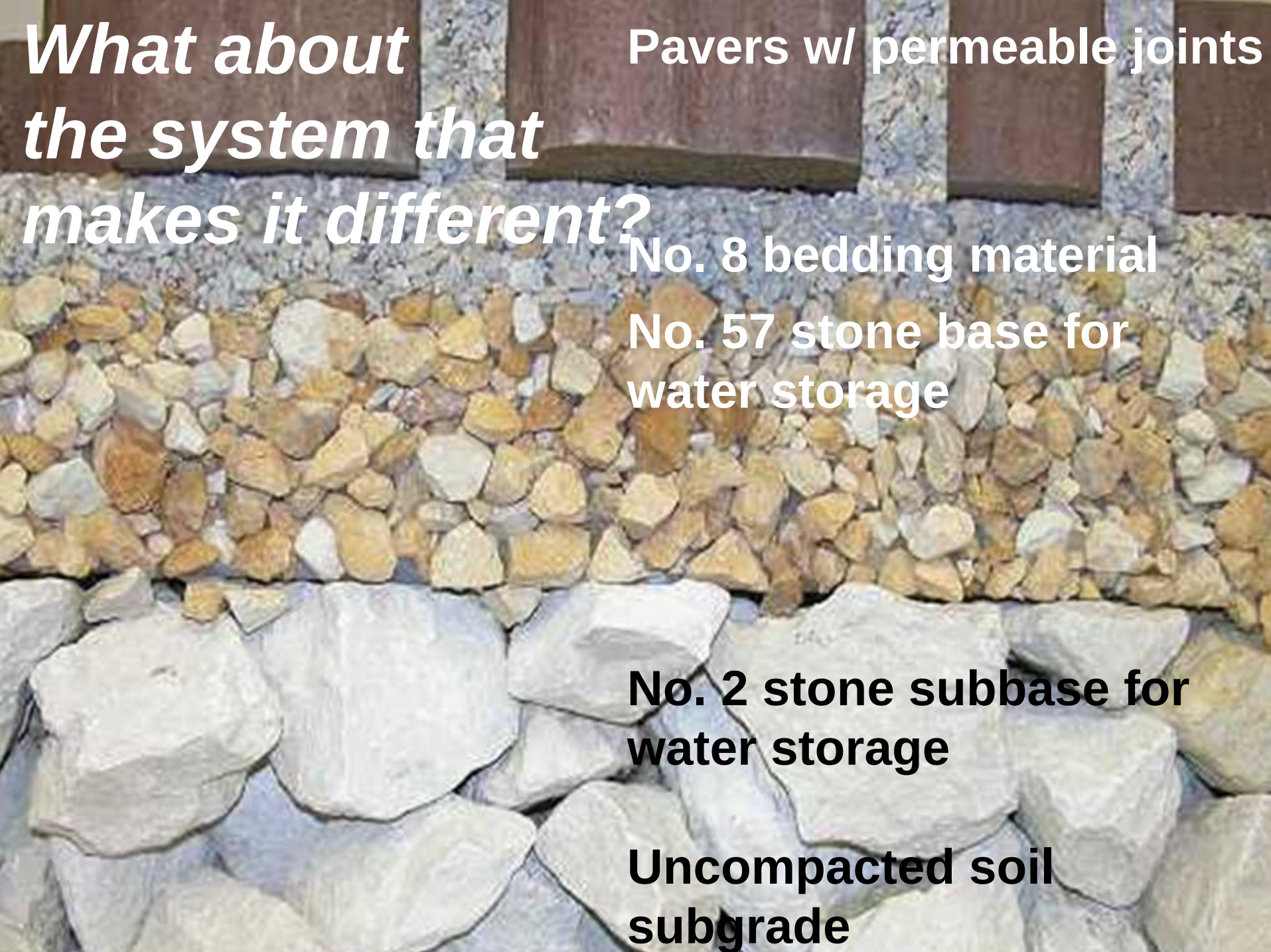
Permeable Interlocking Concrete Pavements

