins on Page 3, must be followed.

- Filter fabric is required along the sides of the storage bed to prevent the migration of fine particles from the surrounding soil. However, unlike systems with underdrains, filter fabric may not be used along the bottom of the storage bed because it may result in a loss of permeability.

- An outlet at the elevation of the WQDS is required to prevent the infiltration of larger storm events; however, additional storage above this elevation may be included to address quantity control requirements.

- At least one inspection port, with a removable cap, must be provided in the storage bed with its location denoted in the maintenance plan. The inspection port must be placed at least 3 feet from any edge. Additionally, each inspection port must be flush with the surface of the surface layer and extend down 4 – 6 inches into the subsoil, and the depth of runoff for the WQDS must be marked on each structure and its level included in the design report and maintenance plan. The size of the inspection port must be large enough to allow for maintenance activities.

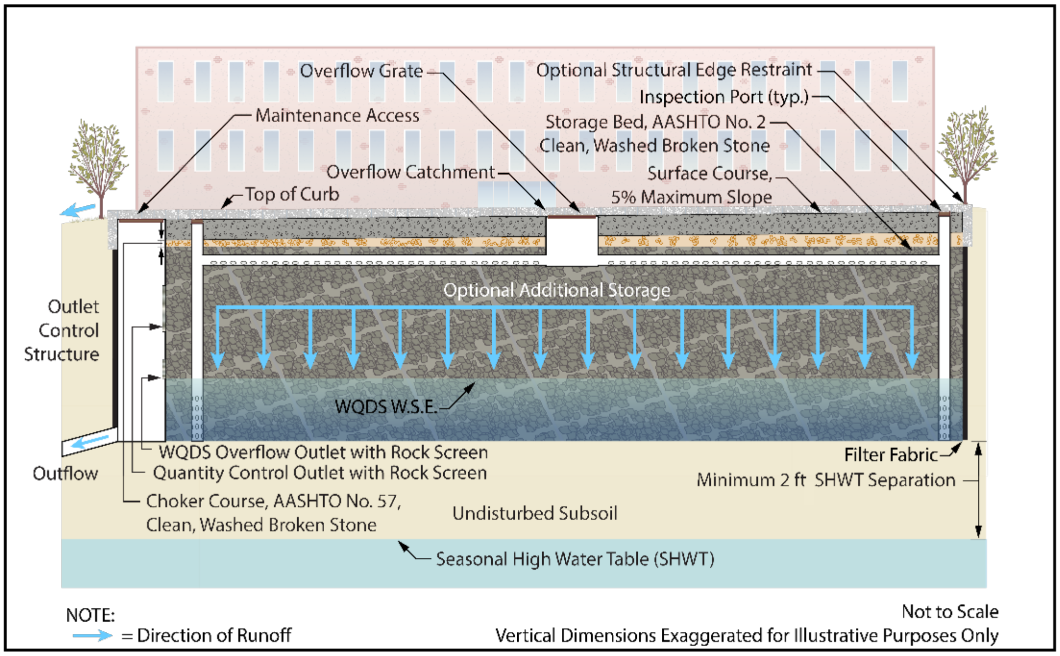
- As with any infiltration BMP, groundwater mounding impacts must be assessed, as required by N.J.A.C. 7:8-5.2(h). This includes an analysis of the reduction in permeability rate when groundwater mounding is present.

  - Additional trials may be required, including using a reduced recharge rate in accordance with the method published in *Chapter 5*, should the calculations demonstrate an adverse impact is produced. Refer to the information labeled "Steps to Follow When an Adverse Impact is Encountered" found on Page 53 of *Chapter 5*.
  - Where the mounding analysis identifies adverse impacts, the pervious paving system designed to infiltrate must be redesigned or relocated, as appropriate. The mounding analysis must provide details and supporting documentation on the methods used and assumptions made, including values used in calculations. For further information on the required groundwater mounding assessment, *see Chapter 13: Groundwater Table Hydraulic Impact Assessments for Infiltration BMPs*.

- Testing must be performed on the subsoil below the storage bed after excavation but prior to placement of the stone in accordance with the Construction and Post-Construction Oversight and Soil Permeability Testing section in *Chapter 12: Soil Testing Criteria* of this manual. Where as-built testing shows a longer drain time than designed, corrective action must be taken. The drain time is defined as the time it takes to fully infiltrate the maximum design storm runoff volume through the most hydraulically restrictive layer.

The illustration on the following page shows one possible configuration and flow path of a pervious paving system designed to infiltrate into the subsoil and is not intended to limit the design. Details of the overflow catchment and outlet control structure are provided on Pages 6 through 8. Note that the surface of the system is sloped and the choker course varies in depth. This example provides additional storage for stormwater runoff produced by storm events larger than the WQDS and the perforated inspection ports are tied into the laterals for distribution of excess runoff at the surface. In this case, the entire contributory drainage area is comprised of motor vehicle surface, meaning pretreatment is not required.

Profile View – Pervious Paving System Designed to Infiltrate into the Subsoil



Types of Surface Courses for Pervious Paving Systems

There are two kinds of surface courses: porous pavement and permeable interlocking pavers. These types of surfaces courses are discussed below along with their design criteria.

Porous Pavement

Porous pavement consists of a contiguous permeable asphalt or pervious concrete surface course installed over a storage bed; stormwater runoff moves vertically through the pores of the surface course and temporarily accumulates in the underlying storage bed until it is discharged from the system or infiltrated into the subsoil. The high rate of infiltration through the surface course is achieved by eliminating the finer aggregates that are typically used in conventional pavement. The remaining aggregates are bound together with an asphalt or Portland cement binder.

Permeable Asphalt

Depending upon the design loads and desired engineering properties of the surface course, permeable asphalt may consist of a permeable asphalt surface course and a permeable asphalt base course over the storage bed or may only include a permeable asphalt surface course over the storage bed. Permeable asphalt is also referred to as an open graded friction course (OGFC). In some instances, a project may specify an OGFC be installed over an impervious base course, usually to increase vehicular traction; however, such a design is ineligible for consideration as a pervious paving system. In order to receive the 80% TSS Removal Rate to comply with the stormwater runoff quality design standard, permeable asphalt must be designed and constructed with a storage bed and in accordance with all of the requirements in this chapter.

- The porosity of the permeable asphalt surface course must be 15-25%.
- The binder used in the surface course must be performance graded for the type of use; therefore, the asphalt plant must also be advised of the type of surface course specified in order to use the correct binder for the installation. For parking lots, polymer modified binder PG 64E-22 must be specified as it has been shown to minimize scuffing caused by automobiles with power steering.
- The porosity of any permeable asphalt base course must be ≥ 25%.
- Minimum air temperature for paving: 50 °F.
- Installation of permeable asphalt requires different temperature guidelines, as follows, than that those of impervious asphalt:
    - Asphalt base course: 200 - 245 °F,
    - Finish rolling base course: 140 – 150 °F,
    - Asphalt surface course: 200 – 220 °F and
    - Finish rolling surface course: 110 - 140 °F.
- Vehicular use is prohibited for at least 48 hours once the pavement installation is complete.
- The minimum choker course thickness is 1 inch.
- Storage bed aggregate must be clean, washed and open-graded AASHTO No. 2 broken stone.

- Post-construction testing of the permeable asphalt surface course is required and must conform to the methods of either ASTM C1701: *Standard Test Method for Infiltration Rate of In-Place Pervious Concrete* or ASTM C1781: *Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems*. At least three locations must be used for the test, and they should be spaced evenly across the pervious paving system. Failure to achieve the minimum design infiltration rate of the surface course at one or more location indicates the system cannot be put in service until the system is corrected to yield all passing values. Unlike the test methodology outlined in the ASTM standards, the test results must not be averaged. The maintenance plan must include a log for recording each location and its test result for future reference.

Pervious Concrete

Pervious concrete is similar to conventional concrete except the fine particles, such as sand, are generally absent. The system of interconnected voids created by the removal of the fines promotes rapid drainage. Flow rates through pervious concrete are generally in the range of 192 – 1,724 inches/hour. In order to receive the 80% TSS Removal Rate for compliance with the stormwater runoff quality design standard, pervious concrete must be designed and constructed with a storage bed and in accordance with all of the requirements in this chapter.

- The porosity of the pervious concrete surface course must be 15-25%.

- If required for added strength, the percentage and type of synthetic fibers or quantity of fine sand required in the mix must be specified and testing must be in accordance with current pervious concrete industry standards.

- The air temperature must be above 32 degrees Fahrenheit on the day of placement and for seven calendar days prior.

- Finishing techniques, such as floating or troweling must not be used, because this would close the surface voids of the concrete.

- Covering pervious concrete with plastic sheeting during curing is required, as it prohibits moisture loss in the concrete mix. Plastic sheeting placement must conform to industry standards for timing and duration. While the plastic sheeting is in place, the pervious concrete must be blocked off from pedestrian or vehicular traffic.

- Post-construction testing of the pervious concrete surface course is required and must conform to the methods of ASTM C1701: *Standard Test Method for Infiltration Rate of In-Place Pervious Concrete*, on the day the plastic sheeting is removed. At least three locations must be used for the test, and they should be spaced evenly across the pervious paving system. Failure to achieve the minimum design infiltration rate of the surface course at one or more location indicates the system cannot be put in service until the system is corrected to yield all passing values. Unlike the test methodology outlined in the ASTM standards, the test results must not be averaged. The maintenance plan must include a log for recording each location and its test result for future reference.

- A choker course is not required.

- Storage bed aggregate must be clean, washed and open-graded broken stone with a minimum size designation of AASHTO No. 57.

Permeable Interlocking Paver Units

Permeable interlocking paver units (PICPs) are similar to porous pavement; however, instead of a contiguous permeable surface course, this system uses an arrangement of pavers installed over a bedding course. These units are most commonly manufactured from concrete or clay or are cut from stone, and the individual units may be shaped to create interesting patterns that interlock. Stormwater runoff moves vertically through the joints between the pavers, or through the voids in a permeable unit, followed by the voids in the bedding and choker courses, respectively, and temporarily accumulates in the underlying storage bed until it is discharged from the system. In order to receive the 80% TSS Removal Rate compliance with the stormwater runoff quality design standard, permeable interlocking paver systems must be designed and constructed with a storage bed and in accordance with all of the requirements in this chapter.

- Permeable interlocking paver units and the manner in which they are arranged must be able to withstand the traffic and other design loads without moving, cracking or deforming.

- The following standards apply to the respective classifications of paver materials:

    - Concrete pavers must conform to ASTM C936 and have a minimum thickness of 3.125 inches when subject to vehicular traffic,
    - Clay pavers must conform to ASTM C1272 and have a minimum thickness of 2.75 inches and
    - Cut stone pavers must conform to ASTM C615 and be at least 3 inches thick.

- The surface slope must not create conditions for erosion of any joint filling material for the maximum design storm.

- The spacing of paver units must provide adequate drainage of the design storm and ensure safe conditions for pedestrians.

- If the proposed edge restraint is flush curb, the subgrade or base material under the curb portion only must be compacted.

- In order to receive an 80% TSS removal rate compliance with the stormwater runoff quality design standard, joint filling material must be used, and it must meet one of the following requirements:

    - The joint filling material must be angular, durable and open-graded, such as ASTM No. 89 or 9 aggregate. The aggregate selected must be clean, i.e., washed, prior to installation, to prevent introduction of fines into the supporting layers.
    - Sand may not be used as a joint filling material.

- Paver units must be installed over a bedding course consisting of clean, washed open-graded AASHTO No. 8 broken stone.

- The minimum choker course thickness is 4 inches.

- Storage bed aggregate must be clean, washed and open-graded AASHTO No. 2 broken stone.

- Post-construction testing of the permeable interlocking paver unit surface course is required and must conform to the methods of ASTM C1781: *Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems*. At least three locations must be used for the test, and they should be spaced evenly across the pervious paving system. Failure to achieve the minimum design infiltration rate of the surface course at one or more location indicates the system cannot be put in service until the system is corrected to yield all passing values. Unlike the test methodology outlined in the ASTM standard, the test results must not be averaged. The maintenance plan must include a log for recording each location and its test result for future reference.

Designing Pervious Paving Systems

Below are two examples on the same site showing the basics of designing a pervious paving system to treat the runoff produced by the Water Quality Design Storm (WQDS); these examples are only two of many ways to configure these systems and are not intended to limit the design. The first example is for a system designed to infiltrate and the second for an underdrained system. Note that both examples show the use of pervious paving systems only in the parking stalls; however, these systems may be used in higher traffic areas as long as the system is designed to withstand the anticipated traffic loads.

Example 1 – Permeable Asphalt Parking Lot Designed to Infiltrate: A proposed commercial site includes a 1-acre parking lot and 0.25-acre roof. The parking stalls will be permeable asphalt and will manage the runoff generated by the WQDS that falls on both them and the adjacent aisles and driveway. Additionally, roof runoff, pretreated in accordance with the inflow and pretreatment requirements on Pages 3 and 4, will be piped directly to the system's storage bed for volume reduction credit for the WQDS. Runoff from all events larger than the WQDS will be temporarily stored in the system and discharged into a downstream collection system. The following parameters apply:

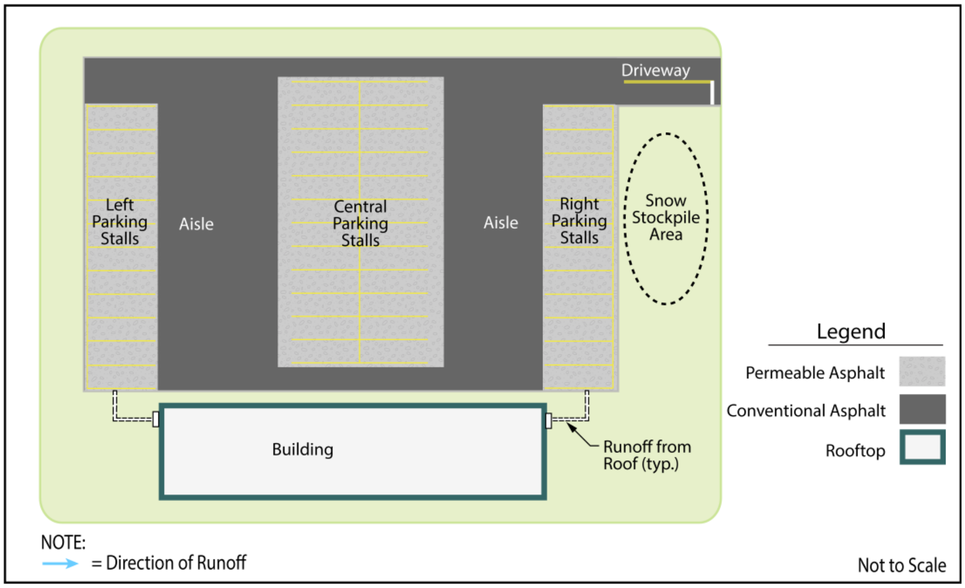
Inflow Drainage Area	Pavement Type	Acreage	CN Value
Driveway and Aisles	Conventional Asphalt	0.50	98
Central Parking Stalls	Permeable Asphalt	0.25	98
Left Parking Stalls	Permeable Asphalt	0.125	98
Right Parking Stalls	Permeable Asphalt	0.125	98
Rooftop	Roof	0.25	98

Tested Subsoil Permeability Rate = 1.00 inches/hour
WQDS: = 1.25 inches in 2 hours

Note that even though a pervious paving system does not produce stormwater runoff, the permeable asphalt surface course must be assigned a CN value of 98 in order to calculate the volume of precipitation collected by the system.

In this example, the pervious paving system is designed for both stormwater runoff quality and quantity control. Therefore, in addition to designing the storage bed to hold the entire stormwater runoff volume produced by the WQDS below the outlet, the storage bed must also be sized to provide detention for larger storm events above invert of the outlet. The sizing calculations for the larger storm events are beyond the scope of this chapter. The layout of the site is illustrated as follows:

Example 1 – Proposed Parking Lot Layout



Step 1: Stormwater Runoff Calculations for the Water Quality Design Storm

Using the NRCS method described in *National Engineering Handbook, Part 630 (NEH)* and discussed in *Chapter 5: Stormwater Management Quantity and Quality Standards and Computations*, the WQDS stormwater runoff volumes were calculated to be as shown on the following page:

Description of Area Producing Runoff	Runoff Volume (cf)
Driveway and Aisles to Left Pervious Parking Stalls	469.4
Driveway and Aisles to Right Pervious Parking Stalls	469.4
Driveway and Aisles to Central Pervious Parking Stalls	938.9
Left Parking Stalls	469.4
Right Parking Stalls	469.4
Central Parking Stalls	938.9
Roof to Left Pervious Parking Stalls	469.4
Roof to Right Pervious Parking Stalls	469.4
Total Runoff Volume	**4,694.2**

Step 2: Storage Volume and Depth of Bed Sizing

As shown in the illustration above, there are three separate permeable asphalt paving areas, which will manage the precipitation falling on them and runoff from the adjacent aisles and from the driveway. For the purposes of this example, stormwater runoff is assumed to be evenly distributed across the three areas. Clean roof runoff from the buildings adjacent to both the right and left parking stalls will be piped directly to the storage beds via leaders connected to the downspouts from the right and left sides of the building.

Because the pervious paving system will receive runoff from areas not occupied by the pervious asphalt, a check of the maximum contributary drainage area limitation are as follows:

Pervious Asphalt Paving Area (A)	Additional Flow Area (B)	Ratio
Central Parking Stalls (0.25 acres)	Driveway and Aisles (0.25 acres)	1
Left Parking Stalls (0.125 acres)	Driveway and Aisles (0.125 acres) and Roof (0.125 acres)	2
Right Parking Stalls (0.125 acres)	Driveway and Aisles (0.125 acres) and Roof (0.125 acres)	2

The area of additional inflow from conventional pavement is not greater than three times the area occupied by the pervious asphalt paving area.

