

# Permeable Interlocking Concrete Pavement "PICP"



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## **Content:**

**Available information  
and resources**

**System Components**

- Pavers
- Aggregates
- Edge Restraints
- Geotextiles

**Design Options**

- PICP Sections

**Installation**


**Maintenance**

**Cost**

**Case Studies,  
Project Photos**



# Technical Assistance

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- › Sustainability
- › Pavement Systems
- › Design
- › Installation
- › Maintenance



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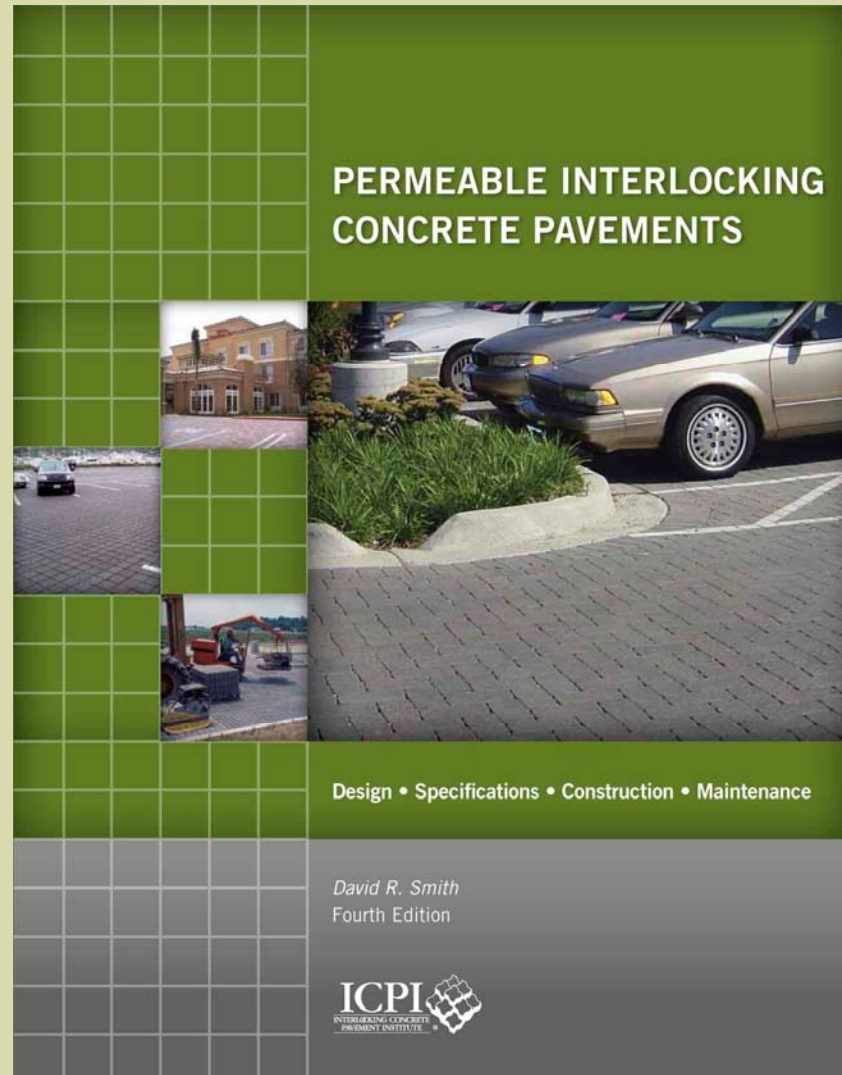
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## PICP 'Design Manual'

- Fourth edition

- Design
- Specifications
- Construction
- Maintenance







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## PICP Permeable Design Pro Design Software

Balances system performance

- Structural support
- Hydraulic capacity



PICP Permeable Design Pro Software



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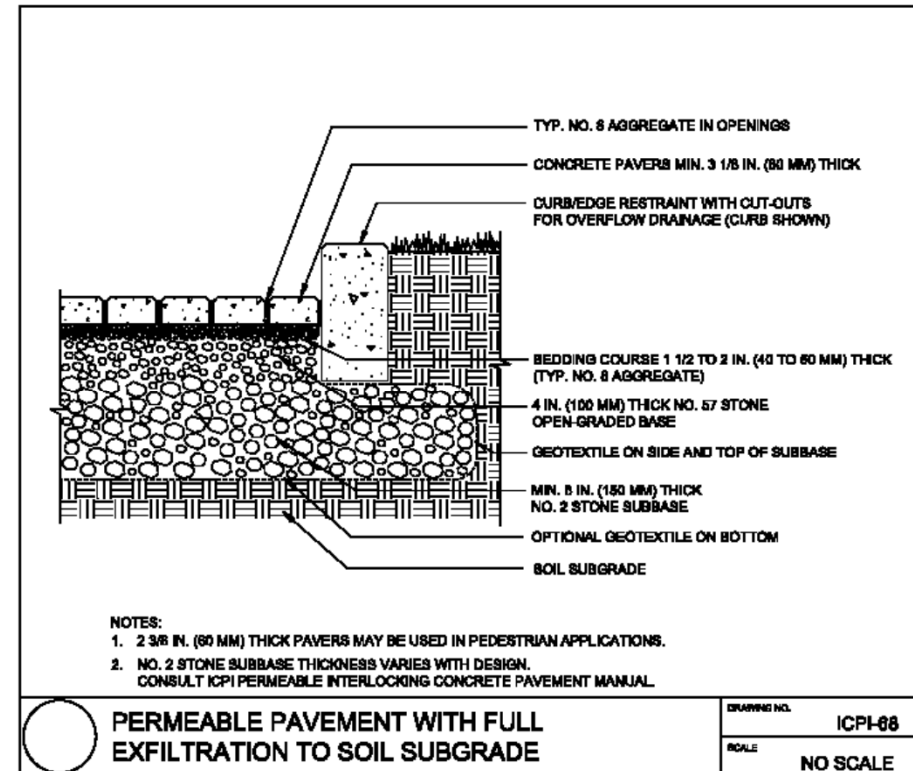
## Design Details

