

Center for Watershed Protection Watershed & Stormwater Management Webcast Series



## Webcast 3: Permeable Pavement

Center for Watershed Protection ICPI INTERLOCKING CONCRETE PAVEMENT INSTITUTE Ecological Paver Systems WAPT TALEGALE STORMWATER NETWORK

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## Welcome to the Webcast

- **To Ask a Question** – The lower left-hand corner of the screen contains a chat box. Click on the “Public” tab and type your question in the box and click on the arrow to submit it. We will try to answer as many questions as possible during the webcast.
- **To Answer a Poll Question** – Polling questions will appear throughout the webcast. To answer a poll question, click on the radio button to the left of your answer and click submit. Do not type your answer in the chat box.
- **To Adjust How the Slides Appear on Your Screen** – On the top of your screen, click on the small down arrow next to the button that looks like . Scroll down to “Zoom” and click on “Auto Fit.”

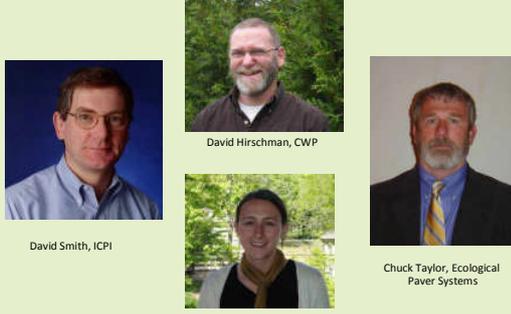
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- **To Complete the Webcast Survey** – After the webcast, we will have a short multiple choice survey to get feedback on your experience. Please take a few minutes to fill the survey out so we can identify areas for improvement.
- **Continuing Education Credits** – We are offering CEUs for our watershed and stormwater management webcast series. A total of 1.0 CEU can be earned for attending five webcasts. Only the registered attendee is eligible to earn the CEU. The registered attendee must watch the entire webcast. Email [webcast@cwpp.org](mailto:webcast@cwpp.org) if you are interested in earning CEUs and did not indicate this during the registration process. Two PDUs are also available for certified professionals (CPESC, CPSWQ) for this webcast.
- **Resources** – After the webcast, we will email a resources sheet, speaker contact information, and the presentation.

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## Webcast Team



David Smith, ICPI

David Hirschman, CWP

Kelly Collins, CWP

Chuck Taylor, Ecological Paver Systems

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## Webcast Overview

- Permeable Pavement Applications
- Innovative Designs and Industry Advancements
- Installation and Maintenance
- Lessons Learned About Permeable Pavement
  - Runoff Reduction & Pollutant Removal
  - Infiltration & Underdrains
  - Clogging
  - Cold & Dry Climates

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## Permeable Pavement Overview and Applications

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## Permeable Pavements

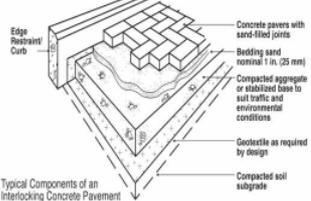


- Permeable Interlocking Concrete Pavers (PICP)
- Pervious Concrete (PC)
- Porous Asphalt (PA)
- Concrete Grid Pavers (CGP)
- Plastic Reinforced Grid Pavers
- Others (XeriPave, Flexi-Pave)

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## Interlocking Concrete Pavement

### Differences between standard Pavements and Permeable?



Typical Components of an Interlocking Concrete Pavement



**Permeable Interlocking Concrete Pavement PICP**

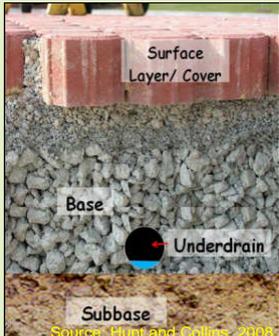
**Pervious concrete**

**Porous asphalt**

Slide courtesy of David Smith, ICPI

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## Pavement Sizing and Design