The storage bed underneath the parking stalls is filled with AASHTO No. 2 coarse aggregate assumed to have 40% voids. The design permeability rate, 0.5 in/hr, is used as the exfiltration rate in the routing calculation. The footprints of the storage beds are the same as the surface areas of the pervious parking areas. Therefore, to manage the entire volume produced by the WQDS for the inflow contributory drainage area, the depth of stormwater runoff in the storage bed is calculated by software while performing the routing calculation, as depicted in the exhibits on the following pages for each of the areas depicted in the previous illustration:

Left Pervious Parking Area (Note that the same report is generated for the right pervious parking area.)

Summary Report:

```
Inflow Area =        16,335 sf,100.00% Impervious,  Inflow Depth =   1.03"   for  Custom event
Inflow      =        1.09 cfs @     1.09 hrs,  Volume=           1,408.3 cf
Outflow     =        0.06 cfs @     0.70 hrs,  Volume=           1,408.3 cf,  Atten= 94%,  Lag= 0.0 min
Discarded =          0.06 cfs @     0.70 hrs,  Volume=           1,408.3 cf

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 0.49' @ 1.86 hrs   Surf.Area= 5,445 sf   Storage= 1,076.7 cf

Plug-Flow detention time= 148.9 min calculated for 1,408.3 cf (100% of inflow)
Center-of-Mass det. time= 148.9 min ( 219.2 - 70.3 )

Volume        Invert       Avail.Storage   Storage Description
  #1          0.00'          1,089.0 cf    Custom Stage Data (Prismatic) Listed below (Recalc)
                                           2,722.5 cf Overall  x 40.0% Voids

  Elevation        Surf.Area          Inc.Store          Cum.Store
     (feet)           (sq-ft)        (cubic-feet)       (cubic-feet)
       0.00            5,445                0.0                0.0
       0.50            5,445            2,722.5            2,722.5

Device   Routing          Invert   Outlet Devices
  #1     Discarded         0.00'   0.50 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.06 cfs @ 0.70 hrs  HW=0.01'   (Free Discharge)
 └1=Exfiltration  (Exfiltration Controls 0.06 cfs)
```

Source: HydroCAD® Summary Report; HydroCAD is a registered trademark of HydroCAD Software Solutions LLC. Used with permission

Tabular Hydrograph Report Excerpt:

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Discarded (cfs)
0.00	0.00	0.0	0.00	**0.00**
1.00	**0.69**	**187.8**	**0.09**	**0.06**
2.00	**0.04**	**1,066.9**	**0.49**	0.06
3.00	0.00	852.4	0.39	0.06
4.00	0.00	625.6	0.29	0.06
5.00	0.00	398.7	0.18	0.06
6.00	0.00	171.8	0.08	0.06
7.00	0.00	0.0	0.00	0.00

Source: HydroCAD® Output; HydroCAD is a registered trademark of HydroCAD Software Solutions LLC. Used with permission.

The greatest depth of stormwater runoff in the storage bed of the left porous pavement area is 0.49 ft. The same result is calculated for the right porous pavement area.

Central Pervious Pavement Parking Area

Summary Report:

```
Inflow Area =         21,780 sf,100.00% Impervious,  Inflow Depth =   1.03"   for  Custom event
Inflow      =       1.45 cfs @    1.09 hrs,  Volume=            1,877.7 cf
Outflow     =       0.13 cfs @    0.80 hrs,  Volume=            1,877.7 cf,  Atten= 91%,  Lag= 0.0 min
Discarded =         0.13 cfs @    0.80 hrs,  Volume=            1,877.7 cf

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 0.29' @ 1.80 hrs   Surf.Area= 0.250 ac   Storage= 0.029 af

Plug-Flow detention time= 90.5 min calculated for 1,877.7 cf (100% of inflow)
Center-of-Mass det. time= 90.5 min ( 160.7 - 70.3 )

Volume        Invert     Avail.Storage    Storage Description
  #1           0.00'         0.050 af     Custom Stage Data (Prismatic) Listed below (Recalc)
                                          0.125 af Overall  x 40.0% Voids

 Elevation      Surf.Area       Inc.Store        Cum.Store
    (feet)        (acres)      (acre-feet)      (acre-feet)
      0.00          0.250            0.000            0.000
      0.50          0.250            0.125            0.125

Device   Routing          Invert   Outlet Devices
  #1     Discarded         0.00'   0.50 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.13 cfs @ 0.80 hrs  HW=0.01'   (Free Discharge)
└1=Exfiltration  (Exfiltration Controls 0.13 cfs)
```

Source: HydroCAD® Summary Report; HydroCAD is a registered trademark of HydroCAD Software Solutions LLC. Used with permission.

Tabular Hydrograph Report Excerpt:

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Discarded (cfs)
0.00	0.00	0.000	0.00	**0.00**
1.00	**0.92**	**0.005**	**0.05**	**0.13**
2.00	**0.05**	**0.028**	**0.28**	0.13
3.00	0.00	0.018	0.18	0.13
4.00	0.00	0.008	0.08	0.13
5.00	0.00	0.000	0.00	0.00

Source: HydroCAD® Output; HydroCAD is a registered trademark of HydroCAD Software Solutions LLC. Used with permission.

The greatest depth of stormwater runoff in the storage bed of the central pervious pavement area is 0.28 ft.

Step 3: Drain Time Calculation

The drain time of a pervious paving system is determined by the design permeability of the most hydraulically restrictive layer, which, in this case, is the subsoil. For the left and right storage beds, the drain time is calculated as follows:

Left pervious paving area (same for the right pervious paving area)

$$Drain\ Time = \frac{WQDS\ Runoff\ Volume}{Surface\ Area\ x\ Subsoil\ Design\ Permeability\ Rate}$$

$$= \frac{1408.2}{\left(0.125\ ac\ x\ \frac{43{,}560\ sf}{ac}\ x\ \frac{0.5\ in}{hr}\ x\ \frac{1\ ft}{12\ in}\right)} = 6.2 \text{ hr}$$

Central pervious paving area

$$Drain\ Time = \frac{WQDS\ Runoff\ Volume}{Surface\ Area\ x\ Subsoil\ Design\ Permeability\ Rate}$$

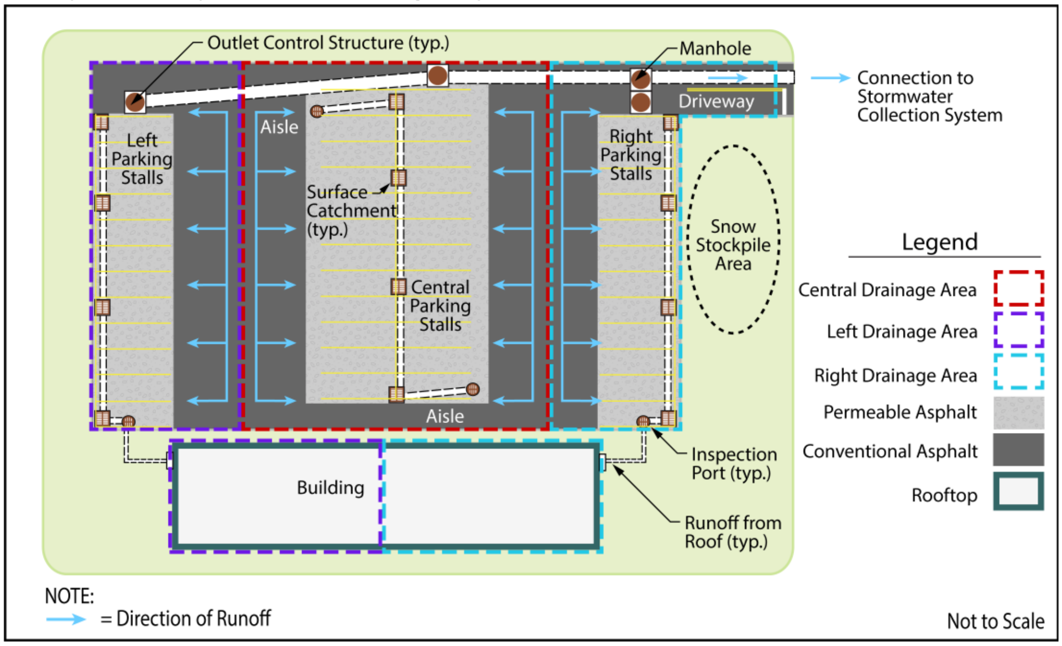
$$= \frac{1877.8}{\left(0.25\ ac\ x\ \frac{43{,}560\ sf}{ac}\ x\ \frac{0.5\ in}{hr}\ x\ \frac{1\ ft}{12\ in}\right)} = 4.2 \text{ hr}$$

Since this is less than the allowable maximum drain time of 72 hours, the storage bed appears, at this stage, to meet the drain time requirements. Using this method, the shallower central storage bed will have a shorter drain time, which is equal to 4.2 hours.

Step 4: Quantity Control for Large Storm Events

As previously stated, stormwater runoff quantity control design will require routing calculations for the stormwater runoff generated by the 2-, 10- and 100-year storm events as well as the hydraulic calculations for the controlled peak flow through the outlets that are beyond the scope of this chapter. Although the design for stormwater runoff quantity control is not shown here, for the purpose of this example, the storage beds and outlet control structures were designed to provide additional storage with detention. Therefore, the first stormwater runoff quantity control outlet is at the water surface elevation (W.S.E.) of the WQDS, as shown in the detail provided on Page 7. Additionally, overflow provisions are required for the surface course, as shown in the outlet structure design criteria found on Pages 6 through 8. The site layout is shown in the illustration below:

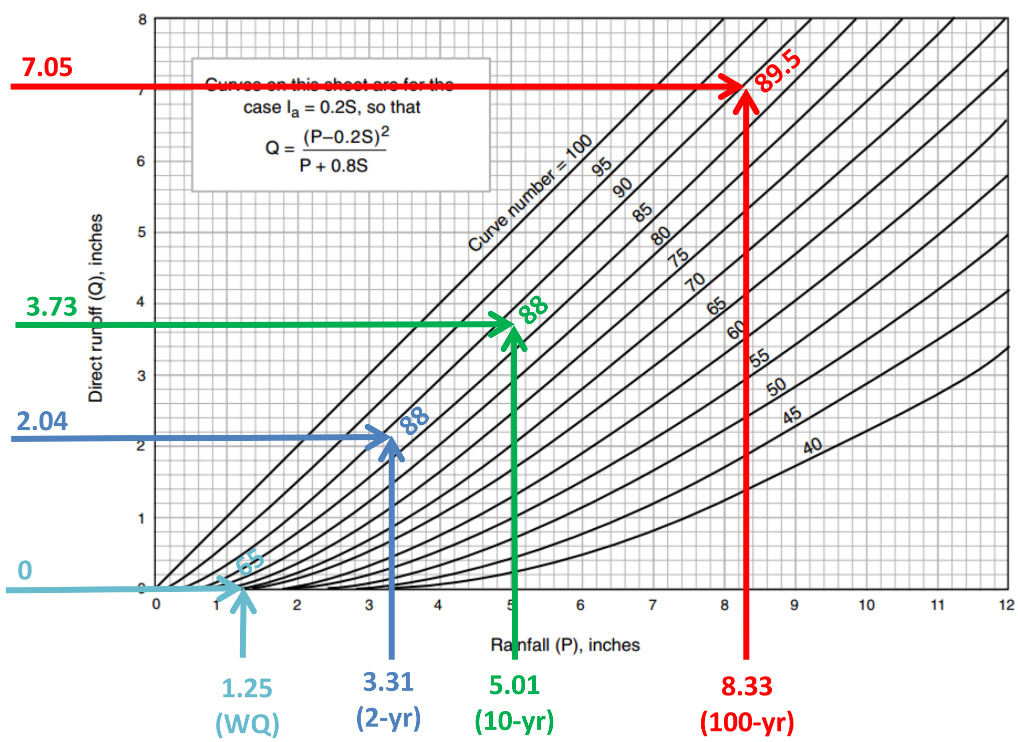
Example 1 – Proposed Site Drainage Layout



Step 5: Reduced CN

The volume retained in the pervious paving system reduces the direct runoff leaving the site. Therefore, a reduced CN can be calculated by using the reduced direct runoff, rainfall depth and Fig 2-1 in *NEH, Part 630*, Chapter 2, as shown in the graph following the table below. The contributory drainage area is 1.25 acre including the pervious driveway, aisles, permeable asphalt and the roof area.

Storm Event	Rainfall (in)	Direct Runoff Volume without Pervious Paving (cf)	Retention Volume (cf)	Runoff Volume Leaving Pervious Paving (cf)	Reduced Direct Runoff (in)	Reduced CN (from Graph)
WQ	1.25	4,695	4,694	0	0.00	65
2-year	3.31	13,946	4,694	9,252	2.04	88
10-year	5.01	21,633	4,694	16,939	3.73	88
100-year	8.33	36,666	4,694	31,972	7.05	89.5



The Reduced CN can be used to calculate the runoff volume. However, when calculating peak flow rate, a routing calculation must be performed on the pervious paving system.

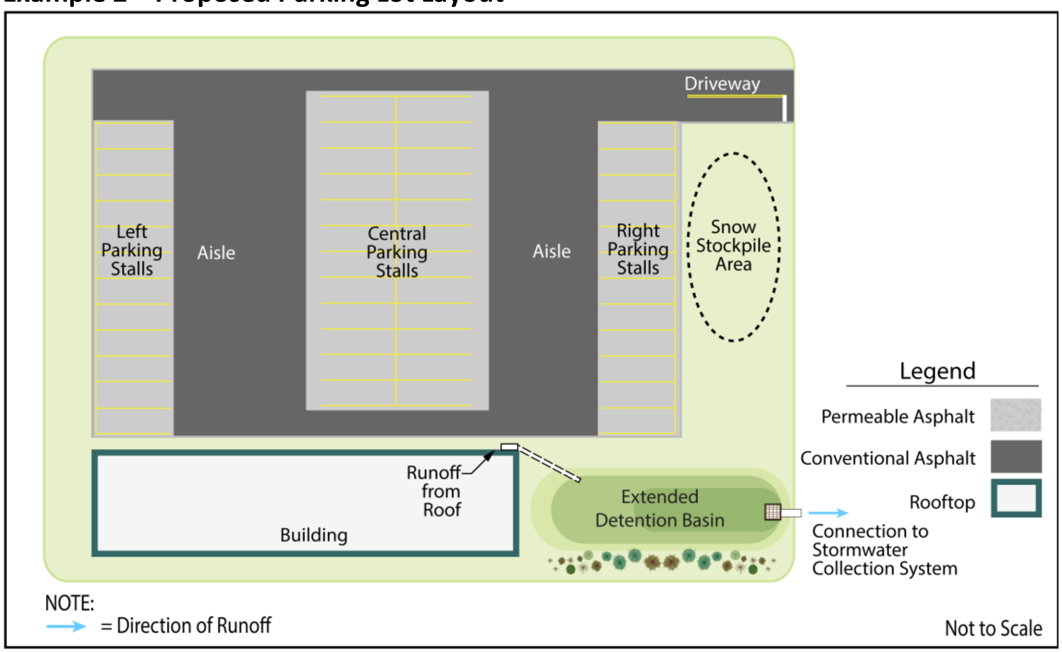
Example 2 – Permeable Asphalt Parking Lot Designed with an Underdrained System: A proposed commercial site includes a 1-acre parking lot and 0.25-acre roof. The parking stalls will be permeable asphalt and will manage the runoff produced by the WQDS that falls on them and the adjacent impervious aisles and driveway. In this example, the permeable asphalt system will be designed solely to meet the stormwater runoff quality design and performance standards; stormwater runoff quantity control requirements will be met by a downgradient extended detention basin. The following parameters apply:

Inflow Drainage Area	Pavement Type	Acreage	CN Value
Driveway and Aisles	Conventional Asphalt	0.50	98
Central Parking Stalls	Permeable Asphalt	0.25	98
Left Parking Stalls	Permeable Asphalt	0.125	98
Right Parking Stalls	Permeable Asphalt	0.125	98
Rooftop	Roof	0.25	98

Tested Subsoil Permeability Rate = 0.50 inches/hour
WQDS: = 1.25 inches in 2 hours
Note that even though a pervious paving system does not generate runoff, the permeable asphalt surface course must be assigned a CN value of 98 in order to calculate the volume of precipitation collected by the system.

As stated above, the tested subsoil permeability rate is 0.5 in/hr, which is below the minimum design permeability rate, which is 1 in/hr. Therefore, a pervious paving system designed to infiltrate into the subsoil may not be used on this site; however, an underdrained system may be used instead. Unlike Example 1, the clean roof runoff is not directed to the storage bed because a pervious paving system with an underdrain cannot be used to reduce volume. The layout of the site is illustrated below:

Example 2 – Proposed Parking Lot Layout



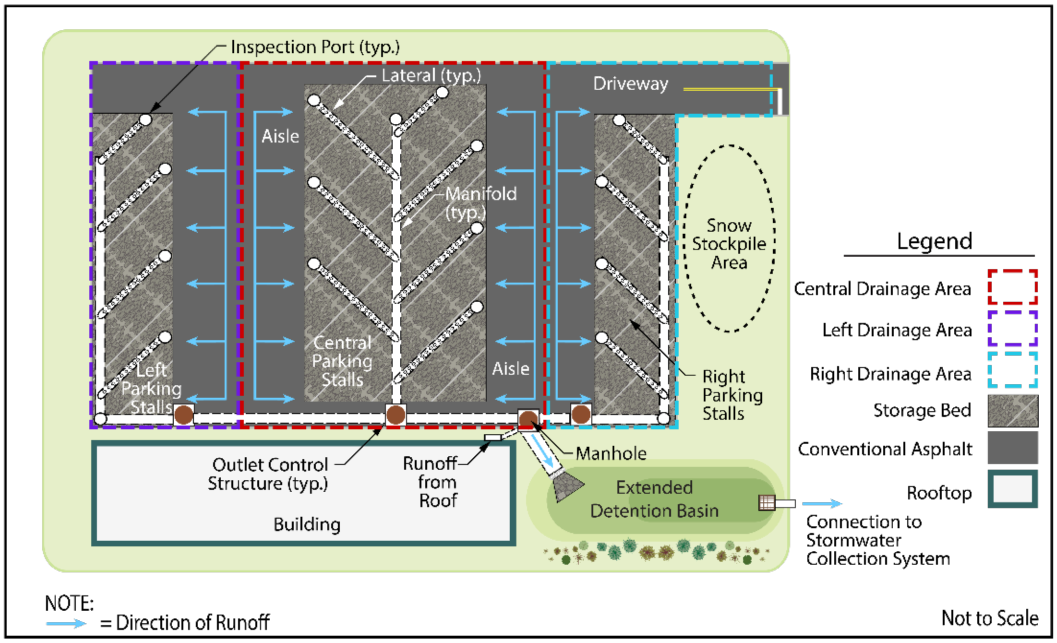
The drainage system design is shown in the illustration at the top of the next page. For illustrative purposes, a horizontal slice has been taken through each of the storage beds to show both the layout of the underdrain manifold with the laterals and the relationship of the storage beds to the areas of conventional asphalt pavement.