## Guide Specifications

## Videos

## Technical Research

## Papers



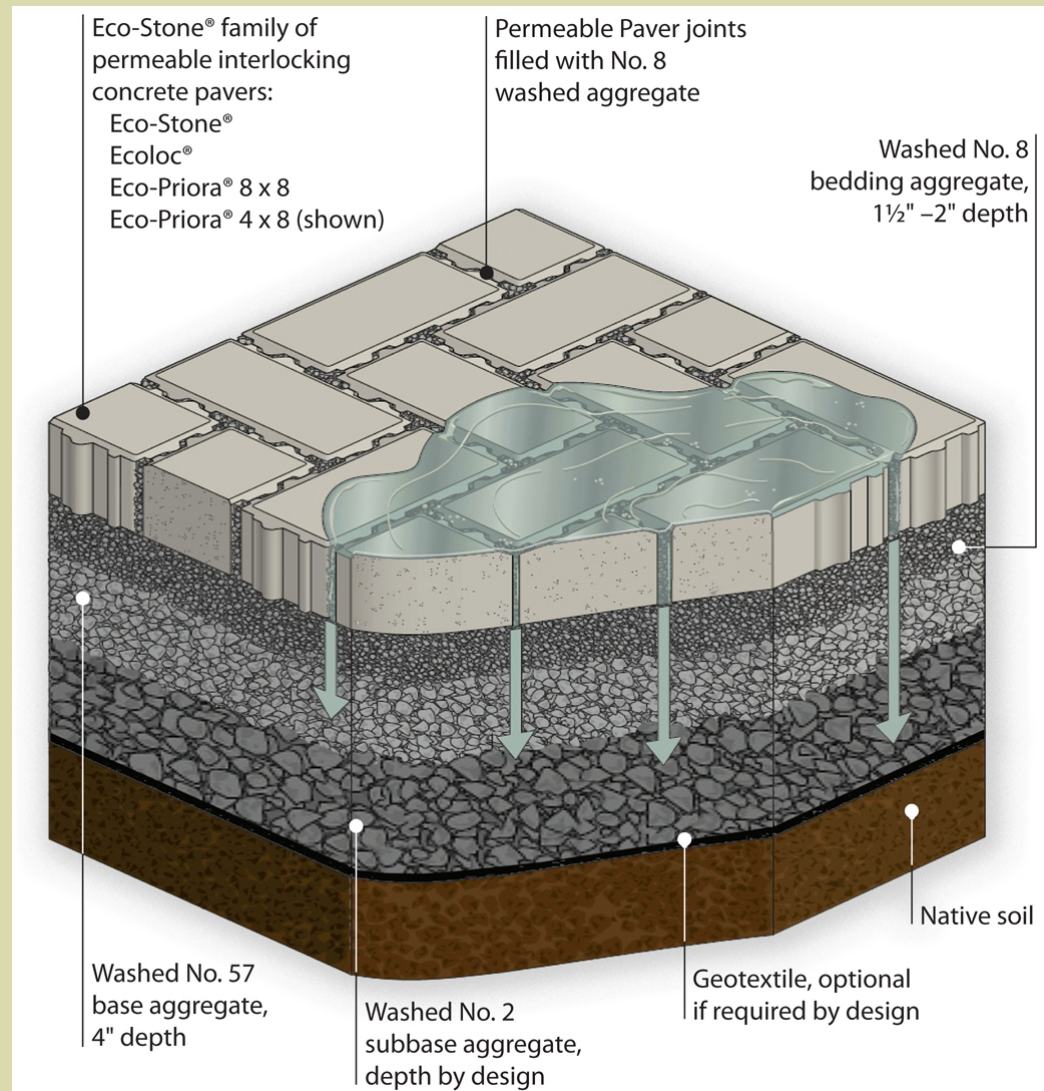
# Additional resource for product information:



[www.uni-groupusa.org](http://www.uni-groupusa.org)



# Permeable Interlocking Concrete Pavement (*PICP*)



# PICP Product Standards

## PICP pavers meet ASTM C 936:

*“Standard Specification for Solid Concrete Interlocking Paving Units,”* (same as impermeable standard pavers):

- Minimum Compressive Strength = 8,000 psi
- Maximum Absorption = 5%
- Freeze-thaw durability per ASTM C 1645
- Aspect ratio (length:thickness) guidelines apply -
  - 4:1 pedestrian only
  - 3:1 to 4:1 for residential driveways
  - 3:1 or less for all vehicular areas

# Typical Paver Shapes for PICP

Drainage joints



Drainage 'features' or shape



# PICP Aggregates

Free-draining (open graded) aggregates comply with the requirements of ASTM D 448:

- Paver Joint fill
  - *No. 8* aggregate, (#16 to 1/2" sieve)
- Bedding course
  - *No. 8* aggregate, (#16 to 1/2" sieve)
- Base material
  - *No. 57* aggregate, (#8 to 1-1/2" sieve)
- Subbase material
  - *No. 2* stone, (3" to 3/4" sieve)

# PICP Aggregates

In addition to gradation requirements:

- Crushed stone
  - *90% fractured faces*
  - *Do not use rounded river rock!*
- Hard, durable material
  - *LA Abrasion < 40 per ASTM C131, min. CBR of 80% per ASTM D1883*
- No fines
  - *Less than 2% passing the #200 sieve*

# PICP Aggregates

When project conditions require, or when recommended aggregates are not available:

**Table 3-5. Filter criteria for PICP bedding, base and subbase aggregates**

Permeability	$D_{15} \text{ Base} / D_{15} \text{ Bedding layer} > 5$
Choke	$D_{50} \text{ Base} / D_{50} \text{ Bedding layer} < 25$
	$D_{15} \text{ Base} / D_{85} \text{ Bedding layer} < 5$

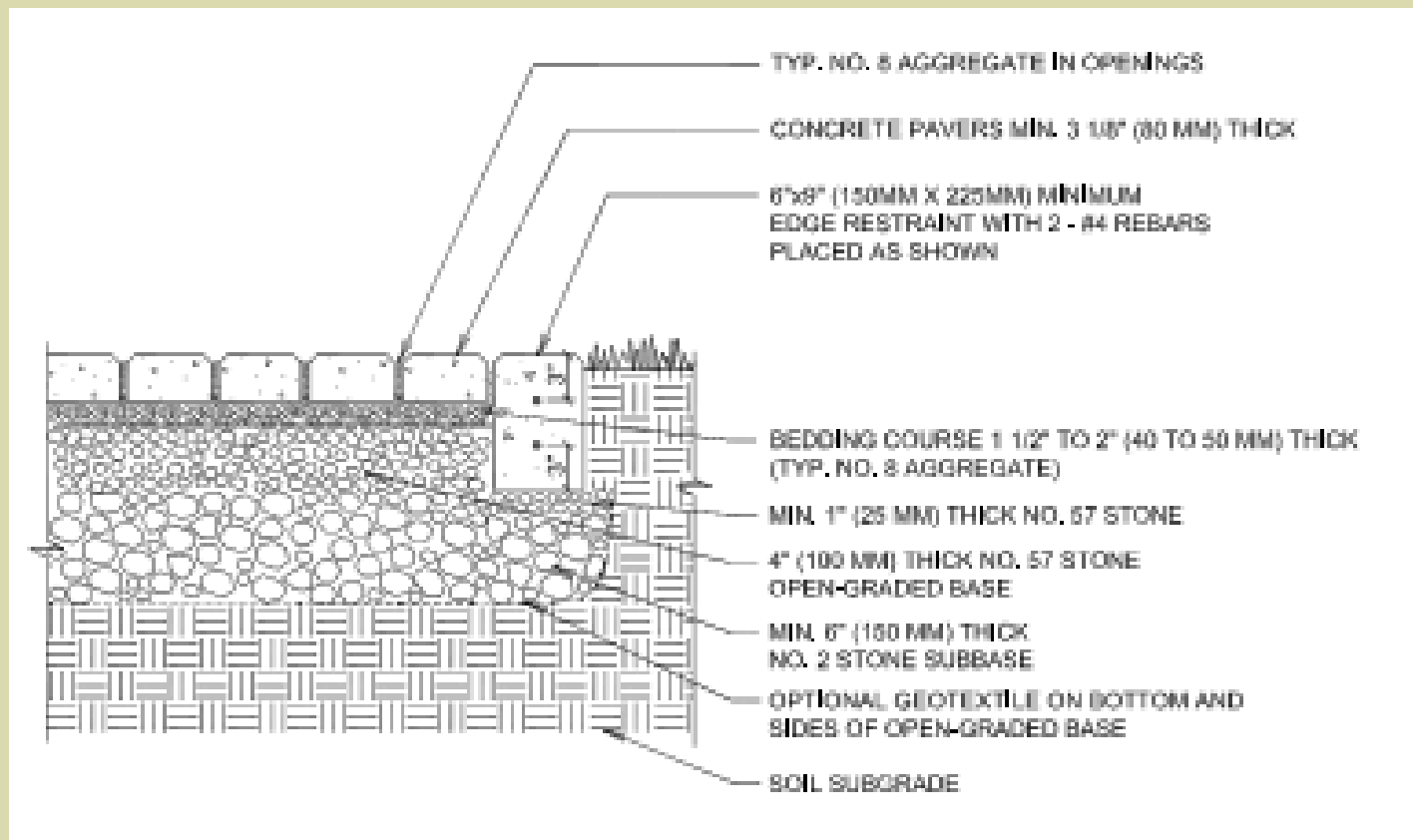
Permeability	$D_{15} \text{ Subbase} / D_{15} \text{ Base} > 5$
Choke	$D_{50} \text{ Subbase} / D_{50} \text{ Base} < 25$
	$D_{15} \text{ Subbase} / D_{85} \text{ Base} < 5$