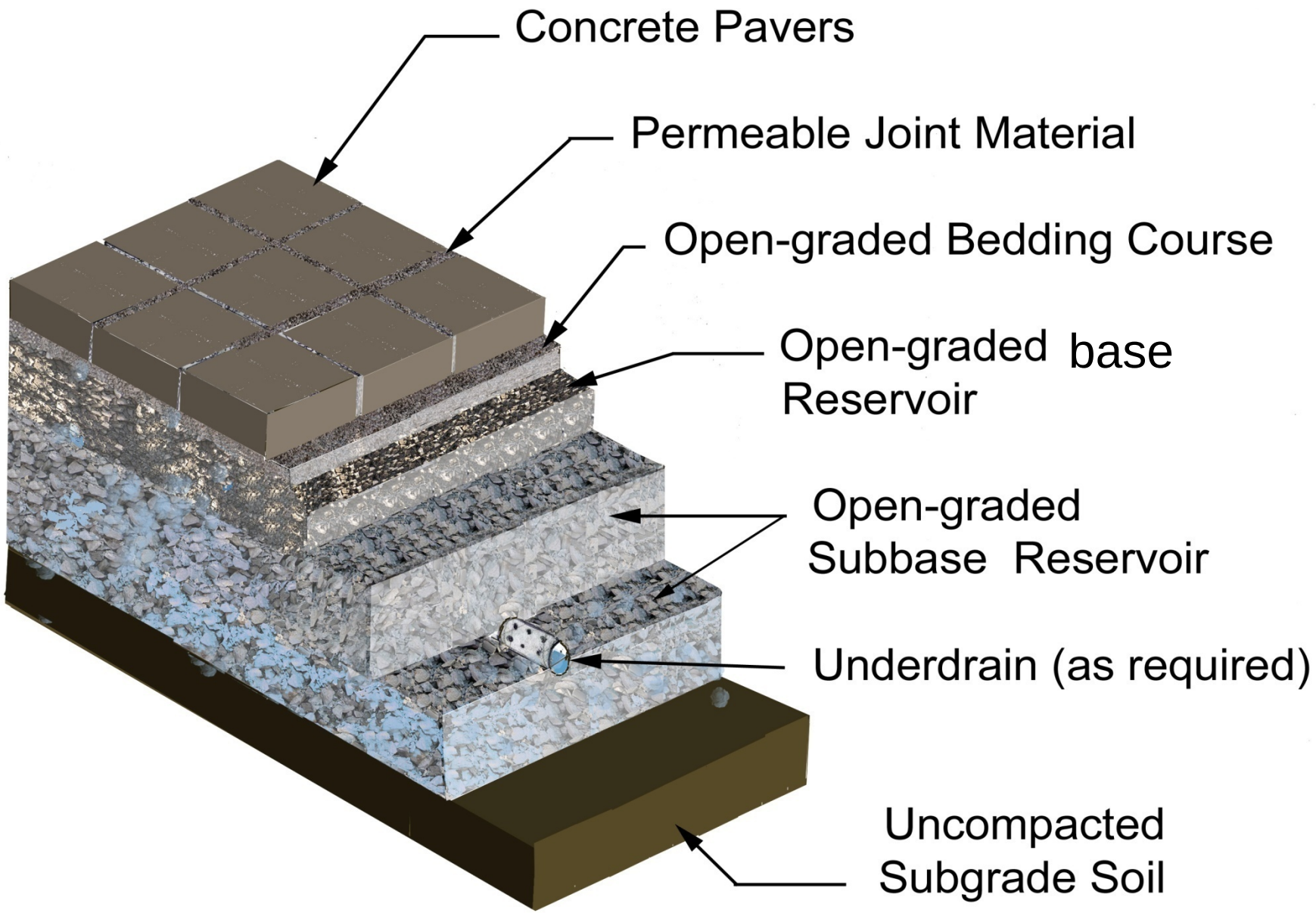
ICPI

INTERLOCKING CONCRETE PAVEMENT INSTITUTE ®

What about…?