Because the pervious paving system will receive runoff from areas not occupied by the permeable asphalt, a check of the maximum contributory drainage area limitation is performed, as follows:

Pervious Asphalt Paving Area (A)	Additional Flow Area (B)	Ratio (B)/(A)
Central Parking Stalls (0.25 acres)	Driveway and Aisles (0.25 acres)	1
Left Parking Stalls (0.125 acres)	Driveway and Aisles (0.125 acres)	1
Right Parking Stalls (0.125 acres)	Driveway and Aisles (0.125 acres)	1

The area of additional inflow from conventional pavement is not greater than three times the area occupied by the pervious asphalt paving area.

Example 2 – Proposed Site Drainage Layout



Step 1: Runoff Calculations for the Water Quality Design Storm

Using the NRCS method described in *National Engineering Handbook, Part 630 (NEH)* and discussed in *Chapter 5*, the WQDS runoff volumes were calculated to be as shown in the table at the top of the following page:

Area Producing Runoff	Runoff Volume (cf)
Driveway and Aisles	1,878
Parking Stalls	1,878
Total Runoff Volume	3,765

Step 2: Storage Volume and Depth of Bed Sizing

As shown in the preceding illustrations, there are three separate permeable asphalt paving areas, which will manage the precipitation falling on them and runoff from the adjacent aisles and from the driveway. For the purpose of this example, the runoff is assumed to be evenly distributed across the three areas. The storage bed underneath the parking stalls is filled with AASHTO No. 2 coarse aggregate assumed to have 40% voids. The contributory drainage area and surface area of storage bed are provided in the table below for each of the three permeable asphalt paving areas.

Location of the Permeable Paving System	Contributory Drainage Area	Storage Bed Surface Area
Central Parking Stalls	0.50 ac (21,780 sf)	10,890 sf
Left Parking Stalls	0.25 ac (10,890 sf)	5,445 sf
Right Parking Stalls	0.25 ac (10,890 sf)	5,445 sf

Step 3: Quantity Control for Large Storm Events and Overflow Measures

In this design example, the permeable asphalt system is not designed to provide stormwater runoff quantity control; therefore, additional storage volume for the larger storm events is not required. However, the outlet control structure design criteria found on Pages 6 through 8 still apply. Solid pipe will be provided to convey stormwater runoff from larger storms from the outlet control structures to the down-gradient detention basin.

Step 4: Drain Time Calculation

The drain time of a pervious paving system is determined by the design permeability of the most hydraulically restrictive component, which, in this case, is the flow capacity of the underdrain, the sizing of which is beyond the scope of this chapter.

As stated earlier, the capacity of the underdrain must be sufficient to drain the stormwater runoff stored in the system within 72 hours. Dividing the WQDS runoff volume by 72 hours is the minimum flow rate required for the underdrain. More precise pipe sizing may be determined by a routing calculation. The actual pipe sizes must be recorded in the maintenance plan.

Considerations

When planning a pervious paving system, consideration should be given to soil characteristics, depth to the groundwater table, sensitivity of the region, and inflow water quality, including site location and shading. It is also important to note that the use of systems designed to infiltrate into the subsoil is recommended in this manual only where the Water Quality Design Storm or smaller storm events are contained below the first outlet control structure. Use of these systems to store larger volumes below the first outlet control structure should only be considered when another applicable rule or regulation requires the infiltration of a larger storm event. In such a case, the pervious paving system should be designed to store the minimum storm event required to address that rule or regulation, below the first outlet control structure.

The placement of pervious paving systems must comply with all applicable laws and rules adopted by Federal, State and local government entities. Additionally, pervious paving systems designed to infiltrate into the subsoil could negatively impact other facilities. Therefore, consideration should be given to the siting of these systems in areas where such facilities exist. These facilities include subsurface sewage disposal systems, water supply wells, groundwater recharge areas protected under the Ground Water Quality Standards rules at N.J.A.C 7:9C, streams under antidegradation protection by the Surface Water Quality Standards rules at N.J.A.C. 7:9B or similar facilities or areas geologically and ecologically sensitive to pollutants or hydrological changes.

Soil Characteristics

For pervious paving systems designed to infiltrate into the subsoil, soils are perhaps the most important consideration for site suitability. In general, County Soil Surveys may be used to obtain necessary soil data for the planning and preliminary design of pervious paving systems; however, for final design and construction, soil tests are required at the exact location of a proposed system. The results of this soil testing should be compared with the County Soil Survey data used to calculate runoff rates and volumes and to design BMPs on-site to ensure reasonable data consistency. If significant differences exist between the soil test results and the County Soil Survey data, additional soil tests are recommended to determine whether there is a need for revised site runoff and BMP design computations. All significant inconsistencies should be discussed with the local Soil Conservation District prior to proceeding with such redesign to help ensure that the final site soil data is accurate.

Geology

The presence or absence of Karst topography, which is characterized by highly soluble bedrock, is an important consideration when planning a pervious paving system designed to infiltrate into the subsoil. If Karst topography is present, infiltration of runoff may lead to subsidence and sinkholes; therefore, only pervious paving systems designed with underdrains should be used in these areas. For more information on design and remediation in areas of Karst topography, refer to the *Standards for Soil Erosion and Sediment Control in New Jersey: Investigation, Design and Remedial Measures for Areas Underlain by Cavernous Limestone.*

Surface Course

The surface course must be durable and have sufficient thickness to resist the wear and tear of traffic patterns and the deformation that may occur in warmer weather. Additionally, in order to minimize the possibility of edge collapse, the inclusion of edge restraints in the design is strongly recommended. Edge restraints may consist of depressed curbs or paver blocks, staking or strip edging and may be combined with vehicular intrusion deterrents, such as planted shrubs, wheel stops and bollards.

In systems where pervious pavement is adjacent to traditional pavement, a full-depth dividing strip between the two types of pavement may be necessary to ensure that structural integrity is maintained and to prevent inadvertent saturation of the adjacent impervious pavement surface course. Additional information regarding current design codes and standards, project cost estimation, detailed maintenance practices and other related topics may be obtained from professional organizations such as, but not limited to, the National Ready Mix Concrete Association, the National Asphalt Pavement Association and the Interlocking Concrete Pavement Institute, along with the Federal Highway Administration.

Construction of a pervious paving system surface course is entirely different from similar looking impervious versions. Care should be taken in hiring and training all contractors and subcontractors, inspectors and other personnel to ensure proper methods and sequences are followed. Construction of a test strip prior to installation of the proposed pervious paving system is recommended to nail down site specific issues. Additionally, until any adjacent landscaping is complete, it is strongly recommended that the surface course be covered with plastic film and held in place with timber to discourage vehicular access and storage of landscaping materials on the surface course.

After construction is complete, a clogged surface does not necessarily mean a pervious paving system is sealed. High efficiency cyclone machines or other emerging technologies may be necessary to restore the infiltration capabilities of a clogged surface course and therefore should be included in the corrective maintenance measures portion of the maintenance plan. Should a surface become clogged, the manufacturer should be consulted for information on the latest and most efficient restoration measures necessary, and afterwards, the infiltration rate of the surface course should be tested and recorded in the maintenance plan.

Alternate Underdrain Design

Where this is sufficient clearance above the seasonal high water table, pervious systems designed with an underdrain may place the underdrain pipe in a trench excavated into the subsoil rather than in the aggregate-filled storage bed. For this option the pipe should be surrounded with a minimum of 3 inches of clean, washed open-graded AASHTO No. 57 broken stone, both above and below the underdrain. Filter fabric should line the bottom and sides of the trench as well. This method may be faster to construct and may protect the underdrain pipes from cracking during compaction of the storage bed aggregate.

Cold Weather

Unlike traditional pavement, consideration should be given to where a pervious paving system will be sited in relation to other site features and how it will be managed during winter months. Locating a pervious pavement system in an area that receives full sun during the winter months may greatly reduce the need for de-icers and provide a safer surface for pedestrians and vehicles. In general, due to the lack of surface ponding and the latent heat resulting from moisture in the subsoil, correctly constructed pervious paving systems are more resistant to freezing than traditional pavements. However, de-icing may still be necessary and some de-icing compounds may react chemically with one or more components in a pervious paving system resulting in deterioration; therefore, care should be taken when selecting these compounds. Take into consideration that some of the volume of commercially available products may contain magnesium or other damaging compounds without being declared on the product packaging; therefore, any compound selected should be used on a test area prior to applying to the whole system. Take further note that that de-icing compounds used on adjacent, traditional pavement may be tracked onto a pervious paving system, and consideration should also be given to the selection of those compounds. The application of a penetrating silane based sealant to a pervious concrete or concrete paver surface course is strongly recommended as additional protection against chemical degradation by de-icing compounds, as long as the chosen sealant does not impair the rate of infiltration of the surface course.

During design, frost penetration and the ability of each layer to fully drain should also be considered when calculating layer thicknesses to ensure that each component is thick enough to prevent frost heave. Finally, because stored runoff may expand during freezing, provisions, such as a lateral drainpipe or an increased depth of the storage bed below the frost line, should be included in the design to reduce the likelihood of frost heave.

Signage

Because pervious paving systems look like traditional pavement, signage may be necessary to eliminate improper application of de-icing compounds, to prevent dumping of hazardous materials and to eliminate the intrusion of vehicles exceeding the design-loading rate of the system, which could compact and deform the surface course.

Trees

Trees may be planted near a pervious parking lot, provided ample clearance and sufficient soil volume for maturation are included, as it is essential to prevent tree roots from penetrating into the stone bed of a pervious pavement installation; however, consideration must also be given to the location of the arboreal dripline and the potential for fallen leaves, icicles and snow to cover the surface of the pervious pavement after a wind event.

Adjacent Landscaping

- Runoff from pervious areas should be directed away from the pervious paving system, where possible.
- Where it is not possible to direct runoff from adjacent landscaping away from a pervious paving system, a gravel strip or swale should be provided to filter and reduce the intrusion of sediment, with additional monitoring and corrective measures added to the maintenance plan.

Care should be taken in the selection of top dressing for nearby vegetated areas; particulates transported by wind or during rainfall or snowmelt could result in the clogging of the surface course. Preventative measures should be included in the maintenance plan and should be re-evaluated as necessary to ensure long-term functionality of the system.

Maintenance

Regular and effective maintenance is crucial to ensure effective pervious paving system performance; in addition, maintenance plans are required for all stormwater management facilities on a major development. In addition to the manufacturer's maintenance requirements, there are a number of required elements in all maintenance plans, pursuant to N.J.A.C. 7:8-5.8; these are discussed in more detail in *Chapter 8: Maintenance of Stormwater Management Measures*. Furthermore, maintenance activities are required through various regulations, including the New Jersey Pollutant Discharge Elimination System (NJPDES) rules, N.J.A.C. 7:14A. Specific maintenance requirements for pervious paving systems are presented below; these requirements must be included in the maintenance plan for pervious paving systems. Detailed inspection and maintenance logs must be maintained.

General Maintenance

- Failure to correctly maintain a pervious paving system will shorten its lifespan or result in system failure; therefore, the maintenance plan must ensure proper training of personnel and include the special equipment necessary in accordance with the industry's or manufacturer's requirements.
- The surface course must be inspected after every storm exceeding 1 inch of rainfall. If mud or sediment is tracked onto the surface course, it must be removed as soon as possible. Removal should take place when all runoff has drained from the surface course.
- The surface course must be inspected, at least once annually, for cracking, subsidence, spalling, erosion, deterioration and unwanted vegetation. Remedial measures must be taken as soon as possible. Herbicides must not be applied.
- The surface course of a pervious paving system must be vacuum swept, not power swept, at least four times per year. Vacuum sweeping must be followed by either air blowing or high-pressure power washing performed in accordance with the specifications recommended for the particular type of system. All dislodged material must be promptly removed.
  - □ The first annual maintenance must be performed in the spring.
  - □ Maintenance must additionally be performed in the autumn, after the fallen leaves are collected and removed.

- Each spring, after the last snow or ice event, the infiltration rate of the surface course must be tested in accordance with the methods of either ASTM C1701 or C1781, as corresponds to the post-construction test performed for the system. At least 3 locations must be tested. One of the locations must be in an area where sediment is most likely to be deposited, such as, but not limited to, a parking lot entrance. The other test locations must be evenly spaced across the system surface. The locations and results obtained must be recorded in the maintenance plan for future reference and compared to the as-built testing results as a metric for determining if a system requires corrective action. The chart provided below shows the approximate infiltration rate based upon the time it takes to infiltrate either 8 or 40 pounds of water specified in the above-cited tests. This chart should be included in the maintenance plan for future reference. The infiltration rate, I, is based upon the following calculation:

$$I = (K * M)/\ (D^2 * t)\text{, where}$$

K = 126,870 in-lbs
M = water mass, lbs
D = ring diameter = 12 inches
t = time, in seconds

Test Methods Per ASTM C1701 or C1781		
Time to Infiltrate the Specified Amount of Water (seconds)	**Approximate Surface Infiltration Rate (inches per hour)**	
	M = 8 lbs	**M = 40 lbs**
30	235	1175
60	118	587
100	70.5	352
200	35.2	176
350	20.1	100.7
360	19.6	97.9
380	18.5	92.7
900	7.8	39.2
1760	4.0	20.0
1910	3.7	18.5
3600	2.0	9.8
5400	1.3	6.5
5470	1.3	6.4
6000	1.2	5.9

Take note that should the test be performed with a different quantity of water, the values in the chart above cannot be used.

- Corrective action must be immediately taken to restore the infiltration capacity of the pervious paving system under the following scenarios:
  - □ Standing water is observed on the surface course; or
  - □ The testing methods above show an infiltration rate of 20 inches per hour or less for a system designed for quantity control or 6.4 or less for a system designed for water quality control only.
- Disposal of debris, trash, sediment and other waste material must be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations.
- Under no circumstances may any sealants or coatings be applied to pervious paving systems, except for those approved by the manufacturer to improve surface course resistance to de-icing chemicals or refresh traffic striping.
- Over the lifetime of the surface course, no more than 10% of its surface area may be patched with impervious material such as bituminous asphalt or concrete. All patching must be recorded in the maintenance manual for future reference to prevent exceedance of this maximum.
- A detailed, written log of all preventative and corrective maintenance performed on the pervious paving system must be kept, including a record of all inspections and copies of maintenance-related work orders. Additional maintenance guidance can be found at https://www.njstormwater.org/maintenance_guidance.htm.

Storage Bed Drain Time

- The approximate drain time for the maximum design storm runoff volume below the top of the surface course must be indicated in the maintenance manual.
- If the actual drain time is significantly different from the design drain time, the components and groundwater levels must be evaluated and appropriate measures taken to return the pervious paving system to minimum and maximum drain time requirements.
- If the system fails to drain the maximum design storm volume within 72 hours, corrective action must be taken.

Cold Weather Maintenance

- Care must be taken when removing snow from the surface course; pervious paving surface courses may be damaged by snowplows or loader buckets set too low to the ground or not equipped with a rubber blade guard. Sand, grit or cinders may not be used on surface courses for snow/ice control.
- De-icing chemicals may not be used on pervious concrete less than one year old.
- De-icers containing magnesium chloride, calcium magnesium acetate or potassium acetate may never be used on pervious concrete.

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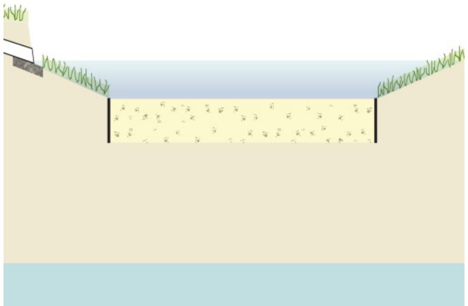
9.8 SMALL-SCALE INFILTRATION BASINS



Small-scale infiltration basins are stormwater management systems constructed with highly permeable components designed to both maximize the removal of pollutants from stormwater and to promote groundwater recharge. Pollutants are treated through settling, filtration of the runoff through and biological and chemical activity within, the components. The total suspended solids (TSS) removal rate is 80%.

N.J.A.C. 7:8 Stormwater Management Rules – Applicable Design and Performance Standards		
	Green Infrastructure	Yes
	Water Quantity	Yes, when designed as an on-line system
	Groundwater Recharge	Yes
	Water Quality	80% TSS Removal

Water Quality Mechanisms and Corresponding Criteria	
Settling	
Storage Volume	Entire Water Quality Design Storm Volume
Infiltration	
Maximum Contributory Drainage Area	2.5 acres
Maximum Design Storm Drain Time	72 hours, Using Slowest Design Permeability Rate
Permeability Rate Factor of Safety	2
Minimum Subsoil Design Permeability Rate	0.5 inches/hour
Maximum Design Permeability Rate	10 inches/hour
Soil Testing Consistent with Chapter 12: Soil Testing Criteria	Required
Minimum Distance between Basin Bottom and Seasonal High Water Table	2 feet
Biological and Chemical Activity	
Minimum Sand Layer Thickness	6 inches
Minimum Sand Layer Permeability Rate	20 inches/hour, tested per *Chapter 12: Soil Testing Criteria*
Maximum % Fines in Sand Layer	15%

Introduction

Small-scale infiltration basins are stormwater management systems constructed in areas of highly permeable soil that provide temporary storage of stormwater runoff and can help to reduce increases in both the peak rate and total volume of runoff caused by land development. Pollutants in runoff are treated through the processes of filtration through and biological and chemical activity within the soil.