Source: David R. Smith, *Permeable Interlocking Concrete Pavements*, 4<sup>th</sup> edition, pg. 41



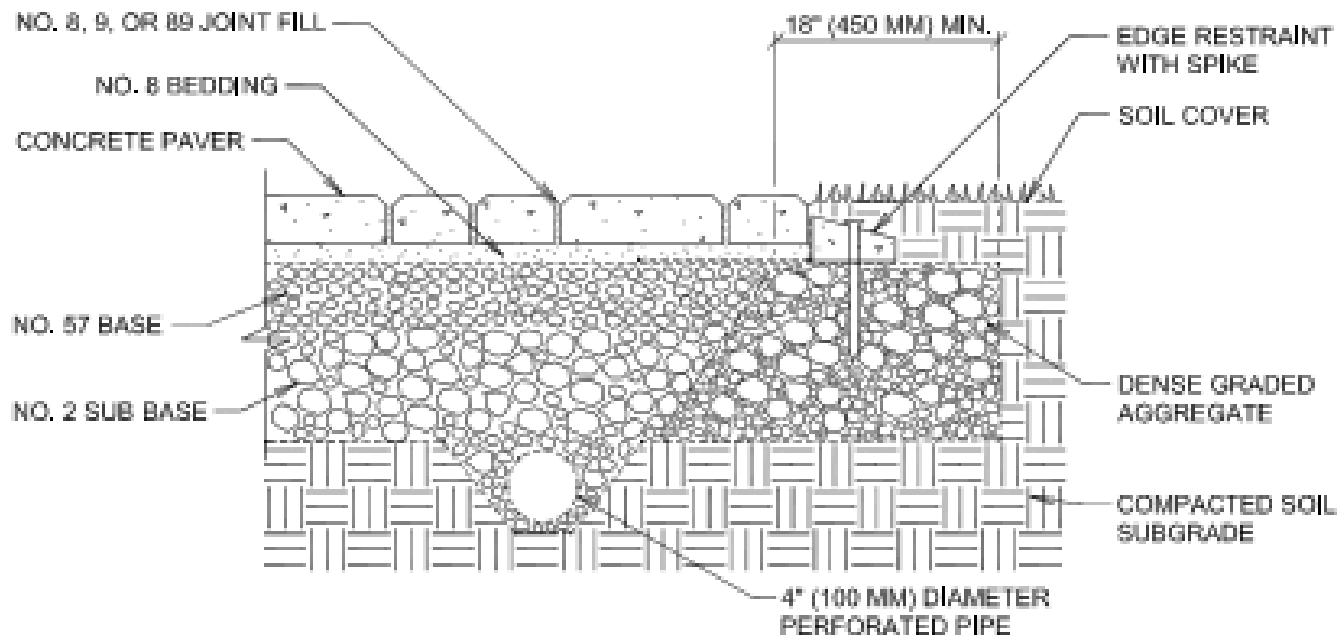
# PICP Edge Restraints

- Suitable for loading conditions
  - Typically concrete (all commercial applications)



# PICP Edge Restraints

Plastic & metal “staked” edging is suitable for residential applications. Use dense graded base under edging only:



# Geotextiles

- Option of the design engineer
- Non-woven recommended (high water flow)
- AASHTO M-288 provides minimum requirements
- AOS selection criteria in PICP manual
- Or use manufacturer's recommendations
- Place on sides & bottom
- Minimum overlap 12 in. (0.3 m)
- Poor soils overlap 24 in. (0.6 m)
- AASHTO M-288
  - Tables 1 & 2: Strength & Subsurface Drainage Geotextile Requirements

# Geolon® HP-Series Woven Polypropylene Geotextiles

## for Stabilization and Soil Reinforcement Applications

*Mirafi® Construction Products offers a wide range of woven geotextiles for stabilization and soil reinforcement applications. These geotextiles are cost-effective reinforcement elements which improve and enhance modern construction techniques in a variety of civil engineering applications.*

### PRODUCT DESCRIPTION

Geolon® HP-Series products are woven geotextiles comprised of high tenacity polypropylene yarns. HP-Series Woven Polypropylene Geotextiles yield ultimate tensile strengths up to 300kN/m (20559 lbs/ft) (machine direction) per ASTM D 4595. Geolon® HP-Series products combine the properties of high tensile strength and modulus and high confinement with their ability to act as a filter and separator.

### FEATURES AND BENEFITS

- **Strength.** Higher tensile strength at 2% and 5% than any comparable stabilization product.
- **Flow.** Uniform openings provide the same filtration and flow characteristics as that of a fine to coarse sand layer.
- **Soil Interaction.** Excellent soil confinement resulting in greater load distribution.
- **Seams.** Panels can be sewn together in

the factory or field, providing cross-roll direction strength to facilitate installation and providing reinforcement strength.

- **Cost.** Woven reinforcement geotextiles provide low cost tensile strength for reinforced soil structures.

### APPLICATIONS

Because of their flexibility and versatility, woven geotextiles are used in a variety of applications, including embankments on soft foundations, retaining walls, steepened slopes, and soil stabilization for road and rail construction. Environmental applications include liner support, voids bridging, and reinforcement over soft, hazardous pond closures. For any application where long term design of earth reinforcement structures are involved, Geolon® HP-Series Woven Polypropylene Geotextiles are a logical choice.

### INSTALLATION GUIDELINES\*

#### Site Preparation

Many conditions affect the degree of site preparation required to provide a working surface compatible with the selected geotextile including:

- Foundation subgrade strength and its

relation to equipment mobility;

- The presence of a vegetative root mat;
- The need for removal of large trees or other obstacles.

Direct placement of the geotextile on the prepared site is usually preferable. Generally, it is advisable to leave vegetative cover such as grass and weeds in place to provide a support matting for construction activities.

#### Geotextile Fabrication and Placement Procedures

Placement of geotextiles can be labor intensive process. This time consuming procedure can be simplified by prefabricating geotextile panels before field placement and using experienced field installation and sewing crews.

Installation of the geotextile must conform to the lines and grades as drawn by the engineer. This may require large roll or panel placement, using manual positioning or equipment-assisted deployment.

\* These guidelines serve as a general basis for installation. Detailed instructions are available from your Mirafi representative.



