Permeable Interlocking Concrete Pavement
A Low Impact Development Tool
Training for Developers

Presented by:
Interlocking Concrete Pavement Institute
The Low Impact Development Center, Inc.
North Carolina State University

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Learning objectives:
- Identify PICP Components
- Examine cost recovery by reduction/elimination of drainage facilities
- Understand the hydrological and structural design principles for the pavement base/subbase
- Understand basic construction & maintenance requirements of PICPs

Contents
- What is PICP?
- PICP Cost Example
- PICP Benefits
  - Sustainable Living
  - Infrastructure Cost Savings
  - Stormwater Management
  - Rapid Installation
  - Curb Appeal
  - LEED® Credits
  - ADA Compliant
- Designing PICP Systems
- Construction
- Maintenance
- PICP Resources
What is PICP?

- A solid interlocking paver system which allows water to drain through permeable joint material.
- A strong and durable paving system well suited for use in low traffic areas such as parking lots, parking bays on streets and low traffic speed streets.

System Components:
- Concrete Pavers
- Permeable Joint Material
- Open-graded Bedding Course
- Open-graded Base Reservoir
- Open-graded Subbase Reservoir
- Underdrain (As required)
- Optional Geotextile Under the Subbase
- Uncompacted Subgrade Soil
What is PICP?
Paver Types: Interlocking Shapes/Patterns

- Notched corners or sides
- Interlocking Shapes
- Built-In Concrete Joint Spacers
  - Enlarged Joints: up to ½ in. (15 mm)
- Porous block, not for freezing climates, use enlarged joints
Why use PICP?

- Reduce Development Costs
- Eliminate Stormwater Fees
- Eliminate Burden on Municipal System
- Increase Land Use – Detention / Retention
- Meet Municipal Pervious / Impervious Ratio
- Green and Sustainable Market Appeal
- Reduce Burden on Watersheds
- Reduce Burden on Municipal Water Quality
- Durable Material/ Lifecycle Cost

PICP Hydrology Example
Economic justification...
1 Acre PICP ~ $300,000 - $400,000

Detention (dry) pond ~ $40,000 - $110,000

Asphalt (3 in.) 1 acre parking lot ~ $200,000

1 acre land savings from PICP
Consider base as drainage cost

PICP: $7 – 10/sf

PICP System Cost Example
Autumn Trails, Moline, IL
### PICP System Cost Example

**Autumn Trails Plan View**

<table>
<thead>
<tr>
<th>PICP Cost Example</th>
<th>PICP</th>
<th>Concrete</th>
<th>Asphalt</th>
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<tbody>
<tr>
<td>Product / ft² (m²)</td>
<td>$2.25 (24.21)</td>
<td>$8.00 (86.08)</td>
<td>$3.00 (32.28)</td>
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<td>Excavating / ft² (m²)</td>
<td>$1.00 (10.76)</td>
<td>$1.00 (10.76)</td>
<td>$1.00 (10.76)</td>
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<td>Stone / ft² (m²)</td>
<td>$2.00 (21.52)</td>
<td>$1.50 (16.14)</td>
<td>$1.50 (16.14)</td>
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<tr>
<td>Install / ft² (m²)</td>
<td>$4.00 (43.04)</td>
<td>Included Above</td>
<td>$1.50 (16.14)</td>
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<tr>
<td>Curbs / ft² (m²)</td>
<td>$1.50 (16.14)</td>
<td>$1.50 (16.14)</td>
<td>$1.50 (16.14)</td>
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<tr>
<td>Maintenance / ft² (m²)</td>
<td>$0.20 (2.15)</td>
<td>None</td>
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<td>Stormwater System Required / ft² (m²)</td>
<td>None</td>
<td>$3.00 (32.28)</td>
<td>$3.00 (32.28)</td>
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<tr>
<td><strong>TOTAL/sf (m²)</strong></td>
<td>$10.95 (117.82)</td>
<td>$14.00 (161.40)</td>
<td>$11.50 (123.74)</td>
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</table>
PICP Benefits

Sustainable Living Green Infrastructure

Local Stormwater Regulations

Rapid Installation

Urban Heat Island & LEED

Infrastructure Cost Savings

Durable ADA Compliant Surface

Curb Appeal

Sustainable Living Green Infrastructure

Local Stormwater Regulations

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Curb Appeal
PICP Benefits
Sustainable Living & Green Infrastructure

Downstream Treatment Train. PICP overflows to grassy swale & rain garden Goldsboro, NC

Retrofit LID Project. Water quality & green infrastructure integration River Front Trails, Payallup, WA

PICP Benefits
Sustainable Living & Green Infrastructure

Chicago, IL & Portland, OR
• Reduced combined sewer overflows
• Less expensive than separating storm & sanitary sewers
• Supports tree growth
• Improves neighborhood character