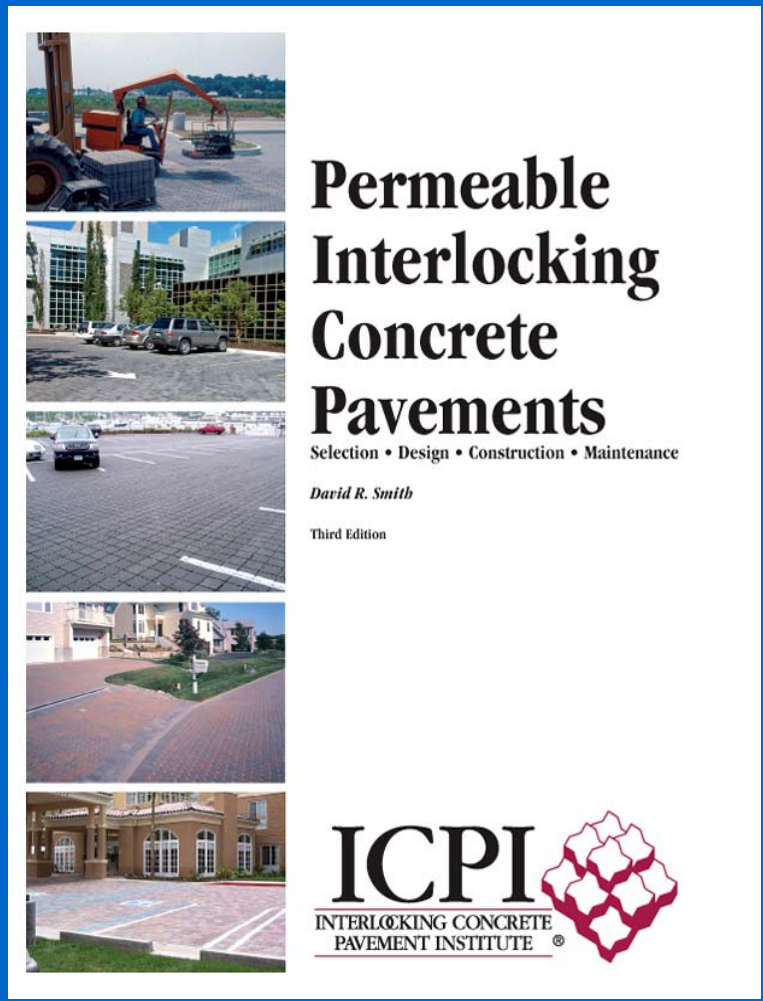

What about the system that makes it different?
Pavers w/ permeable joints
No. 8 bedding material
No. 57 stone base for water storage
No. 2 stone subbase for water storage
Uncompacted soil subgrade

Bedding, base & subbase stone sizes


Concrete Pavers
Permeable Joint Material
Open-graded Bedding Course
Open-graded base Reservoir
Open-graded Subbase Reservoir
Underdrain (as required)
Uncompacted Subgrade Soil

What about hydrological design?

Infiltration trench design
'C' value: 0.2 – 0.3
CN: storage dependent
Detention/drain pipes: design as pond
Contributing impervious areas:
Max 5:1 contributing impervious area:PICP
Provide for overflows




Hilton
Garden In
CLEARANCE 14'-6"

PICP Software – Release July 2008

ARA-ICPI

File Settings Help

Project: Example 2 US C Units Imperial

Definition

- Pavement Structure
  - Pavement Geometry
  - Subgrade Layer
    - Gradation
    - Resilient Modulus
    - Porosity
  - Granular Layer
    - Configuration
    - Subbase
      - Gradation
      - Porosity
    - Base
      - Gradation
      - Porosity
  - Paving Layer
- Structural Design
  - Traffic
  - Design Parameters
  - Structural Base Thickn
- Precipitation
  - Storm Pattern
  - Rainfall
  - Inflow
- Analysis Settings

Run

Analysis

Analysis years: All years

- Analysis Results
  - Graph
  - Details
  - Summary
  - Report

Inflow

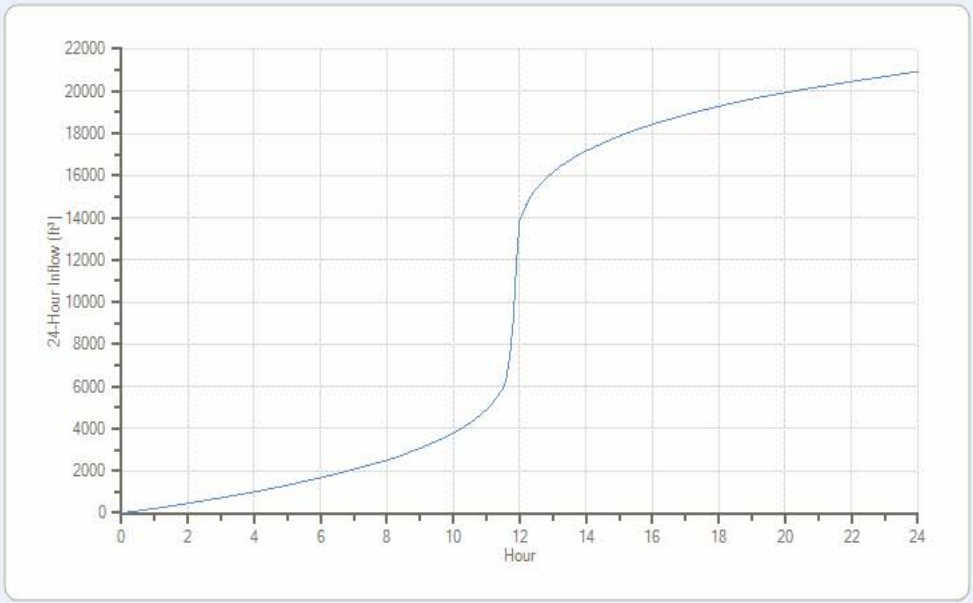
Inflow

Storm Return Period	Rainfall (in)	Inflow (ft³)	Contributing Area Runoff (ft³)	Total Inflow (ft³)
2	3.1	20,933.3	0.0	20,933.3
5	4.1	27,600.0	0.0	27,600.0
10	4.8	32,133.3	0.0	32,133.3
25	5.8	38,533.3	0.0	38,533.3
50	6.5	43,533.3	0.0	43,533.3
100	7.3	48,466.7	0.0	48,466.7