Geolon® HP-Series Polypropylene Woven Geotextile



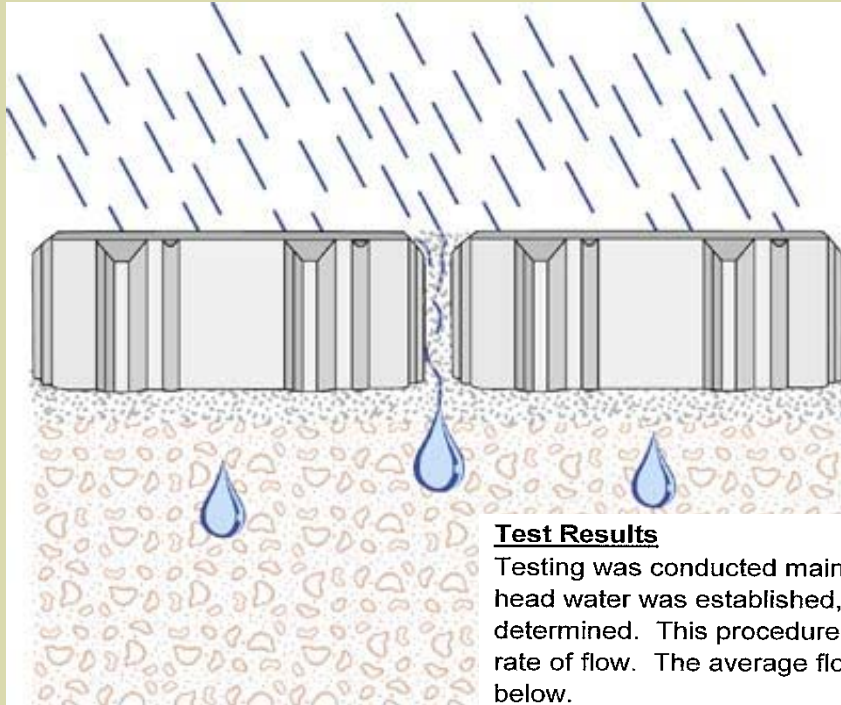
Geolon® HP-Series Geotextile used in pond closure application





Geotextile (optional)

# Surface Infiltration Rates



**Uni Eco-Priora® pavers**

**8 x 8 (200X200mm)**

**3/8" (10mm) Joint**

**Infiltration Rate > 15 in/hr  
after 10 years**

## Test Results

Testing was conducted maintaining three levels of head water above the pavers. The level of head water was established, maintained for a minimum of 30 seconds, and the rate of flow was determined. This procedure was performed multiple times at each level to verify a consistent rate of flow. The average flow rate at each level was determined and is reported in the table below.

Head Water (Inches)	Rate of Flow (Inches per Hour)
0.5	105
1.0	140
2.0	161



Mark L. McKay, P.E.  
Senior Geotechnical Engineer

# PICP Design Basics: Exfiltration Options

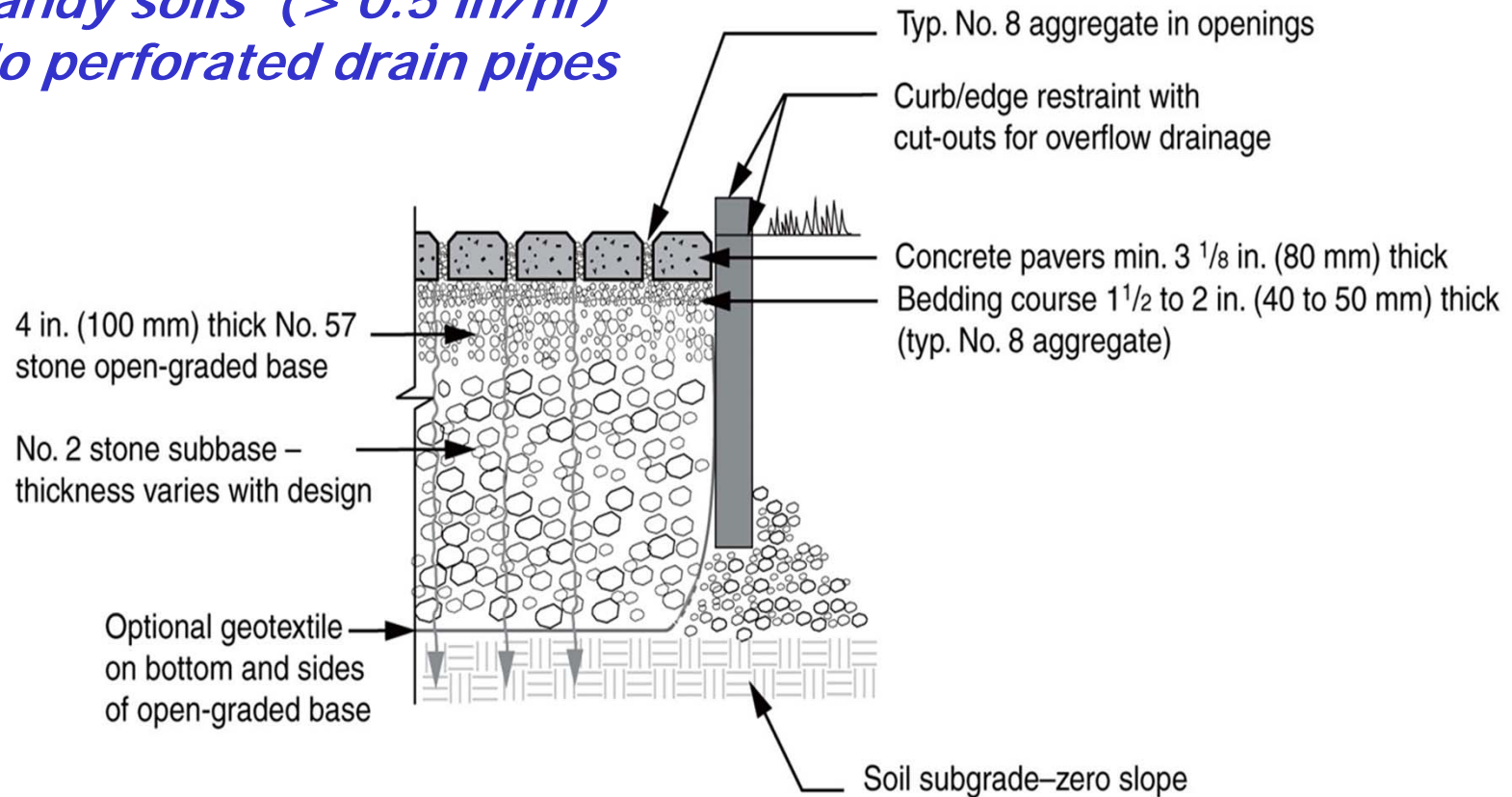
- *Full Exfiltration*
- *Partial Exfiltration*
- *No Exfiltration*