In these systems, the rate of infiltration is affected by the hydraulic conductivity of the underlying soil, the distance separating the lowest basin elevation from the seasonal high water table (SHWT) and the area of the basin bottom. While loss of subsoil hydraulic conductivity through soil compaction is a concern, transport of dissolved pollutants by highly permeable subsoil is of equal concern; therefore, care must be taken when using fertilizers and herbicides upgradient of a small-scale infiltration basin.

Additionally, due to the potential for groundwater contamination, the use of small-scale infiltration basins, and all stormwater infiltration best management practices (BMPs), is prohibited in areas where high pollutant or sediment loading is anticipated. For more information regarding stormwater runoff that may not be infiltrated, refer to N.J.A.C. 7:8-5.4(b)3. However, this prohibition is limited only to areas onsite where this type of loading is expected. Additionally, small-scale infiltration basins may only be used on these types of sites provided the location of the small-scale infiltration basin is not inconsistent with a remedial action work plan or landfill closure plan.

Discharge from small-scale infiltration basins of the smaller storm events occurs through the subsoil; therefore, they may not be used where their installation would create a significant risk of adverse hydraulic impacts. These impacts may include exacerbating a naturally or seasonally high water table so as to cause surficial ponding, flooding of basements, or interference with the proper operation of a subsurface sewage disposal system or other subsurface structure, or where their construction will compact the subsoil. Hydraulic impacts on the groundwater table must be assessed. For more information on groundwater mounding analysis, refer to *Chapter 13: Groundwater Table Hydraulic Impact Assessments for Infiltration BMPs* and the *USGS Paper on Assessment of Impacts* link on the *Additional Guidance Documents* page at www.njstormwater.org.

Finally, a small-scale infiltration basin must have a maintenance plan and must be reflected in a deed notice recorded in the county clerk's office to prevent alteration or removal.

Applications

Pursuant to N.J.A.C. 7:8-5.2(a)(2), the minimum design and performance standards for groundwater recharge, stormwater runoff quality and stormwater runoff quantity at N.J.A.C. 7:8-5.4, 5.5 and 5.6 shall be met by incorporating green infrastructure in accordance with N.J.A.C. 7:8-5.3.

Small-scale infiltration basins may be designed to reduce peak runoff rates when designed as an on-line system in combination with an extended detention basin; however, regardless of the design storm chosen, all small-scale infiltration basins must be designed for stability and in accordance with the *Standards for Soil Erosion and Sediment Control in New Jersey*.

Small-scale infiltration basins may be used to meet the groundwater recharge requirements of the Stormwater Management rules found at N.J.A.C. 7:8. For more information on computing groundwater recharge, see *Chapter 6: Groundwater Recharge.*

To merit the approved TSS removal rate of 80%, small-scale infiltration basins must be designed to treat the Water Quality Design Storm (WQDS) and in accordance with all of the following criteria.

Design Criteria

Basic Requirements

A small-scale infiltration basin may be designed as a surface or subsurface system. The following criteria apply to both configurations. Design criteria specific to small-scale surface infiltration basins may be found beginning on Page 10; design criteria specific to small-scale subsurface infiltration basins may be found beginning on Page 13. Additional requirements for the extended detention option may be found beginning on Page 8.

Contributory Drainage Area

- Pursuant to N.J.A.C. 7:8-5.3(b), the maximum contributory drainage area to a small-scale infiltration basin is 2.5 acres.
- The entire contributory drainage area must be completely stabilized prior to use of the small-scale infiltration basin.

Inflow

- All inflow must be stable and non-erosive and must be consistent with the *Standards for Soil Erosion and Sediment Control in New Jersey*.

Storage Volume

- Small-scale infiltration basins may be constructed as either off-line or on-line systems. In off-line systems, most, or all, of the runoff from storms larger than the Water Quality Design Storm (WQDS) bypass the infiltration basin through an upgradient diversion; this reduces the size of the required basin storage volume, the system's long-term pollutant loading and associated maintenance. On-line systems receive stormwater runoff from all storms events; they provide treatment for the WQDS and they convey the runoff from larger storms through an overflow. These on-line systems store and attenuate flow produced by the larger storm events and provide stormwater runoff quantity control; in such systems, the invert of the lowest quantity control outlet is set at the water surface elevation of the WQDS. Further details are provided beginning on Page 8 under the sub-heading *Requirements for Extended Detention Option.*
- The system must have sufficient storage volume to contain the WQDS stormwater runoff volume without overflow.

- Exfiltration can be used in the design of a small-scale infiltration basin, provided all of the conditions regarding the use of exfiltration in stormwater runoff calculations, as published in *Chapter 5: Stormwater Management Quantity and Quality Standards and Computations* are met. This information is published in the section beginning on Page 7 of *Chapter 5*, entitled "*Conditions Regarding the Use of Exfiltration in Stormwater Runoff Calculations*."

- Small-scale infiltration basins are intended to be free of standing water between storm events in order to allow for sufficient storage for the next rain event; therefore, the drain time for standing water present on the surface of the basin bottom or in the overflow structure must not exceed 72 hours after any rain event. Storage times in excess of 72 hours may render a small-scale infiltration basin ineffective and may result in anaerobic conditions, odor, and both stormwater quality and mosquito breeding issues. If the small-scale infiltration basin is installed in an area subject to pedestrian traffic, such as sidewalk or pedestrian accessible area in parking lot, the drain time should be reduced to 24 hours.

Geometry

- Small-scale infiltration basins may not be constructed in areas where the surrounding slopes are 15% or greater.

- The area of the basin intended for infiltration, or footprint, must be as level as possible in order to uniformly distribute runoff infiltration into the subsoil.

- The system must have a sufficient surface area to prevent the accumulated volume of stormwater runoff from exceeding the maximum depth requirement, which is specific to the type of small-scale infiltration basin. More information is found on Page 12 for surface type small-scale infiltration basins.

- The seasonal high water table (SHWT) or bedrock must be at least 2 feet below the lowest extent of the basin bottom. In surface basins, this distance is measured from the bottom of the sand layer.

Permeability Rates

- The use of small-scale infiltration basins for stormwater management is only feasible where the subsoil is sufficiently permeable to meet the minimum permeability rate as stated below.

- Soil tests are required at the exact location of the proposed basin in order to confirm its ability to function as designed. A minimum of two soil profile pits are required within the infiltration area of any proposed small-scale infiltration basin. Take note that permits may be required for soil testing in regulated areas, such as areas regulated under the Flood Hazard Area Control Act Rules (N.J.A.C. 7:13), the Freshwater Wetlands Protection Act Rules (N.J.A.C. 7:7A), the Coastal Zone Management Rules (N.J.A.C. 7:7) and the Highlands Water Protection and Planning Rules (N.J.A.C. 7:38).

- The testing of all permeability rates must be consistent with *Chapter 12: Soil Testing Criteria* in this manual, including the required information to be included in the soil logs, which can be found in section *3.b Soil Logs*. In accordance with N.J.A.C. 7:9A-6.2(j)1, *Standards for Individual Subsurface Sewage Disposal Systems*, the slowest tested permeability must be used for design purposes.

- Since the actual permeability rate may vary from soil testing results and may decrease over time, a factor of safety of 2 must be applied to the slowest tested permeability rate to determine the design permeability rate. The design permeability rate would then be used to compute the basin's drain time for the maximum design volume. The drain time is defined as the time it takes to fully infiltrate the maximum design storm runoff volume through the most hydraulically restrictive layer.

- The maximum design permeability rate is 10 inches/hour for any tested permeability rate of 20 inches/hour or more.

- The minimum design permeability rate of the subsoil is 0.5 inches/hour, which equates to a minimum tested permeability rate of 1.0 inch/hour.

- As with any infiltration BMP, groundwater mounding impacts must be assessed, as required by N.J.A.C. 7:8-5.2(h). This includes an analysis of the reduction in permeability rate when groundwater mounding is present to confirm the system will drain within 72 hours after the precipitation stops.

    - Additional trials may be required, including using a reduced recharge rate in accordance with the method published in *Chapter 5*, should the calculations demonstrate an adverse impact is produced. Refer to the information labeled "*Steps to Follow When an Adverse Impact is Encountered*" found on Page 53 of *Chapter 5*.
    - Where the mounding analysis identifies adverse impacts, the small-scale infiltration basin must be redesigned or relocated, as appropriate. The mounding analysis must provide details and supporting documentation on the methods used and assumptions made, including values used in calculations. For further information on the required groundwater mounding assessment, *see Chapter 13*.

Safety

- All small-scale infiltration basins must be designed to safely convey overflows to downstream drainage systems. The design of any overflow structure must be sufficient to provide safe, stable discharge of stormwater in the event of an overflow. Safe and stable discharge minimizes the possibility of adverse impacts, including erosion and flooding in down-gradient areas. Therefore, discharge in the event of an overflow must be consistent with the Standards for Off-Site Stability found in the *Standards for Soil Erosion and Sediment Control in New Jersey*.

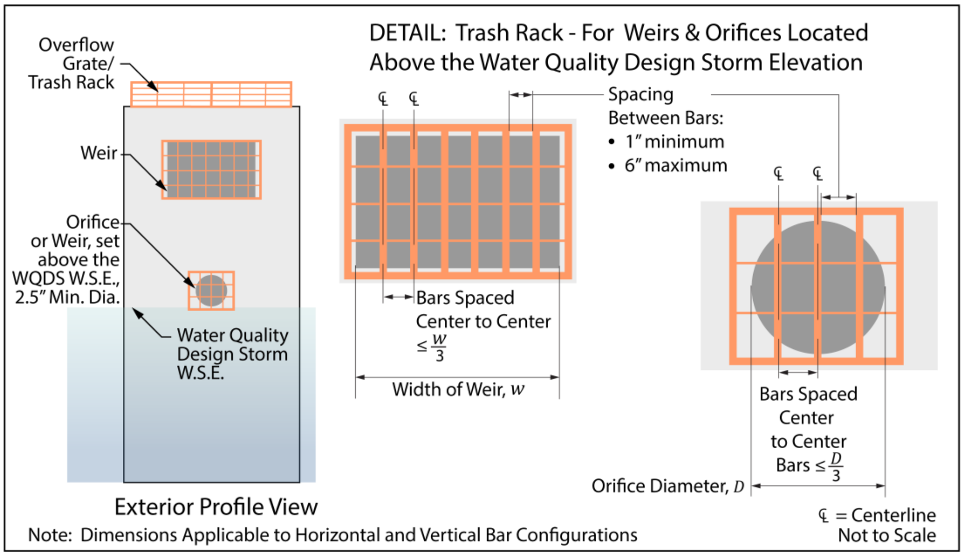
- Small-scale infiltration basins that are classified as dams under the NJDEP Dam Safety Standards at N.J.A.C. 7:20 must meet the overflow requirements under these regulations. Overflow capacity can be provided by a hydraulic structure, such as a weir or orifice, or a surface feature, such as a swale or open channel.

Outlet Structure

- Trash racks must be installed at the intake to the outlet structure. They must meet the following criteria and the detail below illustrates these requirements:

    - Parallel bars with 1-inch spacing between the bars up to the elevation of the WQDS;
    - Parallel bars higher than the elevation of the WQDS must be spaced no greater than one-third the width of the diameter of the orifice or one-third the width of the weir, with minimum spacing between bars of 1 inch and a maximum spacing between the bars of six inches;
    - The trash rack must be designed so as not to adversely affect the hydraulic performance of the outlet pipe or structure;
    - Constructed of rigid, durable and corrosion-resistant material; and

□ Designed to withstand a perpendicular live loading of 300 lbs/sf.



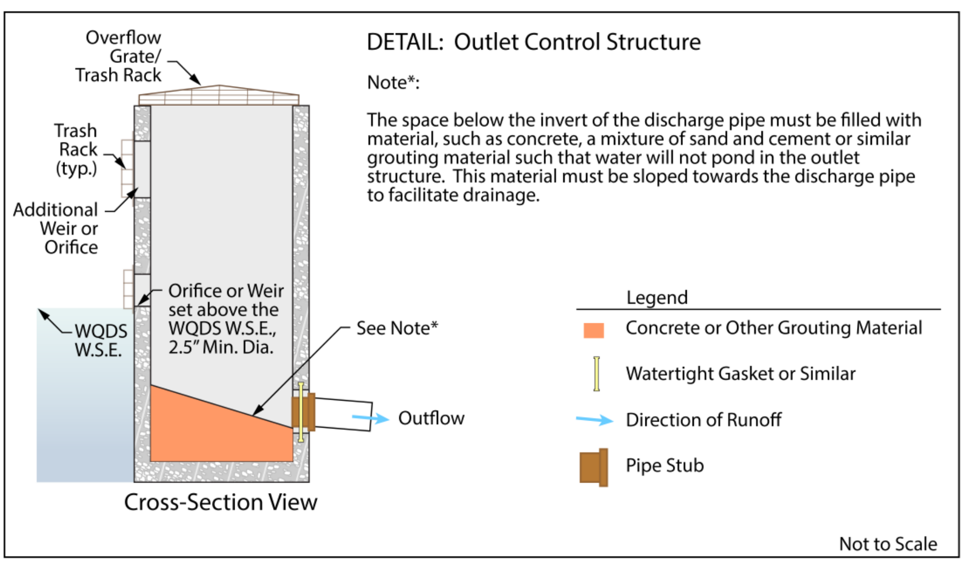
- An overflow grate is designed to prevent obstruction of the overflow structure. If an outlet structure has an overflow grate, the grate must comply with the following requirements:

  □ The overflow grate must be secured to the outlet structure but removable for emergencies and maintenance;

  □ The overflow grate spacing must be no greater than 2 inches across the smallest dimension; and

  □ The overflow grate must be constructed of rigid, durable and corrosion resistant material and designed to withstand a perpendicular live loading of 300 lbs./sf.

- The space below the invert of the discharge pipe must be filled with material, such as concrete, a mixture of sand and cement, or similar grouting material, such that water will not pond in the outlet structure. This material must be sloped towards the discharge pipe to facilitate drainage, as shown in the detail below.



- The minimum diameter of any overflow orifice is 2.5 inches.

- Blind connections to down-gradient facilities are prohibited. Any connection to down-gradient stormwater management facilities must include access points such as inspections ports and manholes, for visual inspection and maintenance, as appropriate, to prevent blockage of flow and ensure operation as intended. All entrance points must adhere to all State, County and municipal safety standards such as those for confined space entry.

- In instances where the lowest invert in the outlet or overflow structure is below the flood hazard area design flood or tide elevation in a down-gradient waterway or stormwater collection system, the effects of tailwater on the hydraulic design of the overflow system, as well as any stormwater quantity control outlets must be analyzed. Two methods to analyze tailwater are:

    - A simple method entails inputting flood elevations for the 2-, 10- and 100-year events as static tailwater during routing calculations for each storm event. These flood elevations are either obtained from a Department flood hazard area delineation or a FEMA flood hazard area delineation that includes the 100-year flood elevation or derived using a combination of NRCS hydrologic methodology and a standard step backwater analysis or level pool routing, where applicable. In areas where the 2-year or 10-year flood elevation does not exist in a FEMA or Department delineation, it may be interpolated or extrapolated from the existing data. If this method demonstrates that the requirements of the regulations are met with the tailwater effect, then the design is acceptable. If the analysis shows that the requirements are not met with the tailwater effects, the detailed method below can be used or the BMP must be redesigned.

    - A detailed method entails the calculation of hydrographs for the watercourse during the 2-, 10- and 100-year events using NRCS hydrologic methodology. These hydrographs are input into a computer program to calculate rating curves for each event. Those rating curves are then input as a dynamic tailwater during the routing calculations for each of the 2-, 10- and 100-year events. This method may be used in all circumstances; however, it may require more advanced computer programs. If this method demonstrates that the requirements of the regulations are met with the tailwater effect, then the design is acceptable. If the analysis shows that the requirements are not met with the tailwater effects, the BMP must be redesigned.

Construction Requirements

- During clearing and grading of the site, measures must be taken to eliminate soil compaction at the location of a proposed small-scale infiltration basin.

- The location of the proposed small-scale infiltration basin must be cordoned off during construction to prevent compaction of the subsoil by construction equipment or stockpiles.

- The use of the location proposed for a small-scale infiltration basin to provide sediment control during construction is discouraged; however, when unavoidable, excavation for the sediment control basin must be at least 2 feet above the final design elevation of the basin bottom.

- Excavation and construction of a small-scale infiltration basin must be performed using equipment placed outside the limits of the basin.

- The excavation to the final design elevation of the small-scale infiltration basin bottom may only occur after all construction within its contributory drainage area is completed and the contributory drainage area is stabilized. If construction of the small-scale infiltration basin cannot be delayed, berms must be placed around the perimeter of the basin during all phases of construction to divert all flows away from the basin. The berms may not be removed until all construction within the contributory drainage area is completed and the area is stabilized.

- The contributing drainage area must be completely stabilized prior to small-scale infiltration basin use.
- Post-construction testing must be performed on the as-built small-scale infiltration basin in accordance with the Construction and Post-Construction Oversight and Soil Permeability Testing section in *Chapter 12* of this manual. Where as-built testing shows a longer drain time than designed, corrective action must be taken. The drain time is defined as the time it takes to fully infiltrate the maximum design storm runoff volume through the most hydraulically restrictive layer.