☐ Show all Storms

☑ Include Contributing Area Runoff

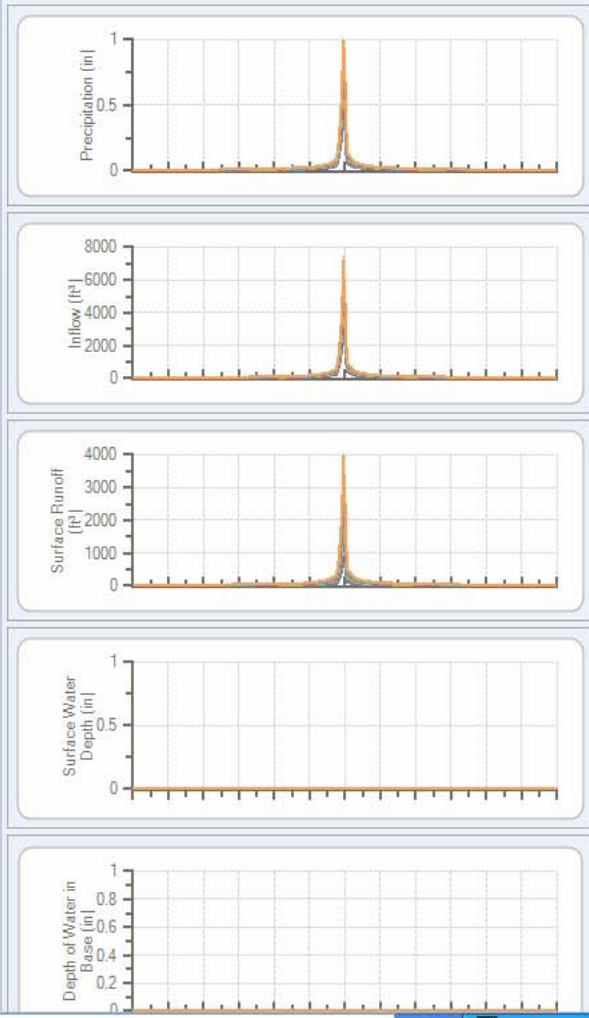
Water Inflow Distribution for: 2-Year Storm including Contributing Area Runoff



Report

Summary Details Report

Graph



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What about base traffic & base thicknesses?

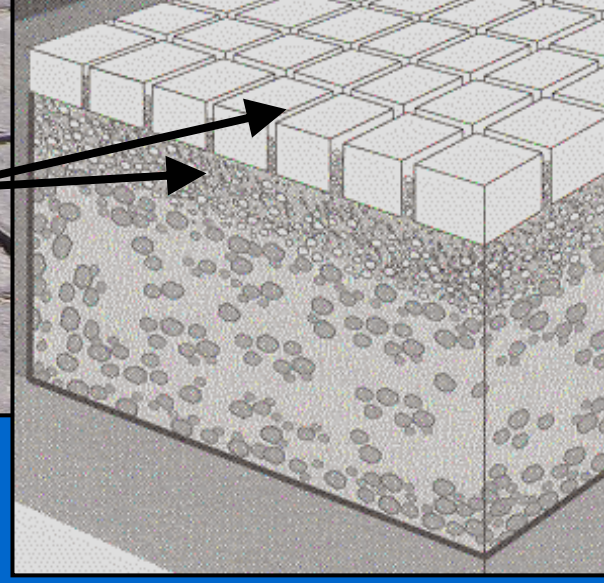
Figure 18 – ICPI PICP manual – or software (AASHTO)