## PICP Design Basics: Exfiltration Options

### *Full Exfiltration*

*Sandy soils (> 0.5 in/hr)  
No perforated drain pipes*





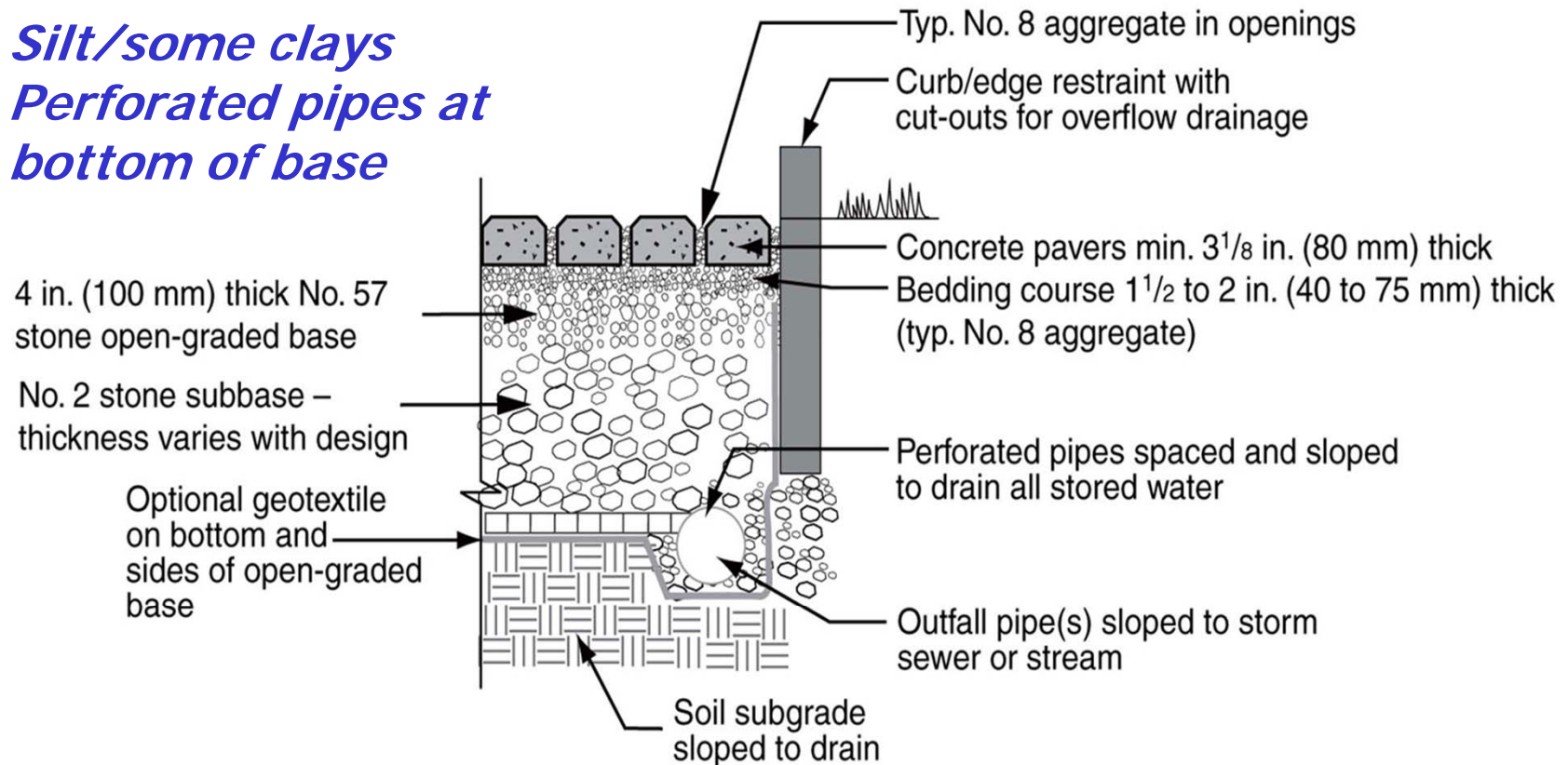




## PICP Design Basics: Exfiltration Options

### ***Partial Exfiltration*** - detention & exfiltration

***Silt/some clays***  
***Perforated pipes at***  
***bottom of base***





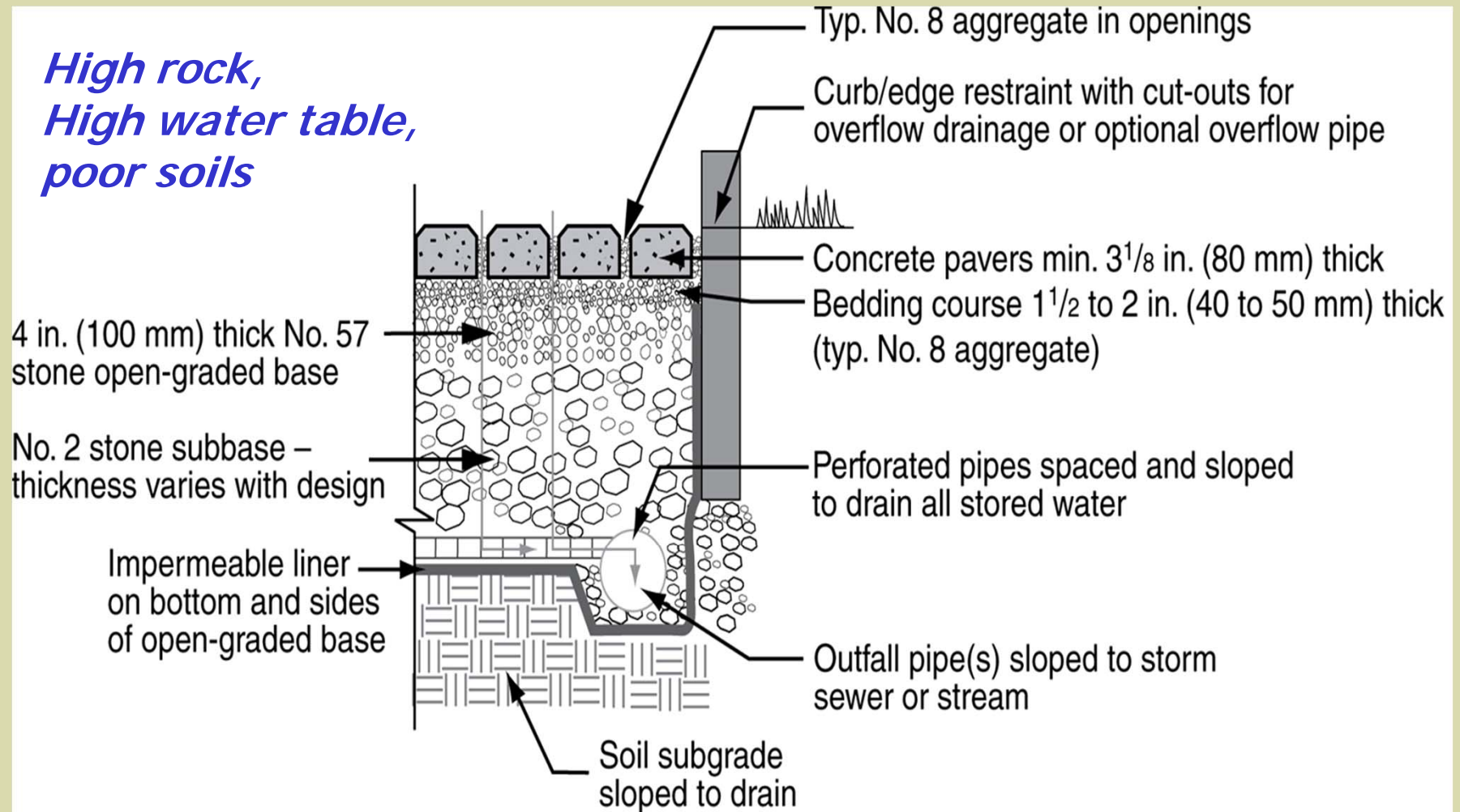




## PICP Design Basics: Exfiltration Options

### ***No Exfiltration*** - detention only

*High rock,  
High water table,  
poor soils*











**Impermeable EPDM (or equivalent) liner**

## Use 'No Exfiltration' design when....

- Near water supply wells (100 ft)
- High water table (3 ft)
- High depth of bedrock
- Some fills & expansive soils
- Contain potential contaminants from entering soils & groundwater
- Rainwater harvesting

# PICP Installation

- During excavation, do not compact native soil
- Compacted soil is 30 to 90% ***less*** permeable than un-compacted soil