Portland, OR

Chicago Green Alley, Chicago, IL
Two images above courtesy of Chicago DOT
PICP Integrated with LID: A Step Toward Sustainable Communities

- Stormwater management using natural systems
- Reduced urban heat Island with cooler pavements
- Improved neighborhood character

PICP Benefits

Sustainable Living & Green Infrastructure

- Rapid Installation
- Durable ADA Compliant Surface
- Local Stormwater Regulations
- Urban Heat Island & LEED
- Sustainable Living Green Infrastructure
- Infrastructure Cost Savings
- Curb Appeal
PICP Benefits
Infrastructure Cost Savings

Residential Subdivision:
Storm sewers eliminated.
Savannah, GA

PICP Benefits

Sustainable Living
Green Infrastructure

Infrastructure Cost Savings

Local Stormwater Regulations

Rapid Installation

Curb Appeal

Urban Heat Island &
LEED

Durable ADA
Compliant Surface
**PICP Benefits**

**Stormwater Regulations**

**Costs**
- Pipe Infrastructure
- Flooding Risk

**Benefits**
- Enhance development while meeting regulations
- Infrastructure Cost Savings
- Environmental Curb Appeal, Marketing Opportunity

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**PICP Benefits**

**Stormwater Regulations**

**Stormwater Management Objectives**

**Some Objectives:**
- Capture first flush, e.g., first ½ inch
- Retain/infiltrate increased volume & flows
- Control specific nutrients, metals
- Control amount of impervious cover
  - Stormwater utility fee
- Imitate pre-development conditions
- Zero discharge – no sewer capacity
PICP Benefits
Stormwater Regulations

Stormwater Management Objectives

...Varies with locality...

Water Quantity
- Retain/infiltrate runoff volumes & peak flows
- Imitate pre-development conditions
- Control amount of impervious cover
- Stormwater utility fees

Water Quality
- Capture percentage of storms
- Control specific nutrients, metals

PICP addresses all objectives

PICP Benefits
Stormwater Regulations

How PICP Manages Stormwater

Water Quantity
- Reduces volumes & peak flows via infiltration
- Imitates predevelopment conditions: no runoff from common storms
- Reduces or eliminates retention/detention facilities & conserves land
- Reduces stormwater utility fees

Water Quality
- Reduced downstream erosion, preserves drainage system
- Filters & reduces nutrients, metals
- Recharges groundwater
- Helps maintain dry-weather stream flows
- Filters oil drippings
- Reduces runoff temperatures
PICP Benefits

- Sustainable Living Green Infrastructure
- Infrastructure Cost Savings
- Local Stormwater Regulations
- Urban Heat Island & LEED
- Rapid Installation
- Durable ADA Compliant Surface
- Curb Appeal

**PICP Benefits**

Rapid Installation
Mechanized Installation Saves Money

5000-7000 sf/day
Ready to go after install.
PICP Benefits

Sustainable Living Green Infrastructure

Local Stormwater Regulations

Rapid Installation

Infrastructure Cost Savings

Urban Heat Island & LEED

Durable ADA Compliant Surface

Curb Appeal

PICP Benefits

Curb Appeal

LID PICP Project Examples

Tahoe Recreation Area, CA

Hilton Garden Inn Calabasas, CA

Dominican University River Forest, IL

Kane Co. Govt. Center Geneva, IL

Elfstrom Stadium Geneva, IL
PICP Benefits

Urban Heat Island Reduction/Cool Pavement & LEED
PICP contributes to LEED Credits

- Decrease pollution through sustainable sites (SS)
- Increase building water use efficiency (WE)
- Reduce energy and atmospheric pollutants (MR)
- Conserve materials and resources (MR)
- Improve indoor air quality (EQ)
- Offer innovative ideas and designs (ID)
PICP Benefits

Urban Heat Island Reduction/Cool Pavement & LEED
Decrease Pollution Through Sustainable Sites (SS)

<table>
<thead>
<tr>
<th>Credit</th>
<th>LEED® Points</th>
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<tr>
<td>6.1 Reduction of stormwater rate and quantity</td>
<td>1</td>
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<tr>
<td>6.2 Treatment of stormwater runoff</td>
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</tr>
<tr>
<td>7.1 Increase albedo (reflection of solar radiation) (non-roof surfaces)</td>
<td>1</td>
</tr>
<tr>
<td>7.2 Increase albedo (segmental paver on roof surface)</td>
<td>1</td>
</tr>
</tbody>
</table>

PICP Benefits

Urban Heat Island Reduction/Cool Pavement & LEED

LEED® Homes, LEED® Neighborhood Development

LEED® Homes: 136 point rating scale
Sustainable Sites and Water Efficiency are the main categories applicable to PICP

LEED® Neighborhood Development: 106 point rating scale
Green Construction & Technology is the main category applicable to PICP: GCT 9 Stormwater Management, 1-5 points