Climate	No Frost	No Frost	No Frost	No Frost	Frost	Frost	Frost	Frost
ESALs* **Traffic Index**	Soaked CBR Base Subbase **R-value**	>15 **>60**	10-14 **47-60**	5 to 9 **24-46**	Gravelly Soils	Clayey Gravels, Plastic Sandy Clays	Silty Gravel, Sand, Sandy Clays	Silts, Silty Gravel, Silty Clays
Pedestrian	No. 57 No. 2	4 (100) 6 (150)	4 (100) 6 (150)	4 (100) 6 (150)	4 (100) 6 (150)	4 (100) 6 (150)	4 (100) 6 (150)	4 (100) 6 (150)
50,000 **6**	No 57 No. 2	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	**
150,000 **7.2**	No. 57 No. 2	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 10 (250)	**
600,000 **8.5**	No. 57 No. 2	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 10 (250)	4 (100) 8 (200)	4 (100) 14 (350)	4 (100) 18 (450)	**

* ESALs = 18 kip (80 kN) Equivalent Single Axle Loads

** Strengthen subgrade with crushed-stone sub-base to full frost depth.

What about surface clogging?

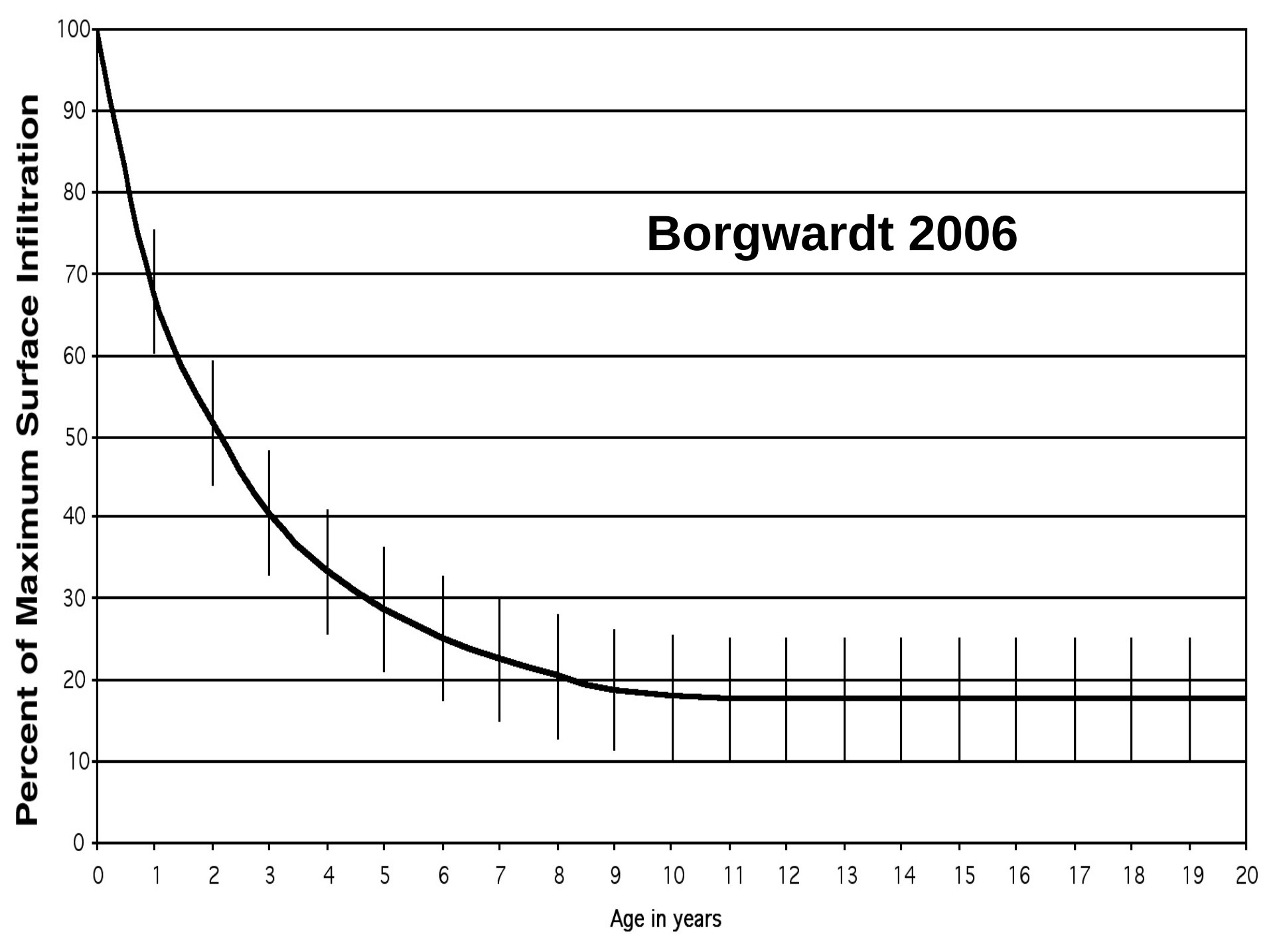


Percent of open surface 5% to 15%
Surface is 100% *pervious*

Researcher	Surface infiltration rate, in./hr
Clausen (2007 UConn)	4.5 (on dense-graded base!)
Collins (2007 NSCU)	6.75
Bean (2004 NCSU)	25-35 (clogged 1 – 3)
Borgwardt (Germany)	4 - 9 (many studies)

Substantial increase when cleaned

Surface openings = *mini-detention ponds*


Borgwardt 2006
Percent of Maximum Surface Infiltration
100
90
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Age in years

What about ADA?