- The depth of the stone reservoir layer (base) is set by several factors:
  - Structural load requirements
  - Underlying soil infiltration rate
  - Maximum drain time
  - Design storms stored or infiltrated
- Will likely fail if not adequately designed for structural loads
- Cross-section specifications different for each kind of pavement

Source: Hout and Pollock, 2008

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## Micro Scale Applications

Surface Area/Contributing Drainage Area = 250 to 1,000 square feet



Walkways, Courtyards

Individual Driveway

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## Small Scale Applications

Surface Area/Contributing Drainage Area = 1,000 to 10,000 square feet



Parking Stalls

Overflow Parking

Small Parking Lots

Road Shoulders, Fire Lanes

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## Large Scale Applications

Surface Area/Contributing Drainage Area > 10,000 square feet



Large Parking Lots

Residential Streets

Photos courtesy of David Smith, ICPI

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## Infiltration and Underdrain Designs

Source: Hunt and Collins, 2008

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## Detailed Peer-Reviewed Design Specification for Permeable Pavement Available at

<http://www.vwrrc.vt.edu/SWC/NonProprietary/BMPs.html>  
(Scroll Down > Permeable Pavement PDF)

- Design Guidelines
- General Hydrologic Sizing Equations
- Construction Specifications

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## Design Considerations

- Underlying soil infiltration rates (underdrain?)
- Limit CDA to nearly 100% impervious cover
- If pervious areas are conveyed to practice, must provide pre-treatment
- Any external drainage area to permeable pavement surface area should not exceed 5:1 ratio, 2:1 recommended
- Design on flat slopes
- 2 foot separation from water table

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## Q & A

Follow-Up Questions: [webcast@cwpp.org](mailto:webcast@cwpp.org)

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## Innovative Designs and Industry Advancements

David Smith, P.E.  
Interlocking Concrete Pavement Institute (ICPI)

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## PICP Overview

### High Profile Projects....

- Green/livable streets
- Green Streets & Alleys for CSO reduction
- Air Pollution Reduction
- Building Energy Enhancement
- ICPI Resources



Warrenville, IL



Ferdinand Street, Chicago, IL



US Cellular Field  
Chicago, IL

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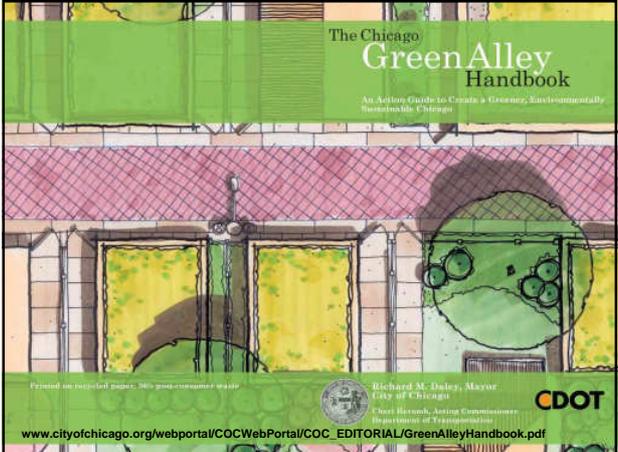


**Chicago Green Alleys Program For CSO Reduction**

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The Chicago Green Alley Handbook  
An Action Guide to Create a Greener, Environmentally Sustainable Chicago



Printed on recycled paper, 50% post-consumer waste

Richard M. Daley, Mayor  
City of Chicago  
Cheri Hirsch, Acting Commissioner  
Department of Transportation

CDOT

[www.cityofchicago.org/webportal/COCWebPortal/COC\\_EDITORIAL/GreenAlleyHandbook.pdf](http://www.cityofchicago.org/webportal/COCWebPortal/COC_EDITORIAL/GreenAlleyHandbook.pdf)

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## Richmond, VA Green Alley Project

5th Street

12th Street

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5th Street Alley

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## Antwerp, Belgium 100,000 sf parking TiO<sub>2</sub> coated pavers

Largest NO<sub>x</sub> reductions on calm, warm days, no wind

**Smog Eaters**

THE ITALIAN CENTERS of Cagliari, Sassari and Selargius plan this month to begin laying a new sidewalk brick that eats smog. The bricks are made with a titanium-dioxide blend that, when exposed to light, turns carbon monoxide (smog) in the air into water and carbon dioxide—the gas in soda pop. Rossano Amandelli, who led tests for the Italian National Research Council, says he was “stunned” by how well the tiles work. Cost: \$24 a square meter, 46 percent more than conventional bricks.