Access Requirements

- An access roadway must be included in the design to facilitate monitoring and maintenance. If the access roadway is constructed of impervious material, take note that it may be subject to the stormwater runoff quality, quantity and/or groundwater recharge requirements at N.J.A.C. 7:8-5.4, 5.5 and 5.6.
- Additional steps may be necessary to eliminate vehicular intrusion into the basin, such as from all-terrain vehicles and utility trucks.

Requirements for Extended Detention Option

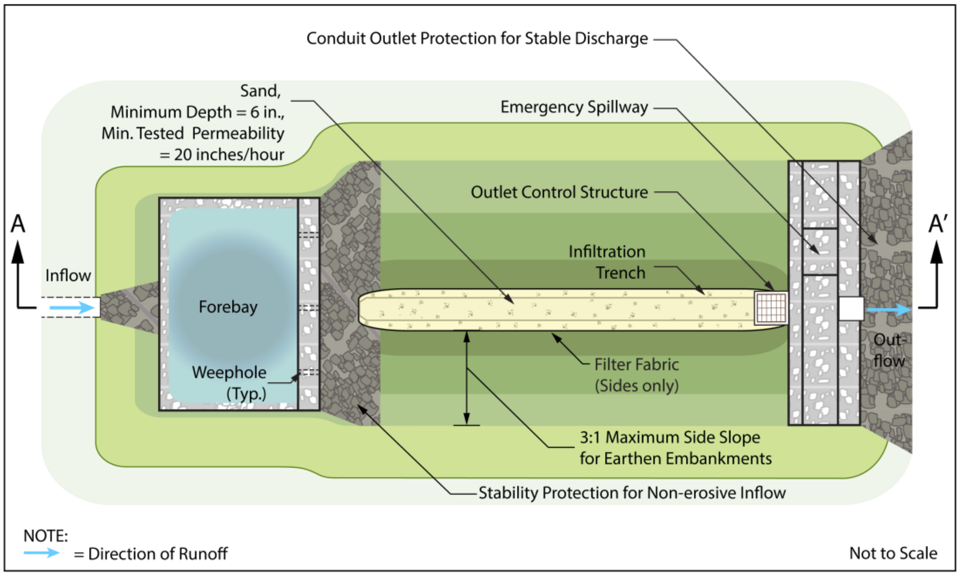
A small-scale infiltration basin may be constructed as part of an on-line, combination system to provide extended detention for larger storms. Such a system could include a level-graded infiltration zone such as that defined by a smaller contour, oval or other discrete area within the basin bottom. Runoff up to the WQDS water surface elevation is temporarily stored and exits the system through infiltration into the subsoil. Runoff in excess of this elevation exits the system through various quantity control devices in the outlet structure. Keep in mind that too small of an infiltration zone is likely to experience groundwater mounding impacts, as discussed in *Chapter 13*.

Storage Volume

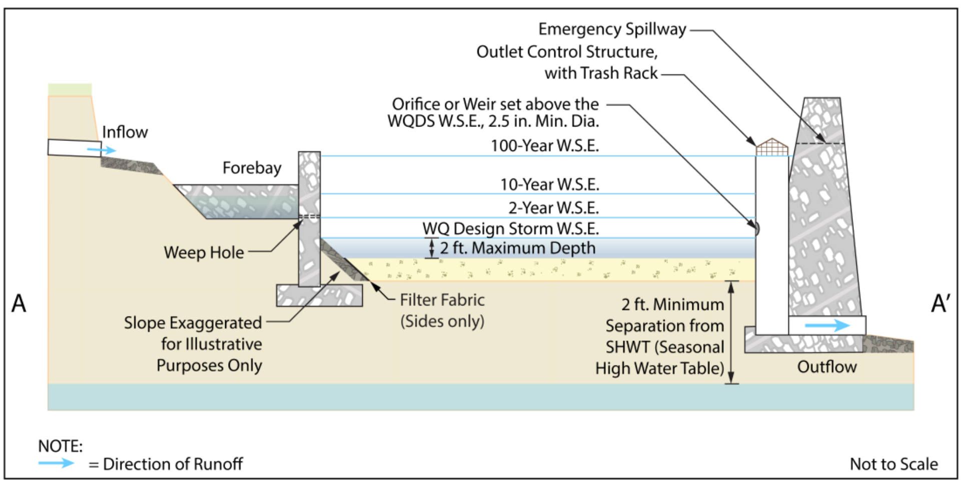
- Small-scale infiltration – extended detention basins may be designed to treat and temporarily store stormwater runoff produced by both small storms, such as the WQDS and larger storms such as the 2-, 10- and 100-year design storms.
- Exfiltration can be used in the design of a small-scale infiltration basin designed to provide extended detention for stormwater runoff quantity control, provided all of the conditions regarding the use of exfiltration in stormwater runoff calculations published in *Chapter 5* are met. This information is published in the section beginning on Page 7 of *Chapter 5*, entitled "*Conditions Regarding the Use of Exfiltration in Stormwater Runoff Calculations*."
- For additional information on the design, operation and maintenance of the extended detention components, refer to *Chapter 11.2*: *Extended Detention Basins.*

The following illustrations depict a surface infiltration – extended detention basin in both plan and profile views; a concrete forebay was selected to provide pretreatment. Although not shown, stormwater quantity control outlets are provided at the water surface elevations of the 2-, 10- and 100-year storm events. To prevent the accumulation of stormwater runoff from exceeding the 2 foot maximum depth limit, an orifice is set at the water surface elevation of the WQDS. For additional information on the design, operation and maintenance of the extended detention components, refer to *Chapter 11.2*: *Extended Detention Basins*.

Small-scale Infiltration - Extended Detention Basin: Plan View



Small-scale Infiltration – Extended Detention Basin: Profile View



Types of Small-Scale Infiltration Basins

There are two types of small-scale infiltration basins:

1. Small-Scale Surface Infiltration Basins
2. Small-Scale Subsurface Infiltration Basins

Individual Types of Small-Scale Infiltration Basins

The following section provides detailed design criteria for each type of small-scale infiltration basin. The illustrations depict possible configurations and flow paths and are not intended to limit the design.

Small-Scale Surface Infiltration Basins

Pretreatment for Small-Scale Surface Infiltration Basins

- Pretreatment is a requirement for small-scale infiltration basins that include exfiltration in the stormwater routing calculations for the 2-, 10- and 100-year design storms.

- Pretreatment may consist of a forebay or any of the BMPs found in *Chapters 9 or 11.*

- There is no adopted TSS removal rate associated with forebays; therefore, their inclusion in any design should be solely for the purpose of facilitating maintenance. Forebays may be earthen, constructed of riprap, or made of concrete and must comply with the following requirements:

  - The forebay must be designed to prevent scour of the receiving basin by outflow from the forebay.
  - The forebay should provide a minimum storage volume of 10% of the WQDS and be sized to hold the sediment volume expected between clean-outs.
  - The forebay should fully drain within nine hours in order to facilitate maintenance and to prevent mosquito issues. Under no circumstances should there be any standing water in the forebay 72 hours after a precipitation event.
  - Surface forebays must meet or exceed the sizing for preformed scour holes in the *Standard for Conduit Outlet Protection* in the *Standards for Soil Erosion and Sediment Control in New Jersey* for a surface forebay.
  - If a concrete forebay is utilized, it must have at least two weep holes to facilitate low level drainage.

- When using another BMP for pretreatment, it must be designed in accordance with the design requirements outlined in its respective chapter. For additional information on the design requirements of each BMP, refer to the appropriate chapter in this manual.

- Any roof runoff that discharges to the small-scale infiltration basin may be pretreated by leaf screens, first flush diverters or roof washers. For details of these pretreatment measures, see Pages 5 and 6 of *Chapter 9.1: Cisterns.*

- The pretreatment requirement for roof runoff can be waived by the review agency if the building in question has no potential for debris and other vegetative material to be present in the roof runoff. For example, a building that is significantly taller than any surrounding trees and does not have vegetative roof should not need the pretreatment. However, in making this determination, the review agency must consider the mature height of any surrounding trees.

Geometry

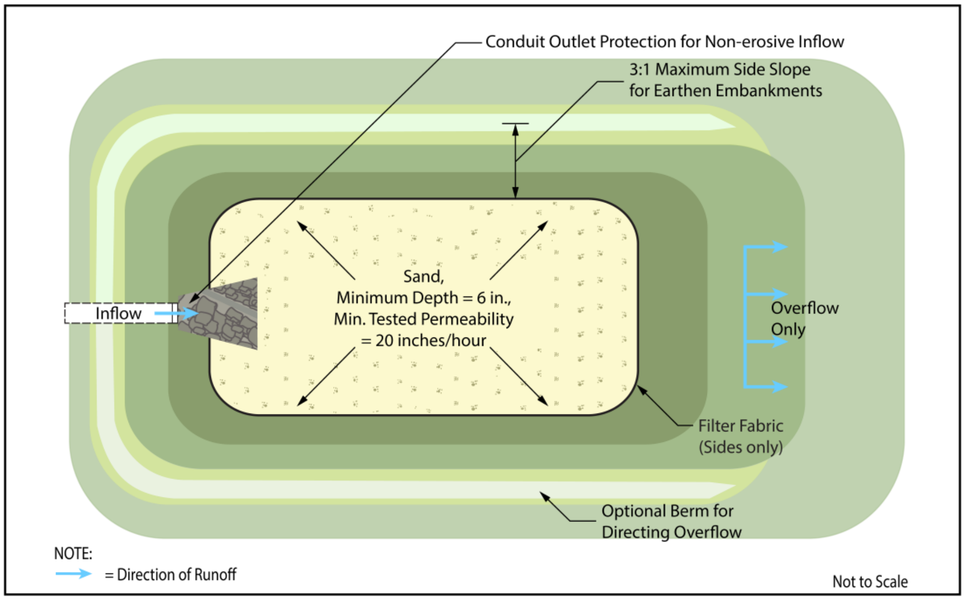
- The maximum interior slope for an earthen dam, embankment or berm is 3:1.
- The vertical distance between the upper surface of the basin bottom and the WQDS water surface elevation must be no greater than 2 feet. This distance is also referred to as the maximum depth of stormwater runoff to be infiltrated.

Sand Layer

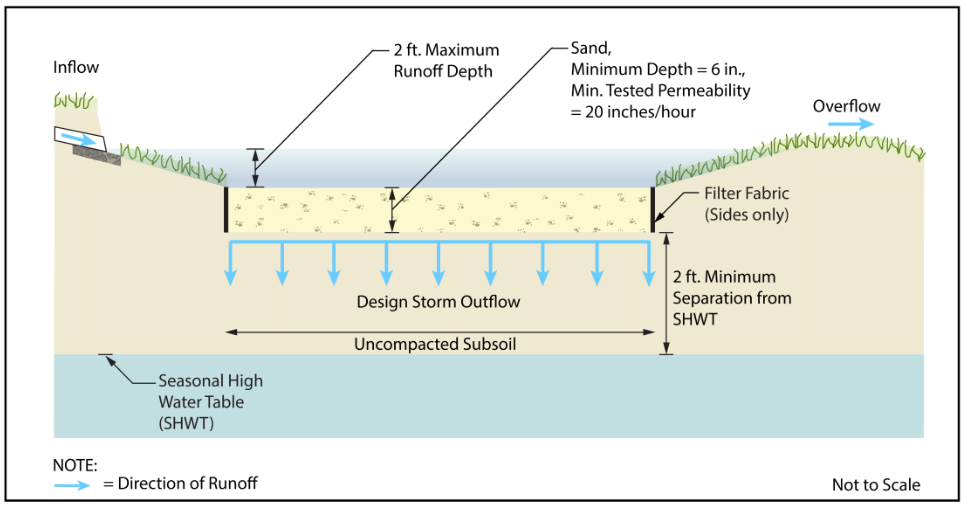
- To ensure that the design permeability rate is maintained over time, a sand layer is required at the bottom of every surface type of small-scale infiltration basin.
- The minimum depth is 6 inches.
- The sand must meet all the specifications for clean, medium-aggregate concrete sand in accordance with AASHTO M-6 or ASTM C-33, as certified by a professional engineer licensed in the State of New Jersey.
- The maximum percentage of fines is 15%.
- The minimum tested permeability rate is 20 inches/hour.
- The use of topsoil and vegetation is prohibited. If a vegetated BMP is desired, refer to *Chapter 10.1: Bioretention Systems (Large-scale)* or *Chapter 9.7: Small-scale Bioretention Systems*.
- Filter fabric is required along the sides of the small-scale infiltration basin to prevent the migration of fine particles from the surrounding soil; filter fabric may not be used along the bottom of the basin because it may result in a loss of permeability.

The following graphics depict a small-scale surface infiltration basin in both plan and profile view. These illustrations show possible configurations and flow paths and are not intended to limit the design.

Small-Scale Surface Infiltration Basin – Plan View



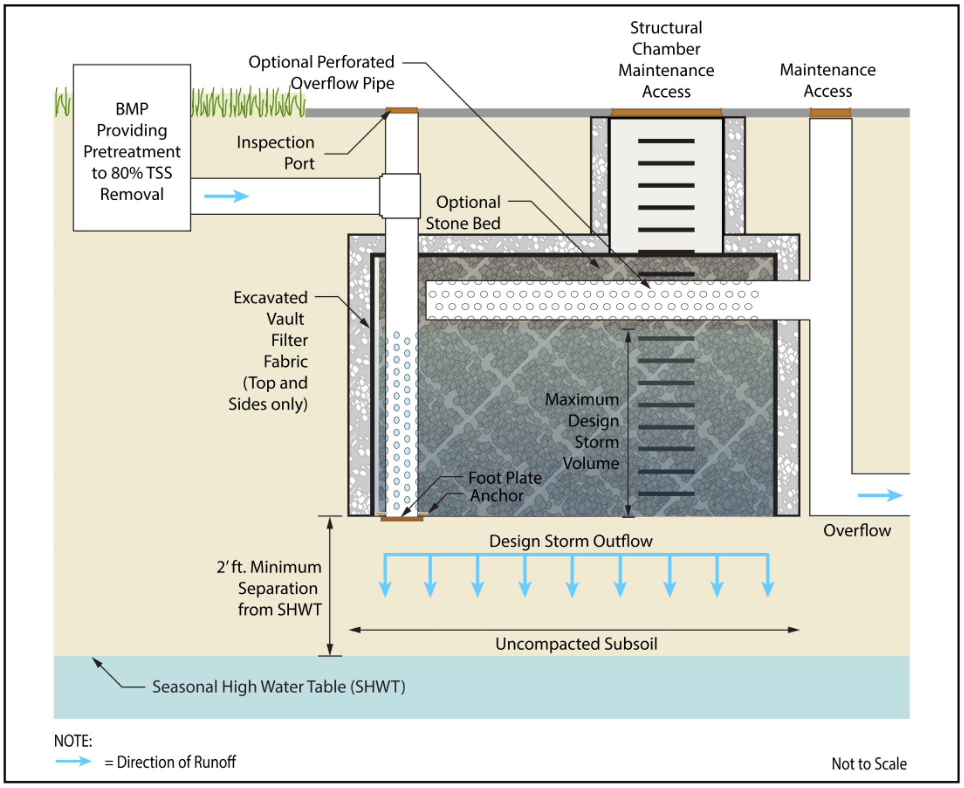
Small-Scale Surface Infiltration Basin – Profile View



Small-Scale Subsurface Infiltration Basins

A small-scale subsurface infiltration basin may consist of a vault, or a network of one or more perforated pipes, either of which may include a stone bed. A typical subsurface infiltration basin constructed as a vault is depicted in the following illustration as an example, but it is not intended to limit the design configuration. Design criteria specific to this type of small-scale infiltration basin immediately follows.

Small-Scale Subsurface Infiltration Basin – Profile View



Pretreatment for Small-Scale Subsurface Infiltration Basins

- Pretreatment is required on all small-scale subsurface infiltration basins.
- Roof runoff that directly discharges into the small-scale subsurface infiltration basin can be pretreated by leaf screens, first flush diverters or roof washers. For details of these pretreatment measures, see Pages 5 and 6 of *Chapter 9.1: Cisterns*.
    - This pretreatment requirement can be waived by the review agency if the building in question has no potential for debris and other vegetative material to be present in the roof runoff. For example, a building that is significantly taller than any surrounding trees and does not have vegetative roof should not need the pretreatment. However, in making this determination, the review agency must consider the mature height of any surrounding trees.

- Pretreatment for non-roof runoff, or roof runoff comingled with stormwater from other surfaces, must remove 80% of the total suspended solids (TSS) in the runoff generated by the WQDS.
- Pretreatment may consist of any of the BMPs found in *Chapters 9 or 11.*
- When using another BMP for pretreatment, it must be designed in accordance with the design requirements outlined in its respective chapter. For additional information on the design requirements of each BMP, refer to the appropriate chapter in this manual.

Component Requirements for Small-Scale Subsurface Infiltration Basins

- Filter fabric is required along the top and sides of a small-scale subsurface infiltration basin to prevent the migration of fine particles from the surrounding soil, unless the basin is enclosed in an impermeable structural housing. Filter fabric may not be used along the bottom of the basin because it may result in a loss of permeability.
- Any aggregate used in a small-scale subsurface infiltration basin must be free from debris, silt or other material that could contribute to clogging.

Access Requirements

- At least one inspection port that extends into the subsoil must be provided in the area of the small-scale infiltration basin to monitor the functionality of the basin. The location of the inspection port must be shown in the maintenance plan. Additionally, the maximum design storm depth of stormwater runoff must be marked on the structure and its level included in the design report and maintenance plan.
- All points of access must also be covered in such a way as to prevent sediment or other material from entering the system and to prevent the accumulation of standing water, which could lead to mosquito breeding.

Designing a Small-Scale Infiltration Basin

The following examples show how to design various small-scale infiltration basins to treat the runoff generated by the WQDS. The examples below are two of many possible ways to configure these basins and are not intended to limit the design.