What about pollutant reduction?

Clausen (2007) – Residential Driveways

Pollutant Export kg/ha/year

Variable	Asphalt	PICP	Stone
Total Suspended Solids	230.1	23.1*	9.6
Nitrate nitrogen	1.78	1.25	0.15
Ammonia nitrogen	0.65	0.12	0.03
Kjeldahl nitrogen	13.06	1.08	0.47
Total Phosphorous	0.81	0.25**	0.04

*90% TSS reduction **69% TP reduction

Van Seters (TRCA 2007): 81% TSS reduction
Hunt (2004): 72% TSS & 63% TP reductions
Booth & Leavitt (1999): significant metals reductions compared to asphalt runoff

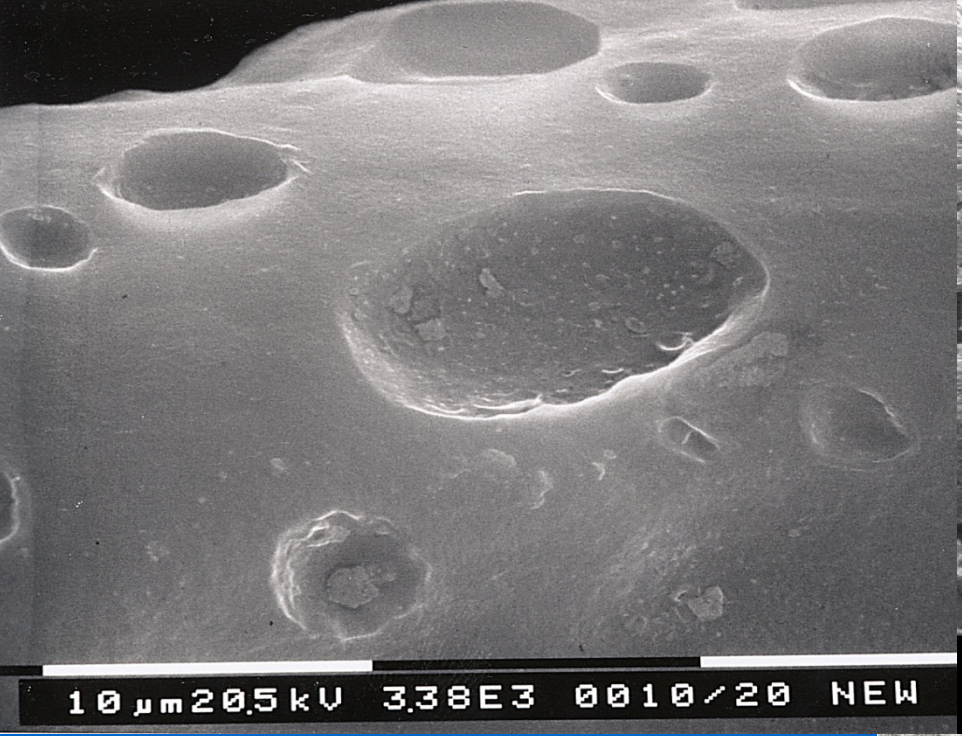
What About Oils?