—BENJAMIN EUTENEIER

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## Air Quality Pre-Data Collection in Chicago

Data Points Include: NO, NO<sub>2</sub>, NO<sub>x</sub>, Wind Speed, UV

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## Chicago Park District Mary Bartelme Park PICP with Photocatalytic TiO<sub>2</sub> Cement Coating

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## Criteria for Chicago's Public Right of Way

Green Alley Standards Manual

Using research data to establish a Chicago Standard for sustainable infrastructure in the public right of way

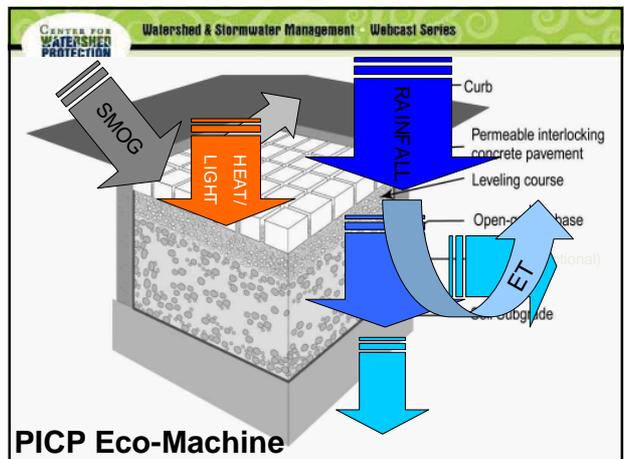
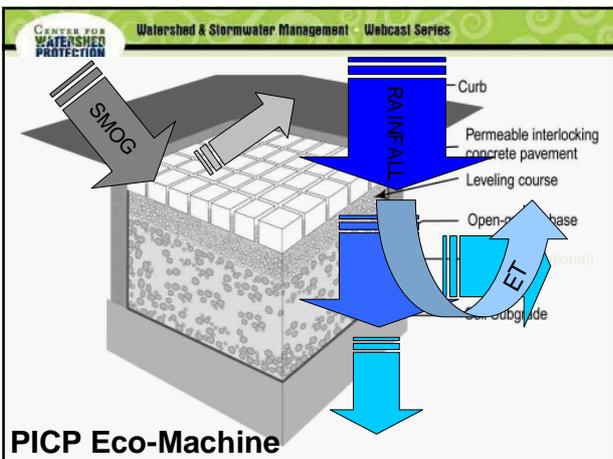
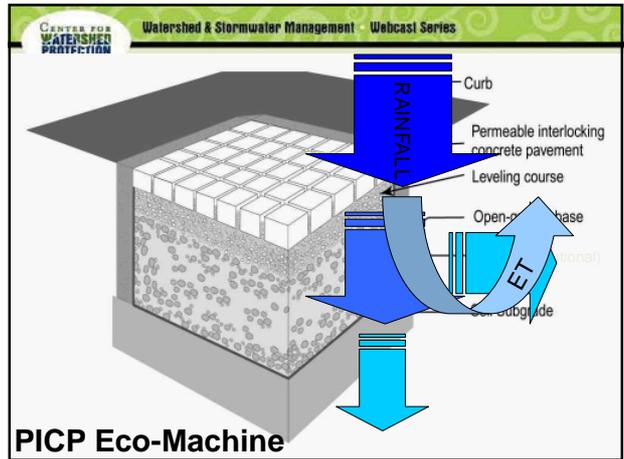
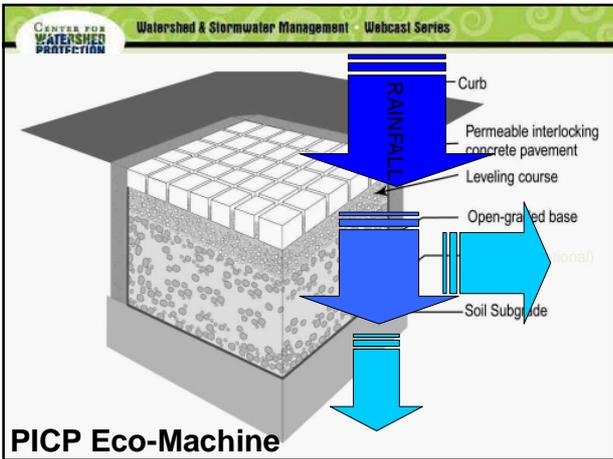
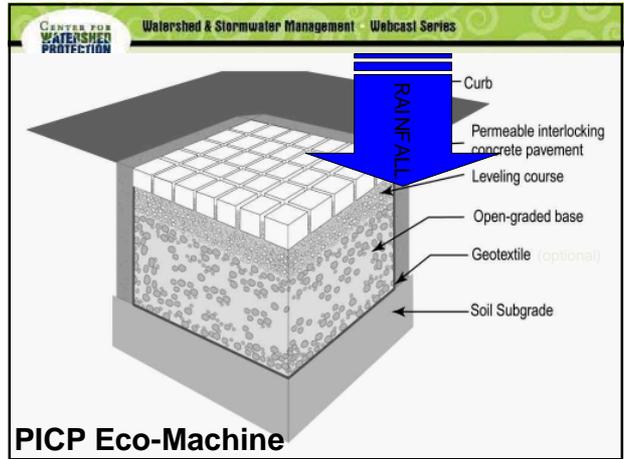
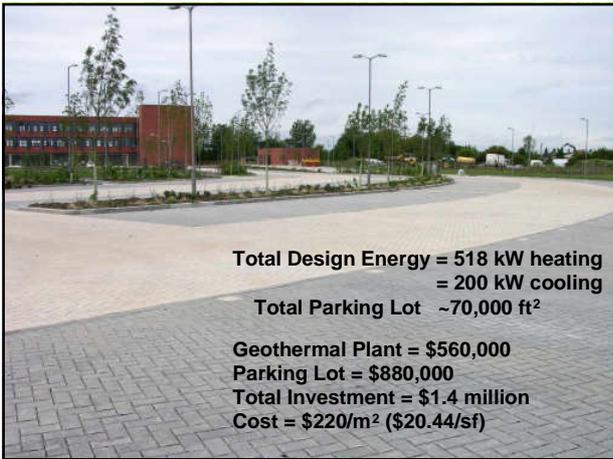
Criteria	Applicability/Exclusions	Data Collection Measurement
Soil Permeability	Applicability of this criteria is based on the soil type. This criteria should be used when the soil is not a clay or silty clay soil.	Soil Permeability Test
Pavement Structure	Green Alley should not be installed on asphalt or concrete pavement.	Soil Permeability Test
Appearance	Appropriate products must be used to meet appearance requirements.	Visual Inspection
Drainage Conditions	Proper drainage design is required to prevent water from pooling on the pavement.	Visual Inspection
Pavement Condition	Pavement should be in good condition and not require repair.	Visual Inspection
Pavement Slope	Pavement cover should be installed on a slope of 1% or greater.	Visual Inspection
Pavement Performance	Pavement should be installed in a location of high traffic volume.	Visual Inspection