Example 1: For one acre of regulated motor vehicle surface, design a small-scale infiltration basin to infiltrate the runoff generated by the WQDS. Runoff will receive pretreatment by a forebay designed in accordance with the criteria established in this chapter. Runoff volumes in excess of the WQDS generated volume will discharge via an emergency spillway. The following parameters apply:

Inflow Drainage Area =	1 ac (100% impervious)
Pavement NRCS Curve Number (CN) =	98
Tested Sand Permeability Rate =	40 in/hr
Tested Subsoil Permeability Rate =	8 in/hr
Maximum Depth of Runoff to be Infiltrated =	2 ft
Sand Layer Depth =	6 in

Step 1: Runoff Calculations

Using the NRCS method described in the *National Engineering Handbook, Part 630* (*NEH*) discussed in *Chapter 5*, the runoff volume for the WQDS was calculated to be 3,755 cf.

Step 2: Forebay Sizing

The forebay must be sized to hold 10% of the WQDS volume. Assuming the depth of water in the forebay is equal to 1 ft, a square forebay with a width of 20 ft and a length of 20 ft will provide adequate storage volume. In order to facilitate drainage, the bottom of the forebay must be elevated above the sand layer in the small-scale infiltration basin; in addition, the perforations in the riser pipe must be designed to ensure that the forebay will drain within 9 hours.

Step 3: Small-Scale Infiltration Basin Sizing

When designing a small-scale infiltration basin, the permeability rate of the subsoil is usually the limiting factor in the design of the system, as is demonstrated in the following analysis. The tested permeability rate of the sand layer is reduced by a safety factor of 2; however, the resulting 20 inches/hour design permeability rate cannot be used in calculations because the maximum design permeability rate allowed is 10 in/hr. As stated, the subsoil has a tested permeability rate of 8 in/hr, which is reduced by the same safety factor to yield the design permeability rate of 4 in/hr; therefore, the design permeability rate of the subsoil will be used in sizing calculations for the bottom of the basin, also known as the infiltration area.

The design soil permeability rate, 4 in/hr, is used for the exfiltration rate in the routing calculation. The maximum depth of stormwater runoff, situated above the sand bed cannot exceed 2 ft. Sizing an infiltration basin with exfiltration as a means of discharge is a trial and error process because the size of the basin footprint is related to the stormwater runoff volume temporarily stored above the sand bed, and it is this volume that is exfiltrated during the routing. Adjusting the basin size will change the drain time, which will further change the exfiltration volume that will, in turn, affect the volume of stormwater runoff temporarily located above the sand bed.

An initial routing calculation for the basin is performed. It is assumed the basin shape is a rectangular prism with vertical sides.

Summary Report:

```
Inflow Area =        43,560 sf,100.00% Impervious,  Inflow Depth =  1.03"
Inflow     =      2.66 cfs @    1.13 hrs,  Volume=           3,755 cf
Outflow    =      0.14 cfs @    0.75 hrs,  Volume=           3,755 cf,  Atten= 95%,  Lag= 0.0 min
Discarded =       0.14 cfs @    0.75 hrs,  Volume=           3,755 cf

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 2.00' @ 1.94 hrs   Surf.Area= 1,500 sf   Storage= 3,005 cf

Plug-Flow detention time= 187.9 min calculated for 3,752 cf (100% of inflow)
Center-of-Mass det. time= 188.1 min ( 261.2 - 73.1 )

Volume        Invert     Avail.Storage    Storage Description
  #1          0.00'         4,500 cf      Custom Stage Data (Prismatic) Listed below (Recalc)

 Elevation          Surf.Area          Inc.Store         Cum.Store
    (feet)            (sq-ft)        (cubic-feet)       (cubic-feet)
      0.00              1,500                  0                  0
      1.00              1,500              1,500              1,500
      2.00              1,500              1,500              3,000
      3.00              1,500              1,500              4,500

Device   Routing          Invert    Outlet Devices
  #1     Discarded         0.00'    4.00 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.14 cfs @ 0.75 hrs  HW=0.04'   (Free Discharge)
 └1=Exfiltration  (Exfiltration Controls 0.14 cfs)
```

Source: HydroCAD® Summary Report; HydroCAD is a register trademark of HydroCAD Software Solutions LLC. Used with permission

Routing Report Excerpt:

Time (hours)	Elevation (feet)	Discarded (cfs)
1.00	0.25	0.14
1.05	0.42	0.14
1.10	0.67	0.14
1.15	0.96	0.14
1.20	1.23	0.14
1.25	1.44	0.14
1.30	1.58	0.14
1.35	1.68	0.14
1.40	1.75	0.14
1.45	1.79	0.14
1.50	1.83	0.14
1.55	1.86	0.14
1.60	1.89	0.14
1.65	1.92	0.14
1.70	1.94	0.14
1.75	1.96	0.14
1.80	1.98	0.14
1.85	1.99	0.14
1.90	2.00	0.14
1.95	**2.00**	0.14
2.00	2.00	0.14
2.05	2.00	0.14
2.10	1.99	0.14
2.15	1.98	0.14
2.20	1.97	0.14

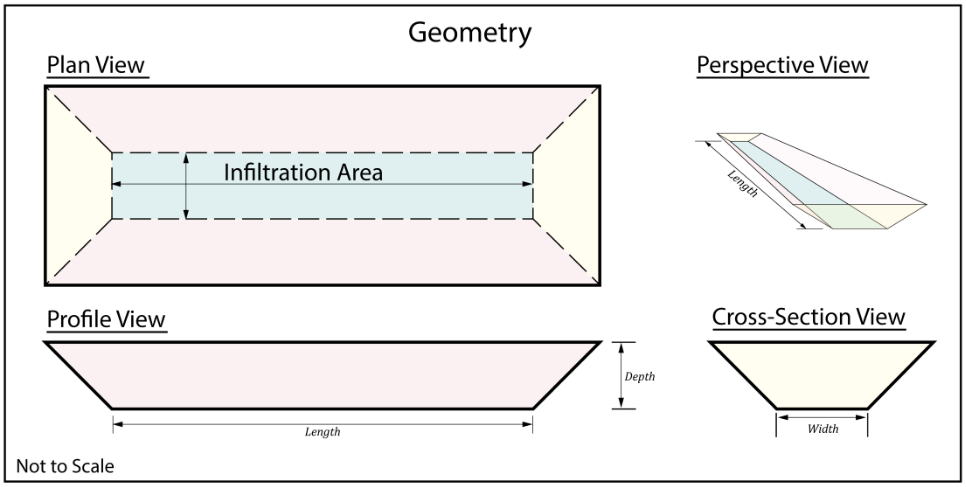
Source: HydroCAD® Report; HydroCAD is a registered trademark of HydroCAD Software Solutions LLC. Used with permission.

The routing report excerpt depicted at left shows that the maximum depth of stormwater runoff generated by the WQDS will be 2 ft when the basin bottom area, or "footprint" is 1,500 sf.

Because the maximum slope of the earthen embankments may not be steeper than 3:1, the small-scale infiltration basin shape cannot be a simple rectangular prism. Therefore, the shape of the basin will initially be set as a trapezoidal prism, as shown below. The infiltration area is shown in blue, the side slopes in pink and the end slopes in yellow. The dimensions of this assumed shape can be calculated by computer programs based on the depth and side slopes.

However, the sloped sides above the 1,500 sf footprint, increase the storage volume available in the basin, meaning, the footprint can be reduced since it is geometrically related to the depth maintained. With this information, a new routing analysis was performed for a trapezoidal prism shaped basin having a footprint of 1,200 sf,and the summary report is provided on the following page.

Example 1 - Geometry



Summary Report:

Inflow Area = 43,560 sf, 100.00% Impervious, Inflow Depth = 1.03"
Inflow = 2.66 cfs @ 1.13 hrs, Volume= 3,755 cf
Outflow = 0.19 cfs @ 1.89 hrs, Volume= 3,755 cf, Atten= 93%, Lag= 45.3 min
Discarded = 0.19 cfs @ 1.89 hrs, Volume= 3,755 cf

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 1.80' @ 1.89 hrs Surf.Area= 2,045 sf Storage= 2,911 cf

Plug-Flow detention time= 155.5 min calculated for 3,752 cf (100% of inflow)
Center-of-Mass det. time= 155.7 min (228.8 - 73.1)

Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	5,790 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
0.00	1,200	0	0
1.00	1,656	1,428	1,428
2.00	2,142	1,899	3,327
3.00	2,784	2,463	5,790

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**4.00 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.19 cfs @ 1.89 hrs HW=1.80' (Free Discharge)
↑**1=Exfiltration** (Exfiltration Controls 0.19 cfs)

Source: HydroCAD® Summary Report; HydroCAD is a registered trademark of HydroCAD Software Solutions LLC. Used with permission.

The summary above shows that with a reduced footprint of 1,200 sf, the greatest depth of stormwater runoff temporarily stored above the basin bottom is 1.8 ft, which is less than the 2 ft maximum depth of stormwater runoff requirement. An excerpt from the tabular hydrograph is provided on the following page.

Tabular Hydrograph Report Excerpt:

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Discarded (cfs)
1.00	1.20	397	0.31	0.12
1.05	1.95	658	0.50	0.13
1.10	2.52	1,036	0.75	0.14
1.15	**2.63**	1,472	1.03	0.15
1.20	2.15	1,874	1.26	0.17
1.25	1.55	2,177	1.43	0.17
1.30	1.10	2,385	1.54	0.18
1.35	0.79	2,523	1.61	0.18
1.40	0.59	2,615	1.65	0.18
1.45	0.48	2,677	1.69	0.18
1.50	0.43	2,725	1.71	0.19
1.55	0.40	2,766	1.73	0.19
1.60	0.37	2,802	1.75	0.19
1.65	0.33	2,831	1.76	0.19
1.70	0.31	2,855	1.77	0.19
1.75	0.30	2,876	1.78	0.19
1.80	0.29	2,895	1.79	0.19
1.85	0.24	2,908	1.80	0.19
1.90	0.17	**2,911**	**1.80**	**0.19**
1.95	0.13	2,904	1.80	0.19
2.00	0.11	2,892	1.79	0.19

Source: HydroCAD® Report; HydroCAD is a registered trademark of HydroCAD Software Solutions LLC. Used with permission.

Step 4: Estimated Drain Time Calculation

As previously stated, the drain time of the basin is determined by the design permeability rate of the subsoil. Note that only the infiltration area, i.e. the footprint, can be credited for infiltration, meaning infiltration may not be applied to the side slopes. The drain time calculation is based on the area of the footprint, which is 1,200 sf.

$$Drain\ Time = \frac{WQDS\ Volume}{Infiltration\ Area\ \ x\ \ Design\ Permeability\ Rate}$$

$$= \frac{3{,}755\ cf\ x\ (12\ in/ft)}{(1{,}200\ sf\ \ x\ 4\ in/hr)} = 9.39\text{ hr}$$

Since this is less than the allowable maximum drain time of 72 hours, the small-scale infiltration basin has been sized correctly, on an initial basis, to ensure the surface and sand layer are fully drained within the maximum allowable time frame.

Step 5: Check Separation from SHWT

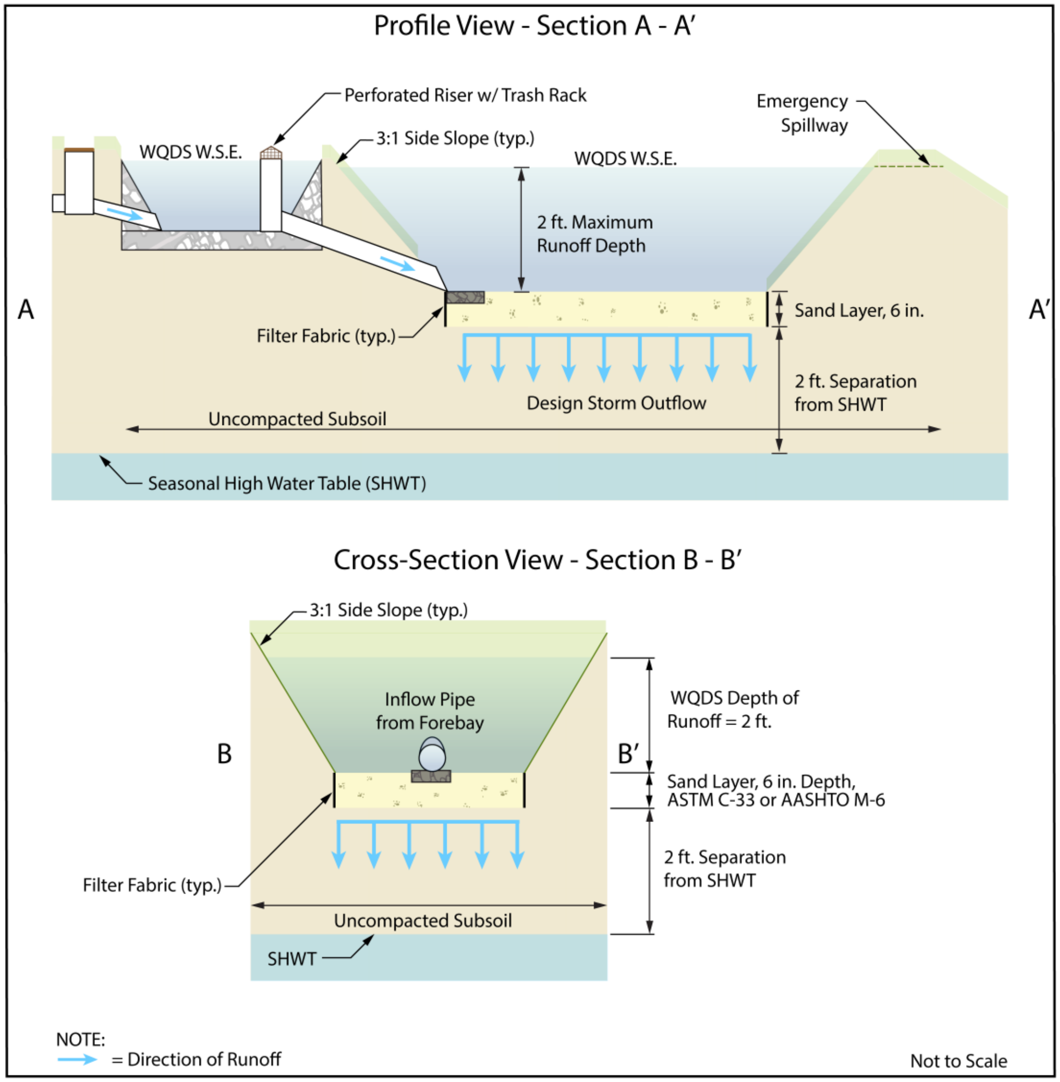
The vertical distance between the lowest elevation of the sand layer and the SHWT must be checked to ensure it meets the minimum requirements. By inspection, the required 2 foot separation from the SHWT is provided.

Step 6: Groundwater Mounding Analysis

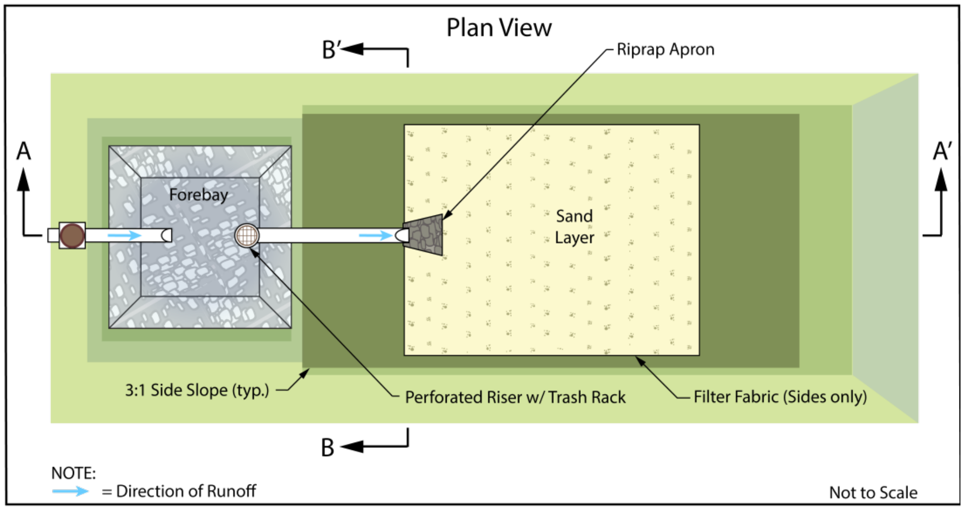
Calculate the height of the groundwater mound caused by infiltration to ensure that it will neither prevent infiltration nor damage nearby structures. For information on conducting a groundwater mounding analysis, see *Chapter 13: Groundwater Table Hydraulic Impact Assessments for Infiltration BMPs*. For this example, it is assumed the design meets the necessary groundwater mound requirements.

Illustrations for this example, exclusive of any refinements, are shown below and on the following page.

Example 1 – Profile and Cross-Section View



Example 1 – Plan View



Example 2: Using the following parameters, design a small-scale subsurface infiltration basin sized both for the WQDS and to provide groundwater recharge. Assume the site is not in an Urban Redevelopment Area. Assume pretreatment to provide 80% TSS removal is provided by an appropriate BMP or MTD.

Inflow Contributory Drainage Area =	1 ac
Existing Conditions:	
Cover = Office Building -	25% Directly Connected Impervious Cover and 75% Lawn and Landscaping Areas
Proposed Conditions:	
Cover = Auto Dealership -	75% Directly Connected Impervious Cover and 25% Lawn and Landscaping Areas
Lawn NRCS Curve Number (CN) =	49
Pavement NRCS Curve Number (CN) =	98
Tested Subsoil Permeability Rate =	4 in/hr
Elevation of the SHWT =	10 ft below the surface

Step 1: Runoff Calculations

Using the NRCS method described in *National Engineering Handbook, Part 630* (*NEH*) and discussed in the NRCS Methodology section of *Chapter 5*, the post-construction runoff volume from the proposed 0.75 acre impervious surface is calculated to be 2,817 cf.