Keep delivery trucks off of native soil, if at all possible

## Spreading Base Material – “back-dumping”







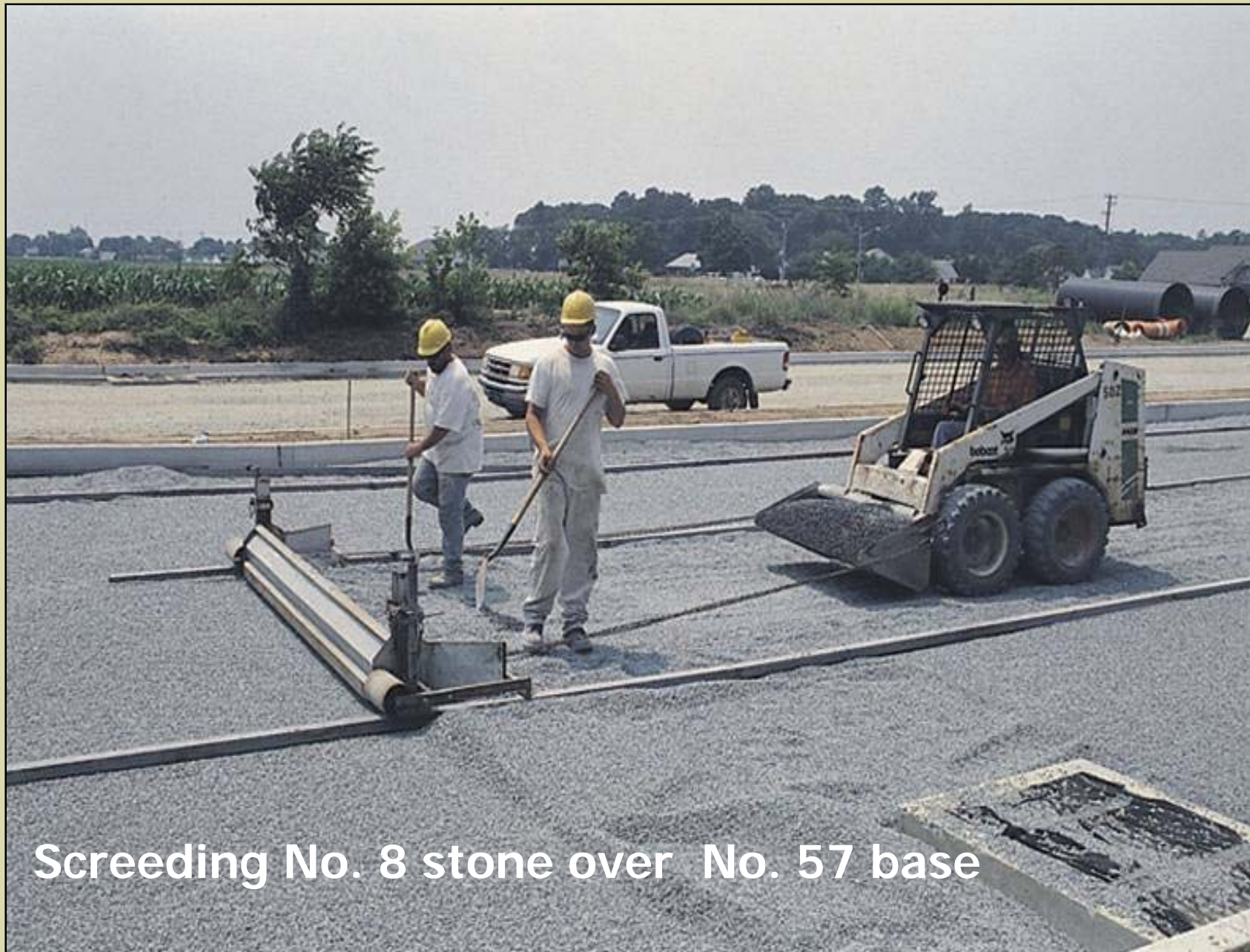
Final grading of base material





Compacting base material





Screeding No. 8 stone over No. 57 base





# Mechanical Installation

Mechanical installation of PICP can decrease construction time 20-80% over manual installation

***Manual paver installation:***

**approx 1,000 sq. ft. per man per day**

***Mechanical paver installation:***

**3,000 – 10,000 sq. ft. per machine per day**



**Edge pavers  
cut and  
placed,  
then  
compacted**





**Compact before sweeping in aggregate**







**Filling the openings with No. 8  
stone, final compaction**



Excess stones removed,  
then final compaction





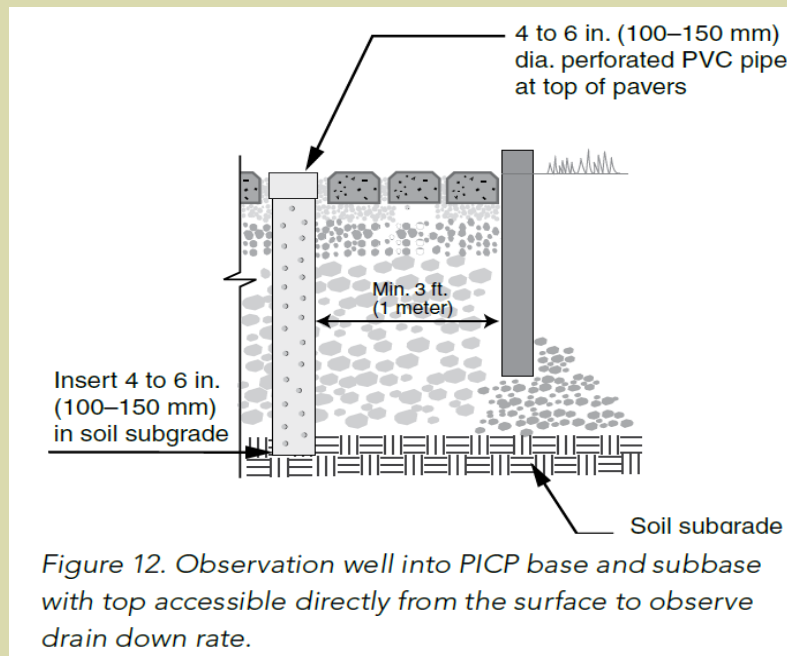


**Keeping sediment**  
**away from**  
**the pavers**



# Observation well:

- Install at lowest point of pavement
- Min. 6 in. dia. perf. pipe w/cap
- Monitor drainage rate, sediment, water quality, temperature



# Maintenance

**Annually: overall system performance inspection,  
check observation well , inspect after major  
storm, vacuum surface (once, twice, or more)  
to ensure optimum design life performance**

**Maintenance checklist (specific to each project)**

**Model maintenance agreement**

**Monitor adjacent uses**



# PICP Inspection Checklist

Vacuum surface	<i>1 to 2 times annually, adjust for sediment loading</i>
Replenish aggregate in joints	<i>As needed</i>
Inspect vegetation around PICP perimeter for cover & stability	<i>Annually, repair/replant as needed</i>
Check drain outfalls for free flow of water and outflow from observation well	<i>Annually and/or after a major storm event</i>