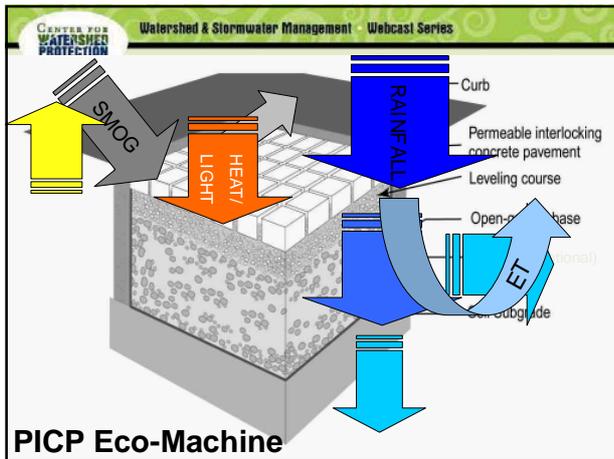
Permeability	Installation Rate (per sq ft)	Installation Rate (per sq ft)	Description and Soil Stability Classification
High	1.00	1.00	Good infiltration capacity.
Medium	0.50	0.50	Medium infiltration capacity. Required for projects with low infiltration.
Low	0.25	0.25	Unsuitable required.

© United States Department of Agriculture in-kind consultation.

**PICP Parking Lot in England with  
Horizontal Ground Source Heating**







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## PICP Resources from icpi.org

This slide features a collage of resources available from icpi.org. On the left is the 'Permeable Interlocking Concrete Pavements Design Manual'. In the center are 'PICP Fact Sheets'. On the right is the 'Trainer Certification Course' and the 'ICPI Installer Technician Certificate Course'. The ICPI logo is also present.

ICPI INTERLOCKING CONCRETE PAVEMENT INSTITUTE www.icpi.org

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**Design Tools**  
 ICPI's technical and educational resources provide design professionals with the latest design insights and technical developments on interlocking concrete pavement and permeable interlocking concrete pavement. As an ICPI member, you will receive timely updates on new publications, trends and industry news through subscription to the Interlocking Concrete Pavement Magazine and ICPI Design Professional Update. Visit our comprehensive Membership area and learn how ICPI can improve your business.

**Be Inspired**  
 Browse our Idea Gallery for design solutions that meet your project's needs.

Commercial Industrial Municipal Residential

**LEED®**  
 United States | Canada  
 Developed by the U.S. Green Building Council (USGBC) in 1998, LEED® is a voluntary system of design for buildings and sites that provides a rating system which encourages the use of technologies that reduce energy and conserve non renewable resources.

**Sustainable Design**  
 Permeable Interlocking Concrete Pavements (PICP) meet LEED® credit requirements under Sustainable Sites. These requirements limit runoff and water pollution by managing stormwater. The pavements can

INDUSTRY PROFESSIONALS SAY  
 "From day one, the Board wanted a permeable lot, a view heightened by the long-term drought in the southeast which drastically lowered lake levels and threatened drinking water supplies. They

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## Q & A

Follow-Up Questions: [webcast@cwpp.org](mailto:webcast@cwpp.org)

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## Installation & Maintenance Tips

Chuck Taylor,  
Ecological Paver  
Systems

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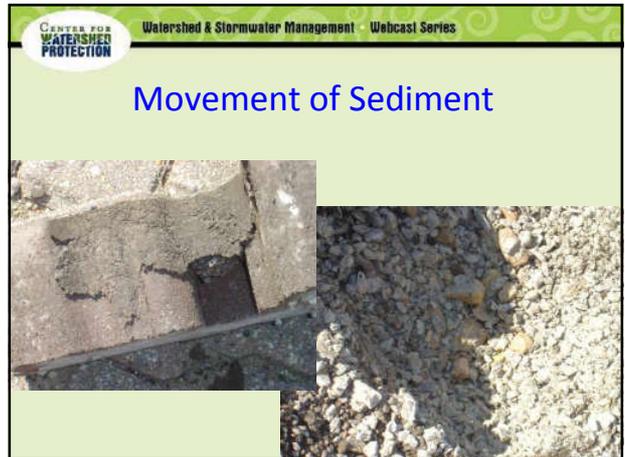
## Urban Myths