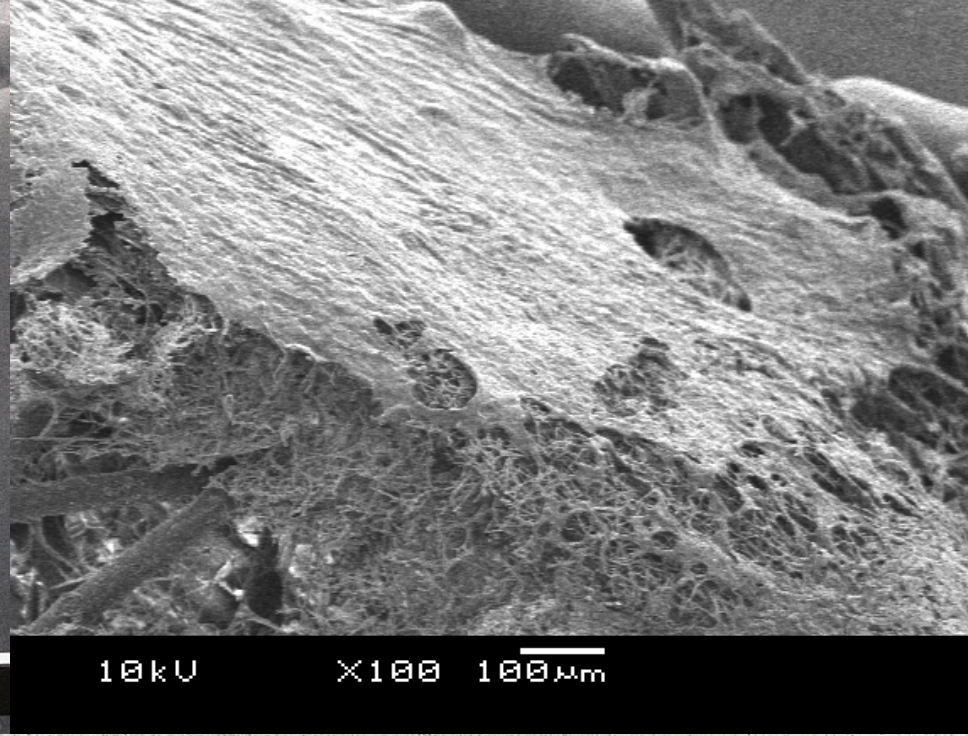
Studies by C. Pratt & S. Coupe
Coventry University, UK

"…the system is capable of degrading at least 70g of oil per square meter per year."

PICP can process occasional drips

Spills are manageable!





Microbial generation and consumption of oil within geotextiles in permeable interlocking concrete pavements

What about construction & inspection?


No. 57
No. 2

Wal-Mart Rehobeth Beach, Delaware 40,000 ft^2

Screeding No. 8 stone bedding layer over No. 57 base

Construction – Mechanical Installation

Construction

Filling the openings with No. 8 stone

Compaction…

What about maintenance?

Monitor Base Inflow & Outflow

- **Observation well at lowest point**
- **Min. 6 in. dia. perforated pipe w/cap**
- **Monitor drainage rate, sediment, water quality**
- **Cap hides under pavers**


ELGIN WHIRLWIND
Series L
JUL 22 2005

What about cost?

$7 – 10/sf

Combined drainage & parking/roads

More income generating land *or* more preserved land

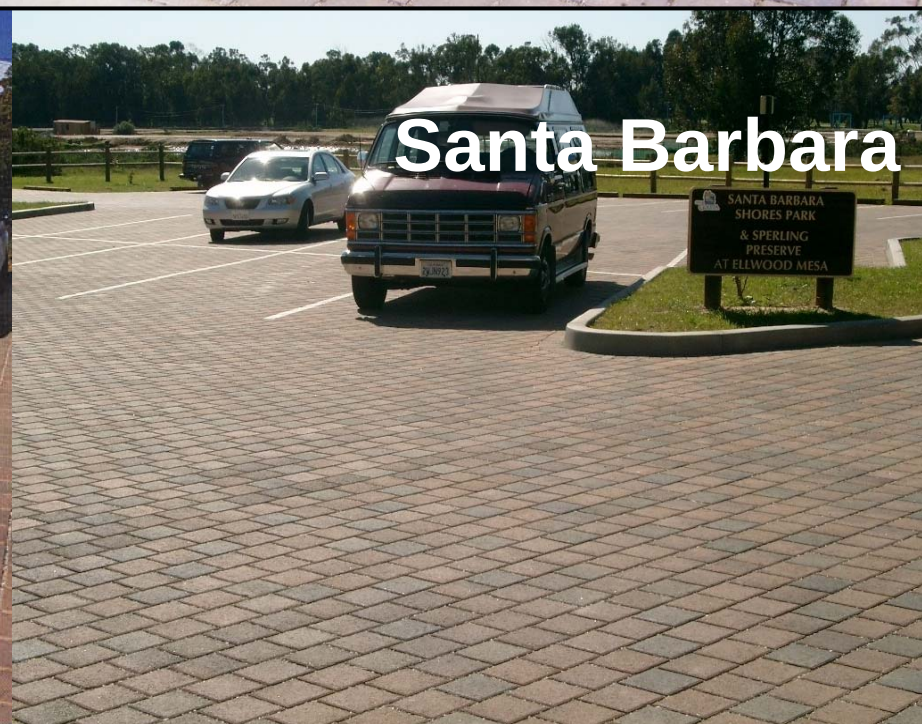
Greater savings in highly urbanized areas