NEW SYSTEMS are UNDER REVIEW
PICP Benefits

Sustainable Living Green Infrastructure

Local Stormwater Regulations

Rapid Installation

Infrastructure Cost Savings

Urban Heat Island & LEED

Curb Appeal

Durable ADA Compliant Surface

PICP handicapped parking over stormwater detention system
Burnaby, BC

PICP Benefits

ADA Compliant
**LID & Stormwater Management**

Low Impact Development (LID) Principles

- Work with the landscape
- Focus on prevention
- Micromanage stormwater on the site
- Keep it simple
- Multi-functional landscapes
- Use LID tools such as PICP

**LID & Stormwater Management**

Use LID to Manage Stormwater

- Cost effective
- A hydrology based, strategic approach to site development
- Environmentally friendly
LID & Stormwater Management
Marketing LID and PICP

- LID practices support marketing efforts - sustainable lifestyle communities
- Lowered infrastructure costs raise profit opportunities
- Multiple benefits from required stormwater treatment
- Higher lot yield potential

LID & Stormwater Management
Treatment Train Site Design
1. Source controls = Infiltrate
2. Conveyance controls = Filter & detain
3. End of Pipe Controls = Retain in ponds, streams or storm sewer
LID & Stormwater Management
Integrated PICP-LID Landscapes Address Multiple Issues

- Livable Communities
- Hydrology Function
- Standardized Construction Specs
- Durable Surfaces
- Stormwater Management
- UHI - Cool Pavements
- Highly Marketable
- LEED® credit eligible
- “Green” development tool

Designing PICP Systems
Structural Design

- Follows standard flexible pavement design procedures

- Consider:
  - Total Traffic
  - Soil Strength
  - Environment
  - Design Life

- Adjust layer depths to meet structural requirements
Designing PICP Systems
PICP Computerized Design

• Design Software is Available
• Permeable Design Pro

• Software integrates:
  – Hydrologic Design
  – Structural Design

• Contact ICPI
to obtain software
www.icpi.org

Designing PICP Systems
11 Design Steps: Steps 1 – 3

1 – Assess soil conditions and design storm depth; determine exfiltration option
2 – Compute increased runoff depth from area contributing to the permeable pavement (if any)
3 – Compute the depth of the base for storage
Designing PICP Systems
11 Design Steps: Steps 4 – 7

4 – Compute the maximum base depth for drainage in 24, 36 & 48 hours given conservative soil infiltration rate
5 – If needed, revise base depth to accommodate storage and site area limitations
6 – Design perforated pipes at base to drain non-infiltrated water
7 – Design overflow for rainfalls exceeding the design storm

Designing PICP Systems
11 Design Steps: Steps 8 – 11

8 – Determine the base thickness for traffic using “Structural Base Thickness Table” (See next slide)
9 – Compare to base thickness for traffic to thickness for water storage:
    always use thicker base
10 – Check clearance from bottom of base to seasonal high water table (> 2 ft)
11 – Check geotextile filter criteria
Designing PICP Systems

Step 8 – Check the structural base thickness
From Figure 18 in PICP Manual

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<td>Soaked CBR Base Subbase</td>
<td>&gt;15</td>
<td>10-14</td>
<td>5 to 9</td>
<td>Gravelly Soils</td>
<td>Clayey Gravels, Plastic Sandy Clays</td>
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PICP Design

- Permeable Design Pro
- Software integrates:
  - Hydrologic Design
  - Structural Design
- Contact ICPI to obtain software www.icpi.org
Designing PICP Systems
Design Details

Edge restraint options
Pedestrian – concrete, plastic for pavers, other pavements

Vehicular – concrete curb to other pavements and at pavement edges

Construction
Construction
Subgrade & Base Preparation

Construction
Paver Installation
Construction
Joint Aggregate Installation

Work continued into the winter as long as the ground was not frozen.
**Maintenance**

- *Annually*: inspection of observation well after major storm, vacuum and sweep surface – improves infiltration
- Model maintenance agreement
- Monitor adjacent uses

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**Maintenance**

*Winter*

- Snow melts faster – lower risk of ice
- Surface does not heave when frozen
- Can be snow plowed – add shoes
- Deicing salts okay
- Sand will clog system
**Maintenance**

Sweeper Effectiveness

Best: Vacuum sweeper (no water)

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

Vacuum essential as brush bristles clean ~ ¼ in. into surface

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**PICP Resources**

- Fact Sheets
- Design manual
- Design software
- Presentations

[www.icpi.org](http://www.icpi.org)
[www.ncsu.edu/picp](http://www.ncsu.edu/picp)
[www.lowimpactdevelopment.org](http://www.lowimpactdevelopment.org)
Looks Good, Makes Money
Questions?