Step 2: Design Volume Calculations

The *New Jersey Groundwater Recharge Spreadsheet* (NJGRS) is used to calculate the amount of groundwater recharge required. Land cover is changed from 25% impervious in the existing condition to 75% in the proposed, resulting in a post-development annual recharge deficit of 20,499 cf, as shown in the following image of the *Annual Recharge Worksheet*:

Example 2 – Post-Development Annual Recharge Deficit Calculation

New Jersey Groundwater Recharge Spreadsheet Version 2.0 November 2003

Annual Groundwater Recharge Analysis (based on GSR-32)

Select Township ↓	Average Annual P (in)	Climatic Factor
MERCER CO., HAMILTON TWP	44.9	1.43

Project Name:	Sample Project
Description:	This is a test application
Analysis Date:	09/01/03

Pre-Developed Conditions

Land Segment	Area (acres)	TR-55 Land Cover	Soil	Annual Recharge (in)	Annual Recharge (cu.ft)
1	0.25	Impervious areas	Woodstown	0.0	-
2	0.75	Open space	Woodstown	11.3	30,748
3	0				
4	0				
5	0				
6	0				
7	0				
8	0				
9	0				
10	0				
11	0				
12	0				
13	0				
14	0				
15	0				
Total =	1.0			Total Annual Recharge (in)	Total Annual Recharge (cu-ft)
				8.5	30,748

Post-Developed Conditions

Land Segment	Area (acres)	TR-55 Land Cover	Soil	Annual Recharge (in)	Annual Recharge (cu.ft)
1	0.75	Impervious areas	Woodstown	0.0	-
2	0.25	Open space	Woodstown	11.3	10,249
3	0				
4	0				
5	0				
6	0				
7	0				
8	0				
9	0				
10	0				
11	0				
12	0				
13	0				
14	0				
15	0				
Total =	1.0			Total Annual Recharge (in)	Total Annual Recharge (cu.ft)
				2.8	10,249
				Total Impervious Area (sq.ft)	32,670

Annual Recharge Requirements Calculation ↓

% of Pre-Developed Annual Recharge to Preserve =	100%	
Post-Development Annual Recharge Deficit=	*20,499*	(cubic feet)

Recharge Efficiency Parameters Calculations (area averages)

RWC=	2.90	(in)	DRWC=	0.81	(in)
ERWC =	0.83	(in)	EDRWC=	0.23	(in)

Procedure to fill the Pre-Development and Post-Development Conditions Tables

For each land segment, first enter the area, then select TR-55 Land Cover, then select Soil. Start from the top of the table and proceed downward. Don't leave blank rows (with A=0) in between your segment entries. Rows with A=0 will not be displayed or used in calculations. For impervious areas outside of standard lots select "Impervious Areas" as the Land Cover. Soil type for impervious areas are only required if an infiltration facility will be built within these areas.

The design volume for a basin treating the WQDS is 2,817 cf. Setting the exfiltration rate to 2 in/hr, results from stormwater modeling software show that an infiltration basin with a footprint of 1,250 sf will provide the required storage volume for the stormwater runoff generated by the WQDS and will yield a maximum depth of runoff of 1.99 ft, which is less than the 2 ft maximum allowable depth. For design purposes, 1 ft of freeboard is included in the software model. The summary report and routing table excerpt are provided on the following page.

WQDS Summary Report

```
Inflow Area =       32,670 sf,100.00% Impervious,  Inflow Depth =   1.03"
Inflow      =      2.17 cfs @    1.09 hrs,  Volume=          2,817 cf
Outflow     =      0.06 cfs @    0.65 hrs,  Volume=          2,817 cf,  Atten= 97%,  Lag= 0.0 min
Discarded   =      0.06 cfs @    0.65 hrs,  Volume=          2,817 cf
Primary     =      0.00 cfs @    0.00 hrs,  Volume=              0 cf

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 1.99' @ 2.05 hrs   Surf.Area= 1,250 sf   Storage= 2,490 cf

Plug-Flow detention time= 367.4 min calculated for 2,814 cf (100% of inflow)
Center-of-Mass det. time= 367.7 min ( 438.0 - 70.3 )

Volume        Invert    Avail.Storage   Storage Description
  #1          0.00'         3,750 cf    Custom Stage Data (Prismatic) Listed below (Recalc)

 Elevation        Surf.Area       Inc.Store       Cum.Store
    (feet)          (sq-ft)     (cubic-feet)    (cubic-feet)
      0.00            1,250               0               0
      3.00            1,250           3,750           3,750

Device   Routing         Invert   Outlet Devices
  #1     Discarded        0.00'   2.00 in/hr Exfiltration over Surface area
  #2     Primary          2.00'   2.5" Vert. Orifice/Grate    C= 0.600

Discarded OutFlow  Max=0.06 cfs @ 0.65 hrs  HW=0.03'   (Free Discharge)
└1=Exfiltration  (Exfiltration Controls 0.06 cfs)

Primary OutFlow  Max=0.00 cfs @ 0.00 hrs  HW=0.00'   (Free Discharge)
└2=Orifice/Grate  ( Controls 0.00 cfs)
```

Source: HydroCAD® Summary Report; HydroCAD is a registered trademark of HydroCAD Software Solutions LLC. Used with permission.

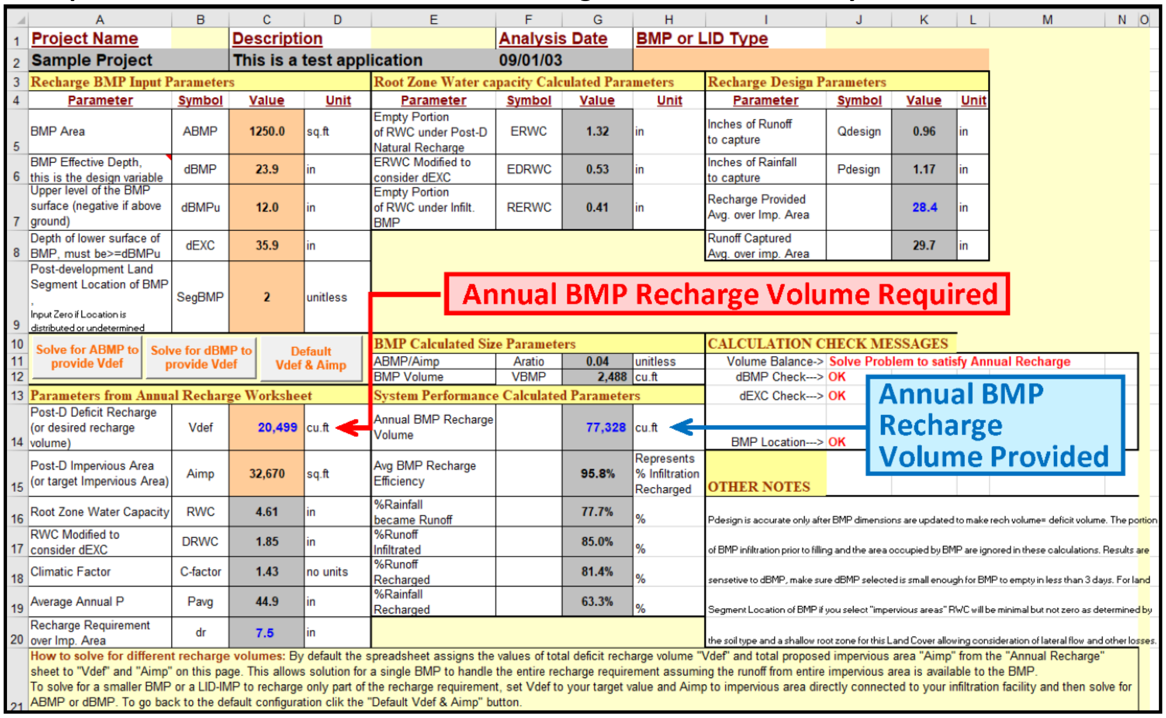
Routing Table Excerpt

Time (hours)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)
0.00	0.00	0.00	0.00
0.50	0.01	**0.02**	**0.02**
1.00	0.39	**0.06**	**0.06**
1.50	1.80	0.06	0.06
2.00	**1.99**	0.06	0.06
2.50	**1.93**	0.06	0.06
3.00	1.84	0.06	0.06
3.50	1.76	0.06	0.06
4.00	1.68	0.06	0.06
4.50	1.59	0.06	0.06

Source: HydroCAD® Routing Table; HydroCAD is a registered trademark of HydroCAD Software Solutions LLC. Used with permission.

However, the calculated area must be checked using the NJGRS to see if it is large enough to meet the annual recharge deficit requirement. To do this, first enter 1,250 for the area of the proposed small-scale infiltration basin, which is representated by the variable ABMP, in Cell C5 on the *BMP Calculations Worksheet* of the NJGRS and set the BMP Effective Depth (dBMP) to 1.99 ft x 12 in/ft = 23.88 in (Cell C6). The value to be entered in Cell C7 for dBMPu, which is the vertical distance from the vegetated ground surface to the maximum water surface level in the BMP and is positive when the maximum water surface level is below the vegetated ground surface, is 12 in, which is the 1 ft of freeboard mentioned above. The next value entered is that for dEXC, which is the vertical distance from the vegetated ground surface to the top of the sand layer in the bottom of the BMP, and is equal to 23.88 in (maximum runoff depth) + 12 in (freeboard) = 35.88 in. Lastly, we must identify the post-developed condition land segment from the *Annual Recharge Worksheet* in which this BMP is located, which is represented by the variable segBMP, and is 2 in this case. The NJGRS calculates the annual BMP recharge volume provided by the proposed small-scale infiltration basin is 77,328 cf, which is greater than the deficit volume (Vdef) of 20,499 cf, as shown in the image below.

Example 2 –Calculation of Groundwater Recharge Volume Provided by the BMP



Project Name	Description	Analysis Date	BMP or LID Type
Sample Project	This is a test application	09/01/03	

Recharge BMP Input Parameters

Parameter	Symbol	Value	Unit
BMP Area	ABMP	1250.0	sq.ft
BMP Effective Depth, this is the design variable	dBMP	23.9	in
Upper level of the BMP surface (negative if above ground)	dBMPu	12.0	in
Depth of lower surface of BMP, must be>=dBMPu	dEXC	35.9	in
Post-development Land Segment Location of BMP , Input Zero if Location is distributed or undetermined	SegBMP	2	unitless

Solve for ABMP to provide Vdef | Solve for dBMP to provide Vdef | Default Vdef & Aimp

Parameters from Annual Recharge Worksheet

Parameter	Symbol	Value	Unit
Post-D Deficit Recharge (or desired recharge volume)	Vdef	20,499	cu.ft
Post-D Impervious Area (or target Impervious Area)	Aimp	32,670	sq.ft
Root Zone Water Capacity	RWC	4.61	in
RWC Modified to consider dEXC	DRWC	1.85	in
Climatic Factor	C-factor	1.43	no units
Average Annual P	Pavg	44.9	in
Recharge Requirement over Imp. Area	dr	7.5	in

Root Zone Water capacity Calculated Parameters

Parameter	Symbol	Value	Unit
Empty Portion of RWC under Post-D Natural Recharge	ERWC	1.32	in
ERWC Modified to consider dEXC	EDRWC	0.53	in
Empty Portion of RWC under Infilt. BMP	RERWC	0.41	in

Recharge Design Parameters

Parameter	Symbol	Value	Unit
Inches of Runoff to capture	Qdesign	0.96	in
Inches of Rainfall to capture	Pdesign	1.17	in
Recharge Provided Avg. over Imp. Area		28.4	in
Runoff Captured Avg. over imp. Area		29.7	in

BMP Calculated Size Parameters

ABMP/Aimp	Aratio	0.04	unitless
BMP Volume	VBMP	2,488	cu.ft

System Performance Calculated Parameters

Annual BMP Recharge Volume		77,328	cu.ft
Avg BMP Recharge Efficiency		95.8%	Represents % Infiltration Recharged
%Rainfall became Runoff		77.7%	%
%Runoff Infiltrated		85.0%	%
%Runoff Recharged		81.4%	%
%Rainfall Recharged		63.3%	%

CALCULATION CHECK MESSAGES

Volume Balance->	Solve Problem to satisfy Annual Recharge
dBMP Check--->	OK
dEXC Check--->	OK
BMP Location--->	OK

OTHER NOTES

Pdesign is accurate only after BMP dimensions are updated to make rech volume= deficit volume. The portion of BMP infiltration prior to filling and the area occupied by BMP are ignored in these calculations. Results are sensetive to dBMP, make sure dBMP selected is small enough for BMP to empty in less than 3 days. For land Segment Location of BMP if you select "impervious areas" RWC will be minimal but not zero as determined by the soil type and a shallow root zone for this Land Cover allowing consideration of lateral flow and other losses.

How to solve for different recharge volumes: By default the spreadsheet assigns the values of total deficit recharge volume "Vdef" and total proposed impervious area "Aimp" from the "Annual Recharge" sheet to "Vdef" and "Aimp" on this page. This allows solution for a single BMP to handle the entire recharge requirement assuming the runoff from entire impervious area is available to the BMP. To solve for a smaller BMP or a LID-IMP to recharge only part of the recharge requirement, set Vdef to your target value and Aimp to impervious area directly connected to your infiltration facility and then solve for ABMP or dBMP. To go back to the default configuration clik the "Default Vdef & Aimp" button.

Step 3: Initial Drain Time Calculation

As previously stated, the drain time of the basin is determined by the design permeability rate of the subsoil.

$$Drain\ Time = \frac{WQDS\ Volume}{Infiltration\ Area\ \ x\ \ Design\ Permeability\ Rate}$$

$$= \frac{2{,}817\ cf\ x\ (12\ in/ft)}{(1{,}250\ sf\ \ x\ 2\ in/hr)} = 13.52\text{ hr}$$

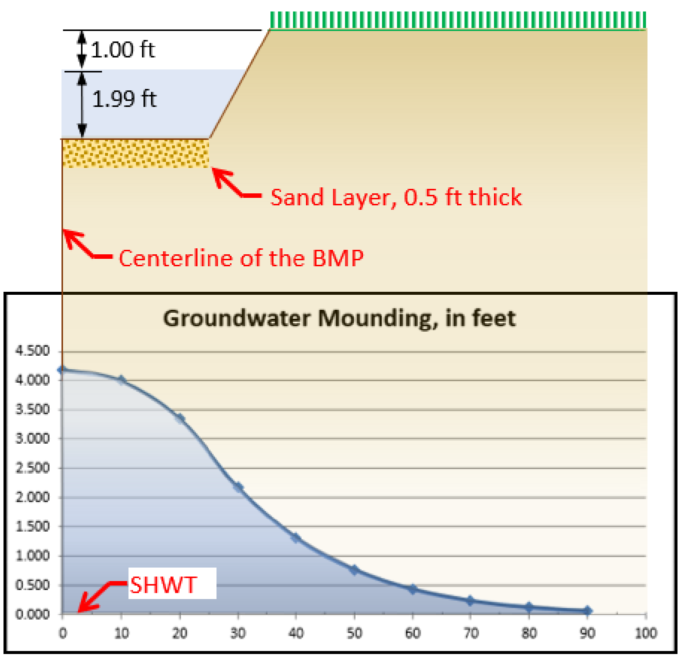
Since this is less than the allowable maximum drain time of 72 hours, the small-scale infiltration basin has been sized correctly.

Step 4: Check for Required Separation from the SHWT

The bottom of the small-scale subsurface infiltration basin must be 2 ft above the SHWT. For this example, the SHWT is located 10 ft below the surface. The basin was designed to provide storage 1.99 ft in depth for the WQDS plus an additional 1 ft of freeboard, which sets the elevation of the surface of the required sand layer at 2.99 ft below ground level. The sand layer is 0.5 ft in thickness. Therefore, the SHWT is 6.51 ft below the bottom of the sand layer, which meets the separation requirement. However, a groundwater mounding analysis is required for any infiltration practice to check whether infiltration of stormwater creates any adverse hydraulic impacts to . For the purpose of this example, assume the basin footprint measures 50 ft by 25 ft and the project area lies within the portion of Hamilton Township that is within the coastal plain. Following the requirements for using the *Hantush Spreadsheet* as addressed in *Chapter 13*, the following results were calculated.

Hantush Spreadsheet Input Values and Calculated Height of Groundwater Mounding

	A	B	C–L
6	Input Values		
7	2.00	R	Recharge rate (permeability rate) (in/hr)
8	0.150	Sy	Specific yield, Sy (dimensionless) default value is 0.15; max value is 0.2 provided that a lab test data is submitted
9	10.00	Kh	Horizontal hydraulic conductivity (in/hr) Kh = 5xRecharge Rate (R) in the costal plan; Kh=R outside the coastal plan
10	25.000	x	1/2 length of basin (x direction, in feet)
11	12.500	y	1/2 width of basin (y direction, in feet)
12	13.52	t	Duration of infiltration period (hours)
13	10.000	hi(0)	Initial thickness of saturated zone (feet)
14			
15	14.19	h(max)	Maximum thickness of saturated zone (beneath center of basin at end of infiltration period)
16	4.19	Δh(max)	Maximum groundwater mounding (beneath center of basin at end of infiltration period)



The maximum mounding height is 4.19 feet. In the *Hantush Spreadsheet*, the SHWT forms the x-axis. For this example, ground level is 10 ft above the SHWT, meaning, the top of the groundwater mounding will be 5.81 feet below the surface. As stated above, the surface of the basin sand layer is 2.99 ft below the adjacent ground surface. Therefore, the top of the groundwater mounding is 2.82 ft below the top of the sand layer forming the basin bottom and will not interfere with the infiltration of stormwater runoff, as depicted in the image to the right. However, the design engineer must also check if there are any underground structures within the extents of the groundwater mounding curve plotted by the *Hantush Spreadsheet*, and the temporary rise in the elevation of the groundwater table, caused by the small-scale infiltration basin, must not adversely impact any underground structure.