- Permeable pavement costs too much to build
- Permeable pavement costs too much to maintain
- Cannot clean permeable pavement when clogged
- Cannot use permeable pavement in heavy loaded areas-fire trucks, semi-trucks, garbage trucks, etc.
- Cannot use permeable pavements in cold climates
- Cannot build on clay soils

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ITEM	PICP	STANDARD CONCRETE	STANDARD ASPHALT
Paving/SF	\$ 2.25	\$ 8.00	\$ 3.00
Excavating/SF	\$ 1.00	\$ 1.00	\$ 1.00
Stone/SF	\$ 2.00	\$ 1.50	\$ 1.50
Installation/SF	\$ 4.00	(in paving cost)	\$ 1.50
Curbs	\$ 1.50	\$ 1.50	\$ 1.50
Maintenance	\$ 0.20		Not Know
Replacement	None	None	Every 12 Years
Detention/Retention required	None	Yes	Yes
Storm Sewer System/sf paving	None	\$ 3.00	\$ 3.00
Total/SF	\$ 10.95	\$ 14.00	\$ 11.50
Total/linear foot-municipal street	\$ 171.00	\$ 218.00	\$ 179.00
Total/linear ft for 30 ft wide street	<b>\$ 230.00</b>	<b>\$ 280.00</b>	<b>\$ 230.00</b>

Cost Comparison of Pavement Systems for Autumn Trails, Moline, Illinois as reported by George Bialecki, Jr., developer of Autumn Trails



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## Cold Weather

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## Maxwell Street Market Parking Plaza

**EPA Primary Research Questions**

- Runoff Volume and Rate
- Surface Water Quality
- Ground Water Quality
- Freeze/Thaw Performance

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## Market Plaza: Preliminary Monitoring Results

Temperature Data (Degrees Fahrenheit) from 1/16/09 (temp in degrees)

Air: -7.0  
Deep: 38.6  
Middle: 34.1  
Shallow: 33.4

Sept 2008- Feb 2009

Legend: Deep (red), Middle (green), Shallow (yellow), Air (blue)

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## Retention/Detention

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## Full exfiltration: no subsurface drain pipes

Overflow drains to inlet

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## Partial Ex-filtration

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### Impermeable Liner

Geo-textile protects Liner

**No Ex-filtration**  
Capture and Treat  
Possible Water Harvesting

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## Construction and Installation

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### Sub-Base

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### Curb Construction

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### Jefferson Farms

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### Elmhurst College Silver LEED

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## LID Streetscape-Low Maintenance

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## Do your existing designs work?

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## Engineered Ecological Paver Systems

**Sustainable solutions that Last**

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## Q & A

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## Permeable Pavement – Lessons Learned

Kelly Collins  
Center for Watershed Protection

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## Pollutant Removal

- High removal rates of heavy metals, oil, grease
- Ongoing studies to evaluate nutrient removal.
  - Nitrogen removal
    - Use of infiltration sump
    - Sand filter layers at subbase
  - Phosphorus removal
    - Some particulate-bound P filtered in surface
    - Use of admixtures in subbase

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## Runoff Reduction Rates

Permeable Pavement Design	Avg. Annual Runoff Reduction
Practices <b>with</b> Underdrains (N=6)	45%
Practices <b>without</b> Underdrains (N=8)	75%

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## Design in Clay Soils

- Pavement monitoring in impermeable soils (0.01 mm/hr permeability) has shown significant volume reductions
  - Storage and subsequent evaporation significant in small storms
  - Slow infiltration into subgrade
- Can be enhanced by using boreholes, ripping, or trenching within subgrade



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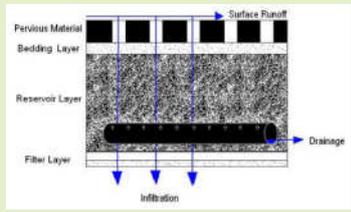
## Regulations and Modeling