# PICP Maintenance



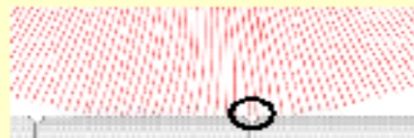
## Sweeper Effectiveness

**Best: Vacuum sweeper  
(no water)**

**OK: Regenerative air  
(broom) sweeper  
(no water)**

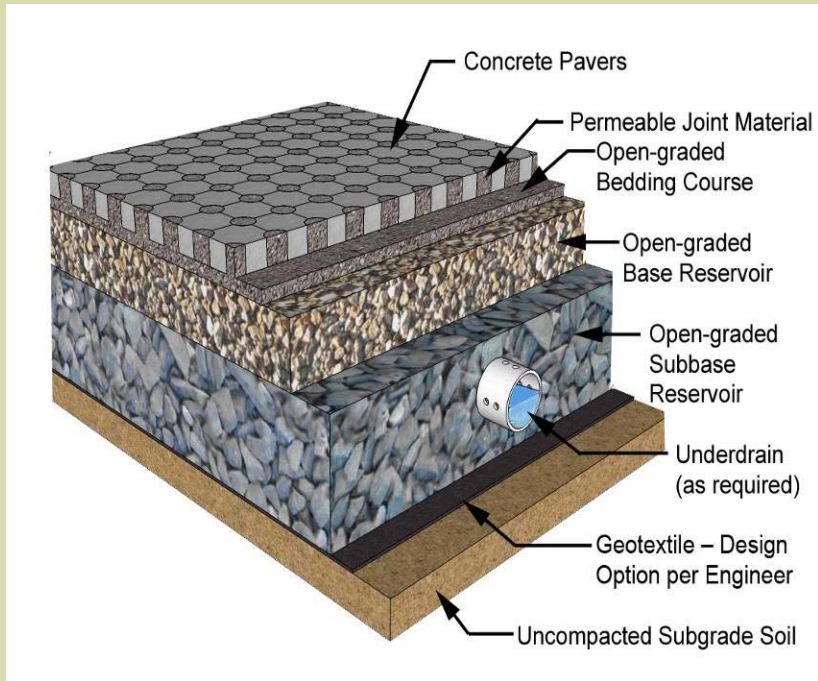


**Vacuum essential as brush  
bristles clean ~ 1/4 in. into surface**



# Maintenance





# Cost

**Furnished and Installed:**  
**\$5.80 to \$14.25 *per sq ft***

## **Includes:**

- Pavers placed, cut, compacted, & swept-**
- 2" of ASTM #8 Bedding Aggregate-**
- 4" of ASTM #57 Base Aggregate**