Burnaby Shopping Center, British Columbia


Calabasas


Livermore


Los Angeles


Santa Barbara
SANTA BARBARA
SHORES PARK
& SPERLING
PRESERVE
AT ELLWOOD MESA

Antwerp, Belgium

100,000 sf parking

TiO_2 coated pavers

Largest NO_x reductions on calm, warm days, no wind

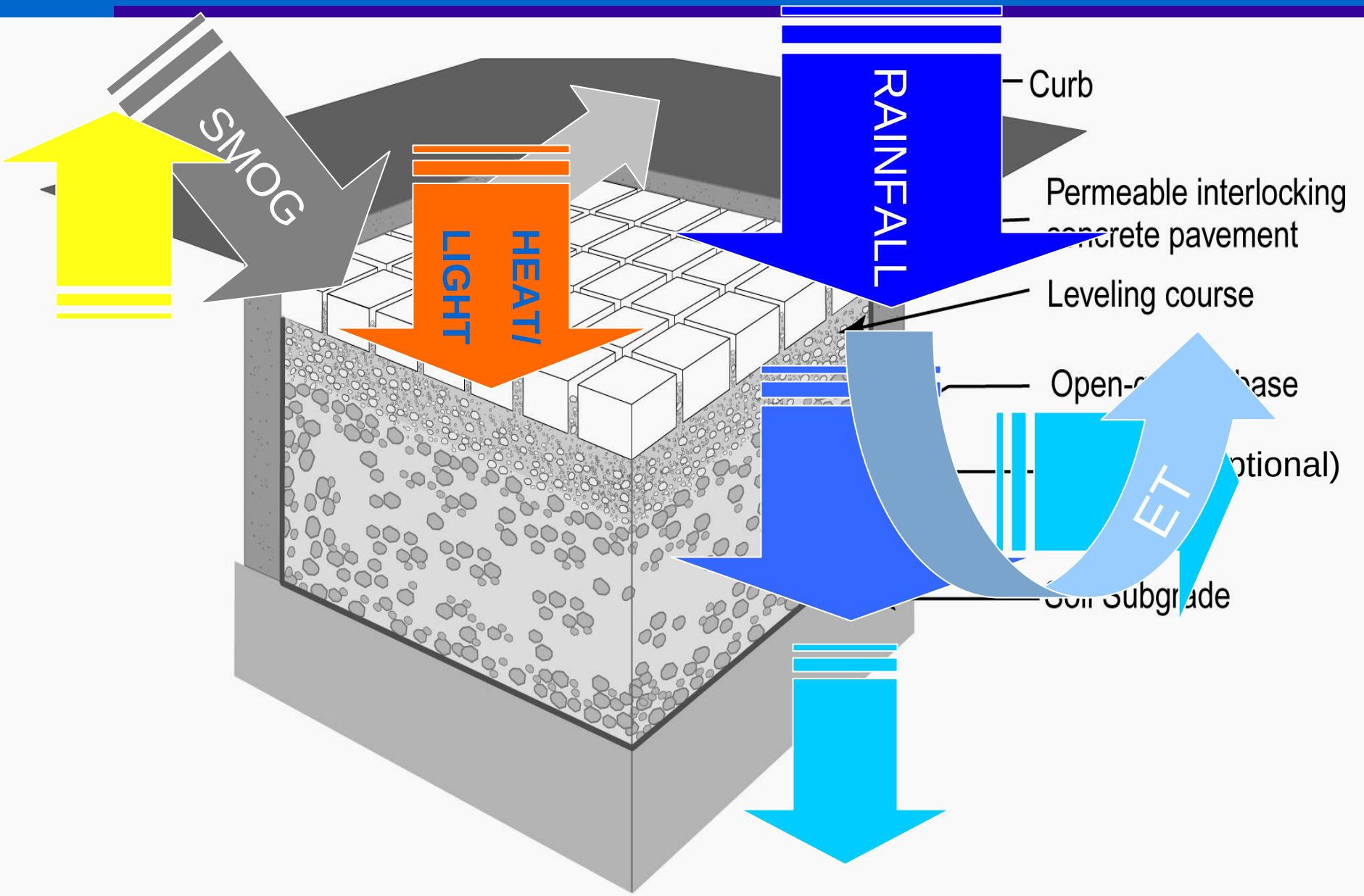
Smog Eaters

THE ITALIAN CITIES 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 Amadelli, 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 SUTHERLAND

Cagliari is one of the test cities

PICP Eco-Machine



www.icpi.org

Thank you!

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