- Curve Number Adjustments (MD, RI)
- Volume Reduction Credit (VA, TN)
- Impervious Cover Adjustment (NC)
- Modeling hydrology:
  - TR-55 methodology
  - HydroCAD, SWMM, Industry Models – ICPI Design Pro, NRMCA Model

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## Use of Geotextiles

- Can use along vertical sides of practice
- Avoid at practice bottom- Prone to clogging
- Alternative - Optional sand/pea gravel filter layer



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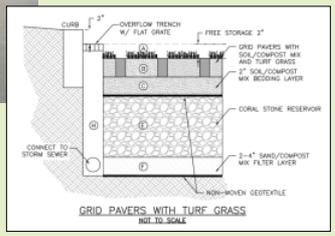
## Stormwater Hotspots and Karst Areas

- Avoid use at hotspots due to high risk of surface clogging
- If using in karst areas, use impermeable liner and underdrain



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## Island Adaptations

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## Construction

- Certified Installer Recommended
- Need to ensure:
  - Proper site stabilization and site preparation
  - Compaction of surface and reservoir layers
  - Proper mix ratios (PC, PA)
  - Proper mix and cure times (PC, PA)




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## Overall Design Guidelines

- Infiltration designs reduce more runoff than underdrain designs
- Stable CDA (~100% IC)
- Do not site near disturbed areas
- Needs based maintenance
- Maintenance agreements – required tasks and actions to be avoided

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## Take Home Points

- Permeable Pavements can be cost- and performance- effective BMPs for stormwater management
- Many recent innovations in design applications
- Need to ensure proper design, construction and maintenance to realize long-term performance benefits

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## Resources

- Speaker Contact Information
- Permeable Pavement Design, Installation & Maintenance Resources
- General Resources
- Selected Research

Resources Will Be Emailed After The Webcast

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## A Few More Questions

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- **Participation Certificate** – Participation certificates are also available. If you have multiple attendees, please save the certificate to your computer. You can type the attendees name in the name field and then print the certificate.

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## Webcast Archive

- We will make every effort to post the archive as quickly as possible. The archive should be available on the first Monday following the webcast, pending any edits.
- Registered participants will receive email instructions for accessing the archived webcast.
- The archive will be downloadable and can be saved on your local machine.

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## Upcoming Webcasts – for 2010

- **Rooftop Disconnection, Filter Strips & Rainwater Harvesting (October 20)**
- **Better Site Design Gets Better (December 15)**

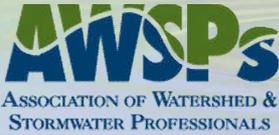
Register at <http://www.cwp.org/Webcasts>

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## Join the Association of Watershed and Stormwater Professionals (AWSPs) for an Introductory Membership Price of \$219.

Benefits include:

- Two issues of our journal (due out in Fall '10 and Spring '11)
- Substantial webcast discounts
- 50% discounts on publications
- Membership through August '11
- Subscription to our quarterly, e-newsletter, Runoff Rundown.



To register visit [www.cwp.org/awsp](http://www.cwp.org/awsp)

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## Speaker Contact Info

<p><b>David Smith, P.E.</b> Interlocking Concrete Pavement Institute (ICPI) 13921 Park Center Road, Suite 270 Herndon, VA 20171 USA 703-657-6900 x201 <a href="mailto:dsmith@cwpp.org">dsmith@cwpp.org</a> <a href="http://www.icpi.org">www.icpi.org</a></p>	<p><b>Chuck Taylor</b> Ecological Paver Systems 67 Stonehill Road Oswego, IL 630-608-1190 <a href="http://crt@ecologicalpaversystems.com">crt@ecologicalpaversystems.com</a></p>
<p><b>Kelly Collins, E.I.T.</b> Center for Watershed Protection 8390 Main Street, 2nd Floor Ellicott City, MD 21043 410-461-8323 <a href="mailto:kac@cwpp.org">kac@cwpp.org</a> <a href="http://www.cwp.org">www.cwp.org</a></p>	