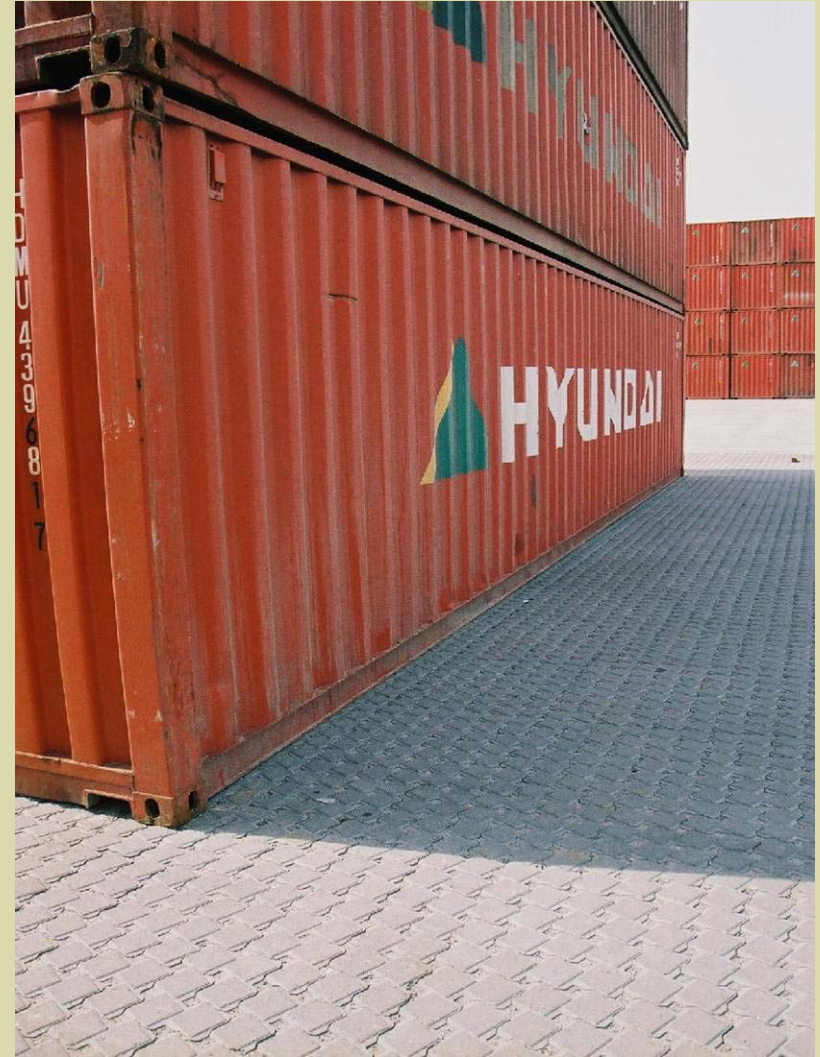
# **Case Studies & Project Profiles**

# JORDAN COVE URBAN WATERSHED STUDY





# Port of New York and New Jersey







# Tacoma Community College











10/01/2004









**Snoqualmie Fire Station**





**Mercer Island, WA**





**Mercer Island, WA**





**Mercer Island, WA**



## Woodinville Condos





## Lynwood Residence







**Medina Development in Spanaway**



**Medina Development in Spanaway**





**The Bridge Tacoma, WA**

## Lowes / Safeway in Lacey, WA





## City of La Center, WA



## City of La Center, WA





## Marysville, WA Park & Ride



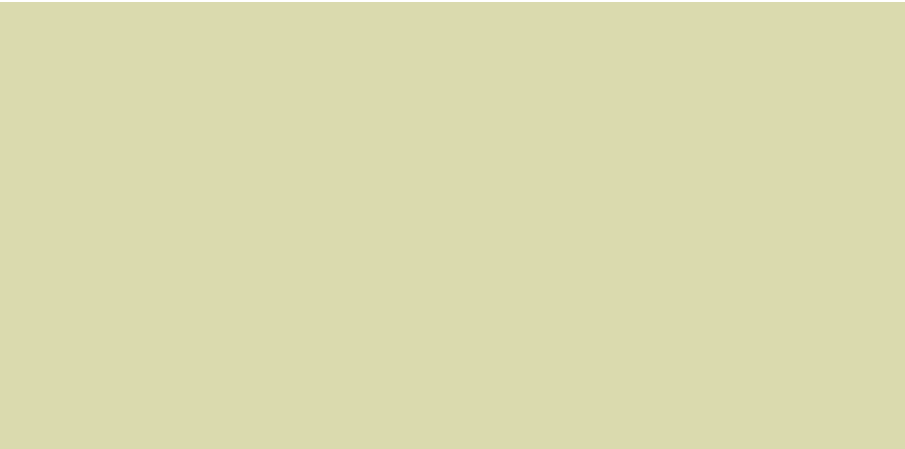








**Railway Museum Restoration, Snoqualmie, WA**



**Holbrook Ave    Everett, WA**





**Westlake Union**





**Tacoma Landfill Pervious Pave Demo**





**Mutual Materials Branch, Vancouver, WA**



**Pediatric Dental Clinic, Bellingham, WA**





**Railroad Avenue, Bellingham, WA**





**Vineyard Lanes, Bainbridge Island**





**River Front Trail Puyallup, WA**





**Highpoint Development W. Seattle**





**South Lake Union Street Car Facility**





**West Seattle Mix Use Building**





**Columbia City Live Above, Seattle, WA**



**Union Station, Marysville, WA**





03/07/2005



**Twin County Credit Union, Lacey, WA**





**Wastewater Treatment Plant, Winlock, WA**





**Prairie Line Trail, Yelm, WA**

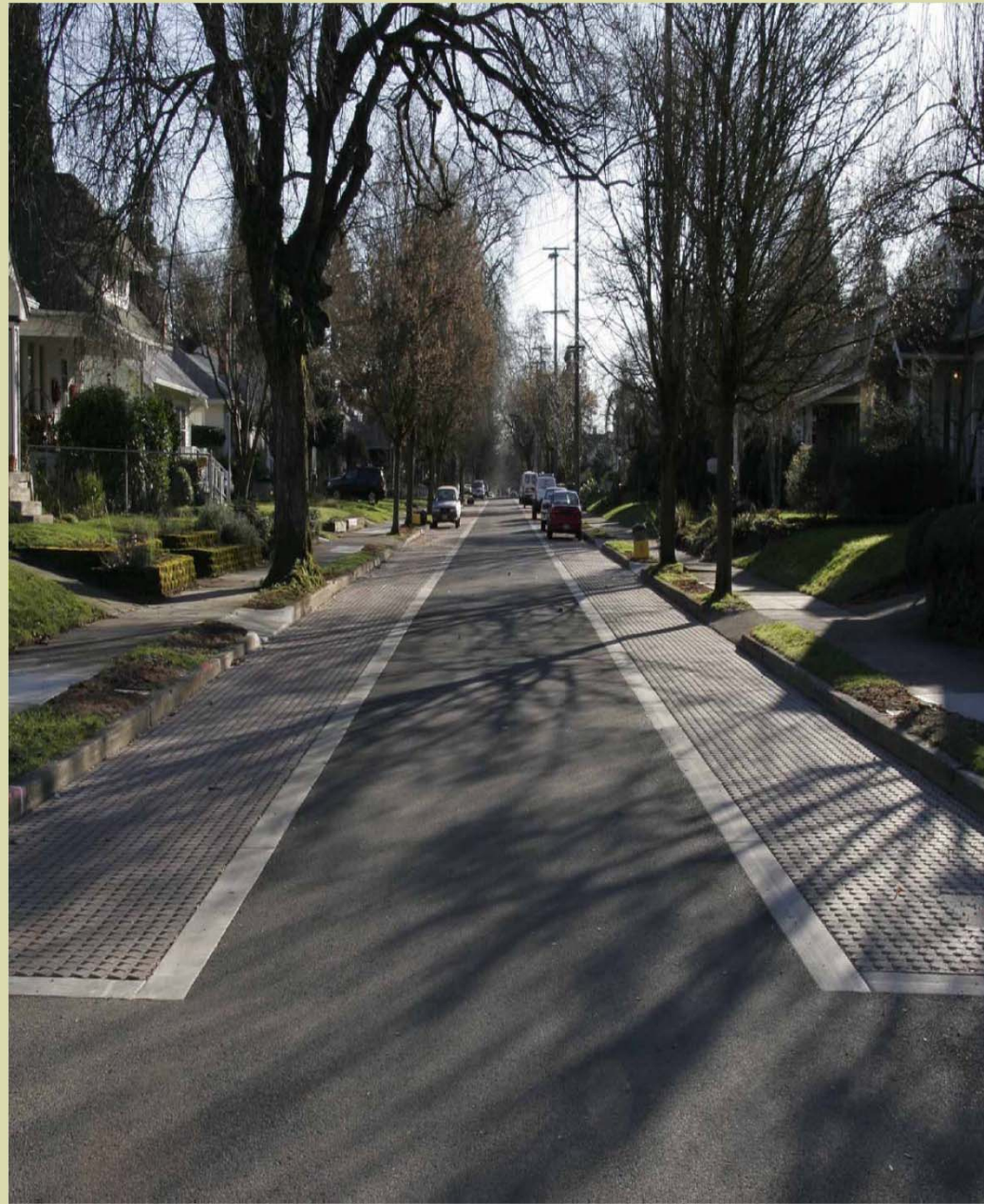




**Wedge Park Fife, WA**













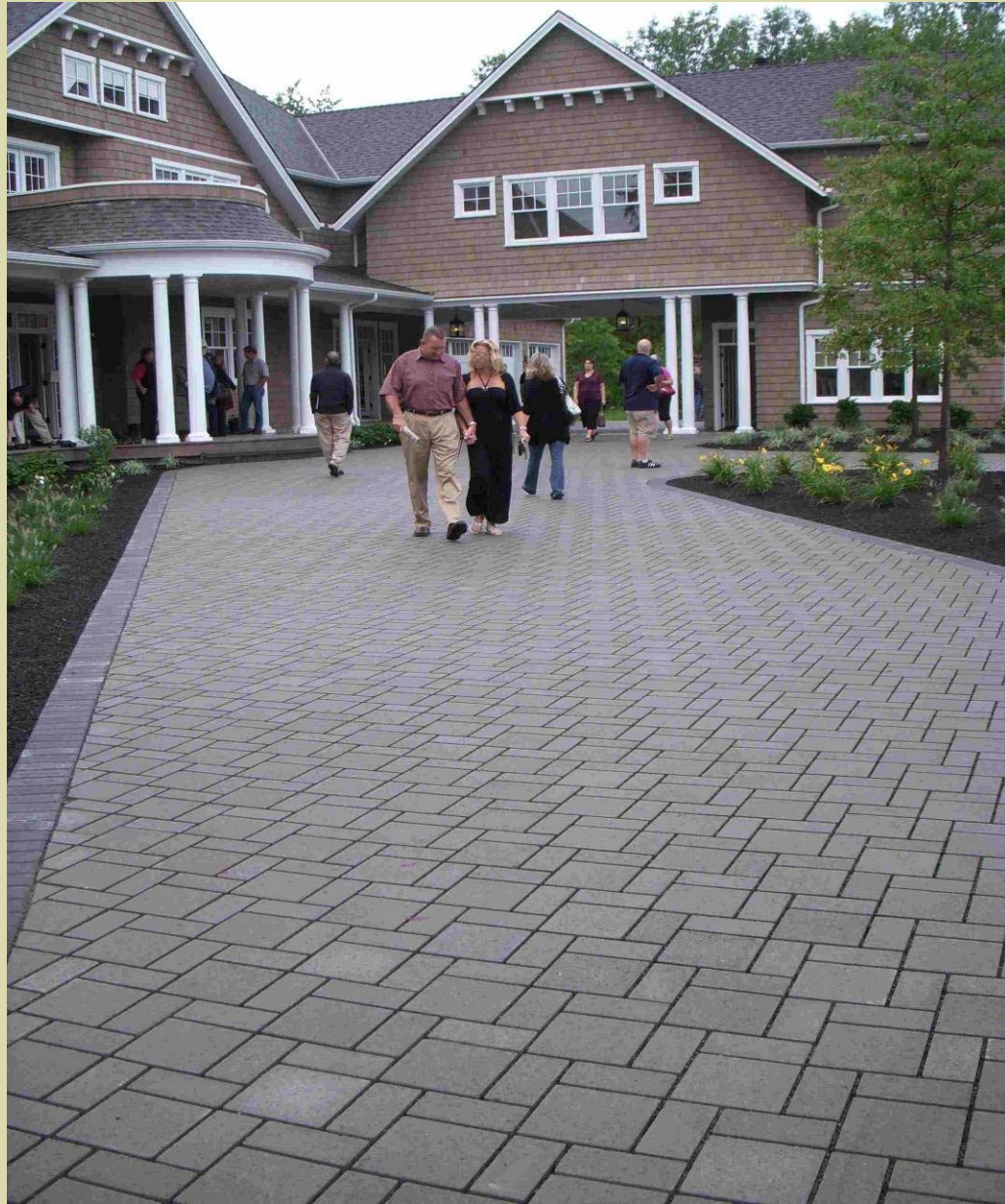




























**Thank you!**

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