Considerations

When planning a small-scale infiltration basin, consideration should be given to soil characteristics, depth to the groundwater table, sensitivity of the region and inflow water quality. It is also important to note that the use of small-scale infiltration basins is recommended in this manual only where the WQDS or smaller storm events are contained below the first outlet control structure. Use of these basins to store larger volumes below the first outlet control structure should only be considered when another applicable rule or regulation requires the infiltration of a larger storm event. In such a case, the small-scale infiltration basin should be designed to store the minimum storm event required to address that rule or regulation, below the first outlet control structure.

In addition to the prohibition of recharge in the areas with high pollutant loading or with runoff exposed to source material as defined in N.J.A.C. 7:8-5.4(b)3, the utilization of small-scale infiltration basins should consider the impact of infiltration on subsurface sewage disposal systems, water supply wells, groundwater recharge areas protected under the Ground Water Quality Standards rules at N.J.A.C 7:9C, streams under antidegradation protection by the Surface Water Quality Standards rules at N.J.A.C. 7:9B, or similar facilities or areas geologically and ecologically sensitive to pollutants or hydrological changes. Furthermore, the location and minimum distance of the small-scale infiltration basin from other facilities or systems shall also comply with all applicable laws and rules adopted by Federal, State and local government entities.

Pretreatment

As with all other best management practices, pretreatment may extend the functional life and increase the pollutant removal capability of a small-scale infiltration basin by reducing incoming velocities and capturing coarser sediments. Note that pretreatment is a requirement for small-scale surface infiltration basins that include exfiltration in the stormwater routing calculations and small-scale subsurface infiltration basins. Pretreatment requirements specific to these types of infiltration basins can be found in the above section entitled *"Individual Types of Small-Scale Infiltration Basins."*

- Pretreatment may consist of a forebay or any of the BMPs found in *Chapters 9 or 11.*

- There is no adopted TSS removal rate associated with forebays; therefore, their inclusion in any design should be solely for the purpose of facilitating maintenance. Forebays may be earthen, constructed of riprap, or made of concrete and must comply with the following requirements:

  - □ The forebay must be designed to prevent scour of the receiving basin by outflow from the forebay.
  - □ The forebay should provide a minimum storage volume of 10% of the WQDS and be sized to hold the sediment volume expected between clean-outs.
  - □ The forebay should fully drain within nine hours in order to facilitate maintenance and to prevent mosquito issues. Under no circumstances should there be any standing water in the forebay 72 hours after a precipitation event.
  - □ Surface forebays must meet or exceed the sizing for preformed scour holes in the *Standard for Conduit Outlet Protection* in the *Standards for Soil Erosion and Sediment Control in New Jersey* for a surface forebay.
  - □ If a concrete forebay is utilized, it must have at least two weep holes to facilitate low level drainage.

- When using another BMP for pretreatment, it must be designed in accordance with the design requirements outlined in its respective chapter. For additional information on the design requirements of each BMP, refer to the appropriate chapter in this manual.

- Any roof runoff that discharges to the small-scale infiltration basin may be pretreated by leaf screens, first flush diverters or roof washers. For details of these pretreatment measures, see Pages 5 and 6 of *Chapter 9.1: Cisterns.*

  - The pretreatment requirement for roof runoff can be waived by the review agency if the building in question has no potential for debris and other vegetative material to be present in the roof runoff. For example, a building that is significantly taller than any surrounding trees and does not have vegetative roof should not need the pretreatment. However, in making this determination, the review agency must consider the mature height of any surrounding trees.

Soil Characteristics

Soils are perhaps the most important consideration for site suitability. In general, County Soil Surveys may be used to obtain necessary soil data for planning and preliminary design of small-scale infiltration basins. However, as previously mentioned, for final design and construction, soil tests are required at the exact location of the proposed basin in order to confirm its ability to function properly without failure. In order to confirm reasonable data consistency, the results of soil testing should be compared with the County Soil Survey data that was used in the computation of runoff rates and volumes and the design of on-site BMPs. If significant differences exist between the soil test results and the County Soil Survey data, additional soil tests are recommended to determine and evaluate the extent of the data inconsistency and whether there is a need for revised site runoff and BMP design computations. All significant inconsistencies should be discussed with the local Soil Conservation District prior to proceeding with such a redesign to help ensure that the final site soil data is accurate.

Geology

The presence or absence of Karst topography is an important consideration when designing a small-scale infiltration basin; in areas of the State with this type of geology, the bedrock is composed of highly soluble rock. If Karst topography is present, infiltration of runoff may lead to subsidence and sinkholes; therefore, careful consideration must be taken in these areas. For more information on design and remediation in areas of Karst topography, refer to the *Standards for Soil Erosion and Sediment Control in New Jersey: Investigation, Design and Remedial Measures for Areas Underlain by Cavernous Limestone.*

Maintenance

Regular and effective maintenance is crucial to ensure effective small-scale infiltration basin performance; in addition, maintenance plans are required for all stormwater management facilities on a major development. There are a number of required elements in all maintenance plans, pursuant to N.J.A.C. 7:8-5.8; these are discussed in more detail in *Chapter 8: Maintenance of Stormwater Management*

Measures. Furthermore, maintenance activities are required through various regulations, including the New Jersey Pollutant Discharge Elimination System (NJPDES) rules, N.J.A.C. 7:14A. Specific maintenance requirements for small-scale infiltration basins are presented below; these requirements must be included in the basin's maintenance plan.

General Maintenance

- Proper and timely maintenance is essential to continuous, effective operation; therefore, an access route must be incorporated into the design and it must be properly maintained.
- All structural components must be inspected, at least once annually, for cracking, subsidence, spalling, erosion and deterioration.
- Components expected to receive and/or trap debris and sediment must be inspected for clogging at least four times annually, as well as after every storm exceeding 1 inch of rainfall.
- Sediment removal should take place when all runoff has drained and the basin is dry.
- Disposal of debris, trash, sediment and other waste material must be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations.
- Access points for maintenance are required on all enclosed areas within a small-scale infiltration basin; these access points must be clearly identified in the maintenance plan. In addition, any special training required for maintenance personnel to perform specific tasks, such as confined space entry, must be included in the plan.
- Stormwater BMPs may not be used for stockpiling of plowed snow and ice, compost, or any other material.

Drain Time

- The basin must be inspected at least twice annually to determine if the permeability of the basin has decreased.
- The design drain time for the maximum design storm runoff volume must be indicated in the maintenance manual.
- If the actual drain time is longer than the design drain time, the components must be evaluated and appropriate measures taken to return the small-scale infiltration basin to the original tested as-built condition.
- If the small-scale infiltration basin fails to drain the WQDS within 72 hours, corrective action must be taken and the maintenance manual revised accordingly to prevent similar failures in the future. Note that annual tilling of the sand layer, using lightweight equipment, may assist in maintaining the infiltration capacity of a surface type system by breaking up clogged surfaces.

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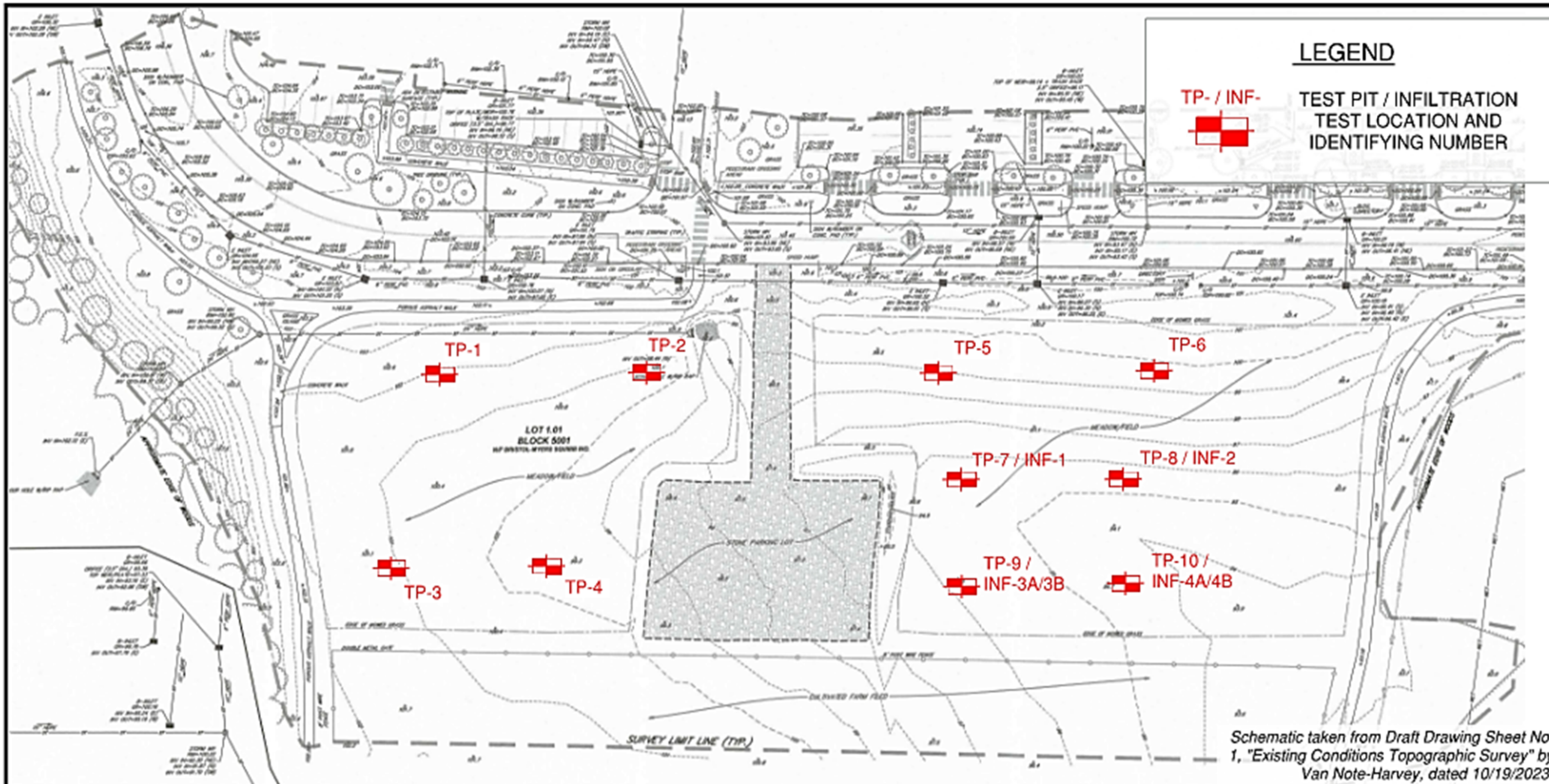

Schematic taken from Draft Drawing Sheet No. 1, "Existing Conditions Topographic Survey" by Van Note-Harvey, dated 10/19/2023.

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DRAWN BY:	SCALE:	DATE:
TH	NTS	03/05/2024
CHECKED BY:	FIGURE No.	
MA	TL-1	
PROJECT No:		
BRMYS23006		

TEST LOCATION PLAN - 3401 Princeton Pike, Lawrence Twp, NJ

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Infiltration Test Number: INF-1

Project: Parking Lot Expansion	Project Number: BRMYS23006	Date: 02/29/2024
Location: 3401 Princeton Pike, Lawrence Twp, NJ	Test Location: TP-7	Testing Depth (ft): 3.0
Test Performed By: T. Hall	Ring Seating Depth (in): 4	Ring Diameter (in): 6
Ground Surface Elev. 95.7		Testing Elev. 92.7
Test Soil Strata: Loamy Sand		
Limiting Zones: Not Encountered		

Trial #	Initial Water Height (in.)	Final Water Height (in.)	ΔHeight (in.)	ΔTime (min)	Infiltration Rate (in/hr)	Converted Hydraulic Conductivity (in/hr)
Pre Soak	3.00	0.00	3.00	30.00	6.00	2.05
1	3.00	2.00	1.00	11.00	5.45	1.87
2	3.00	2.00	1.00	13.00	4.62	1.58
3	3.00	2.00	1.00	13.05	4.60	1.57
4	3.00	2.00	1.00	13.00	4.62	1.58
5						
6						
7						
8						
9						
10						
				Hydraulic Conductivity (in/hr)		1.58

Infiltration Test Number: INF-2

Project: Parking Lot Expansion	Project Number: BRMYS23006	Date: 02/29/2024
Location: 3401 Princeton Pike, Lawrence Twp, NJ	Test Location: TP-8	Testing Depth (ft): 3.0
Test Performed By: T. Hall	Ring Seating Depth (in): 4	Ring Diameter (in): 6
Ground Surface Elev. 95.5		Testing Elev. 92.5
Test Soil Strata: Loamy Sand		
Limiting Zones: Not Encountered		

Trial #	Initial Water Height (in.)	Final Water Height (in.)	ΔHeight (in.)	ΔTime (min)	Infiltration Rate (in/hr)	Converted Hydraulic Conductivity (in/hr)
Pre Soak	3.00	0.00	3.00	42.00	4.29	1.47
1	3.00	2.00	1.00	21.50	2.79	0.96
2	3.00	2.00	1.00	22.50	2.67	0.91
3	3.00	2.00	1.00	22.33	2.69	0.92
4	3.00	2.00	1.00	22.42	2.68	0.92
5						
6						
7						
8						
9						
10						
				Hydraulic Conductivity (in/hr)		0.92

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SINGLE RING DATA SHEET

Infiltration Test Number: INF-3A

Project: Parking Lot Expansion	Project Number: BRMYS23006	Date: 02/29/2024
Location: 3401 Princeton Pike, Lawrence Twp, NJ	Test Location: TP-9	Testing Depth (ft): 3.0
Test Performed By: T. Hall	Ring Seating Depth (in): 4	Ring Diameter (in): 6
Ground Surface Elev. 95.8		Testing Elev. 92.8
Test Soil Strata: Silt Loam		
Limiting Zones: Not Encountered		

Trial #	Initial Water Height (in.)	Final Water Height (in.)	ΔHeight (in.)	ΔTime (min)	Infiltration Rate (in/hr)	Converted Hydraulic Conductivity (in/hr)
Pre Soak	3.00	1.75	1.25	60.00	1.25	0.43
1	3.00	2.25	0.75	60.00	0.75	0.26
2						
3						
4						
5						
6						
7						
8						
9						
10						
				Hydraulic Conductivity (in/hr)		< 1.00

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Infiltration Test Number: INF-3B

Project: Parking Lot Expansion	Project Number: BRMYS23006	Date: 02/29/2024
Location: 3401 Princeton Pike, Lawrence Twp, NJ	Test Location: TP-9	Testing Depth (ft): 4.0
Test Performed By: T. Hall	Ring Seating Depth (in): 4	Ring Diameter (in): 6
Ground Surface Elev. 95.8		Testing Elev. 91.8
Test Soil Strata: Loamy Sand		
Limiting Zones: Not Encountered		

Trial #	Initial Water Height (in.)	Final Water Height (in.)	ΔHeight (in.)	ΔTime (min)	Infiltration Rate (in/hr)	Converted Hydraulic Conductivity (in/hr)
Pre Soak	3.00	0.00	3.00	15.00	12.00	4.11
1	3.00	2.00	1.00	6.00	10.00	3.42
2	3.00	2.00	1.00	6.17	9.73	3.33
3	3.00	2.00	1.00	6.25	9.60	3.29
4	3.00	2.00	1.00	7.00	8.57	2.93
5	3.00	2.00	1.00	7.00	8.57	2.93
6						
7						
8						
9						
10						
				Hydraulic Conductivity (in/hr)		2.93

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Infiltration Test Number: INF-4A

Project: Parking Lot Expansion	Project Number: BRMYS23006	Date: 02/29/2024
Location: 3401 Princeton Pike, Lawrence Twp, NJ	Test Location: TP-10	Testing Depth (ft): 2.0
Test Performed By: T. Hall	Ring Seating Depth (in): 4	Ring Diameter (in): 6
Ground Surface Elev. 94.7		Testing Elev. 92.7
Test Soil Strata: Silt Loam		
Limiting Zones: Not Encountered		

Trial #	Initial Water Height (in.)	Final Water Height (in.)	ΔHeight (in.)	ΔTime (min)	Infiltration Rate (in/hr)	Converted Hydraulic Conductivity (in/hr)
Pre Soak	3.00	2.13	0.88	60.00	0.88	0.30
1	3.00	2.50	0.50	60.00	0.50	0.17
2						
3						
4						
5						
6						
7						
8						
9						
10						
				Hydraulic Conductivity (in/hr)		< 1.00

Pennoni

SINGLE RING DATA SHEET

Infiltration Test Number: INF-4B

Project: Parking Lot Expansion	Project Number: BRMYS23006	Date: 02/29/2024
Location: 3401 Princeton Pike, Lawrence Twp, NJ	Test Location: TP-10	Testing Depth (ft): 3.0
Test Performed By: T. Hall	Ring Seating Depth (in): 4	Ring Diameter (in): 6
Ground Surface Elev. 94.7		Testing Elev. 91.7
Test Soil Strata: Loamy Sand		
Limiting Zones: Not Encountered		

Trial #	Initial Water Height (in.)	Final Water Height (in.)	ΔHeight (in.)	ΔTime (min)	Infiltration Rate (in/hr)	Converted Hydraulic Conductivity (in/hr)
Pre Soak	3.00	0.00	3.00	51.00	3.53	1.21
1	3.00	2.00	1.00	23.25	2.58	0.88
2	3.00	2.00	1.00	26.00	2.31	0.79
3	3.00	2.00	1.00	26.03	2.30	0.79
4	3.00	2.00	1.00	26.08	2.30	0.79
5						
6						
7						
8						
9						
10						
				Hydraulic Conductivity (in/hr)		0.79