BELGARD

Oldcastle®

8th Port & Terminal Conference USA

March 23, 2016

Charleston SC

Water is Nature's resource

Nature's resource needs protection

Engineered Ecological Paver Systems

Sustainable Solutions that Last…..

Industrial

Regulations

Contaminants in stormwater run-off are a significant source of water pollution to coastal waters in Southern California. We will be working with the Regional Board, the cities, the ports and their tenants to minimize the impact of port operations on water quality – Alexis Strauss, Water Division Director (2007)

Growth to meet demands?

Permeable Interlocking Pavement Systems

KEY ENVIRONMENTAL OPPORTUNITIES

The port sector is working with EPA to improve performance by:

- ❒ Reducing air emissions;
- ❒ Improving water quality;
- ❒ Minimizing impacts of growth; and
- ❒ Promoting environmental management systems

Permeable Interlocking Concrete Pavement (PICP) can address the above targets in a natural engineered system

Improving Water Quality

Ports can improve the quality of surrounding waters by enhancing stormwater management and exploring new technologies to reduce the impact of invasive species.

Ports can work towards minimizing impacts of growth

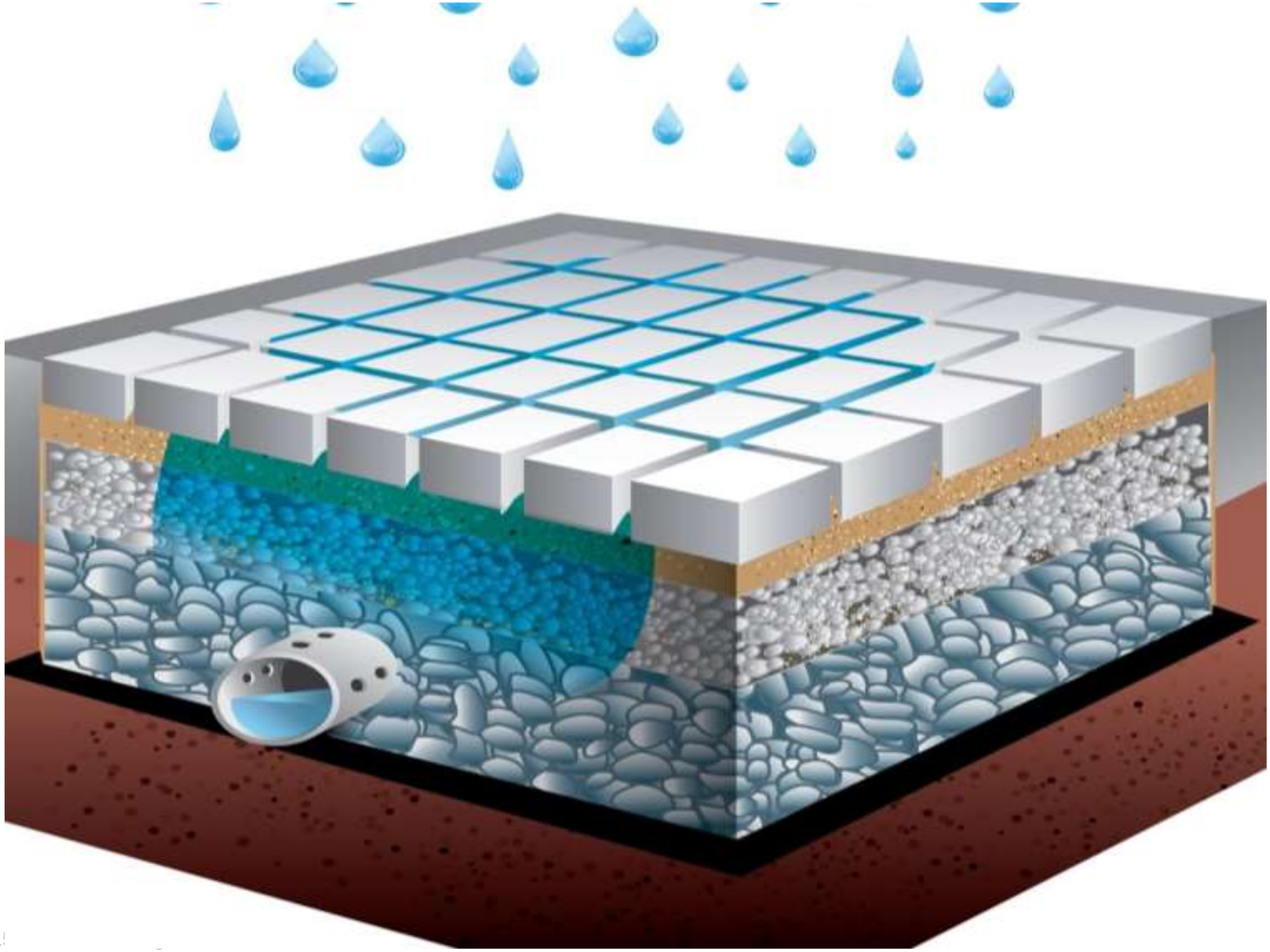
Stormwater Management - Port of Tampa

The port installed an advanced stormwater system to help reduce the pollutant load into Ybor Channel, which leads to Tampa Bay. This system utilizes collection basins and baffle boxes that are capable of removing sediments and other suspended particles from stormwater so that they will not enter Ybor Channel.

Port of Tampa - Berth 208
Tampa Port Authority, Tampa, FL

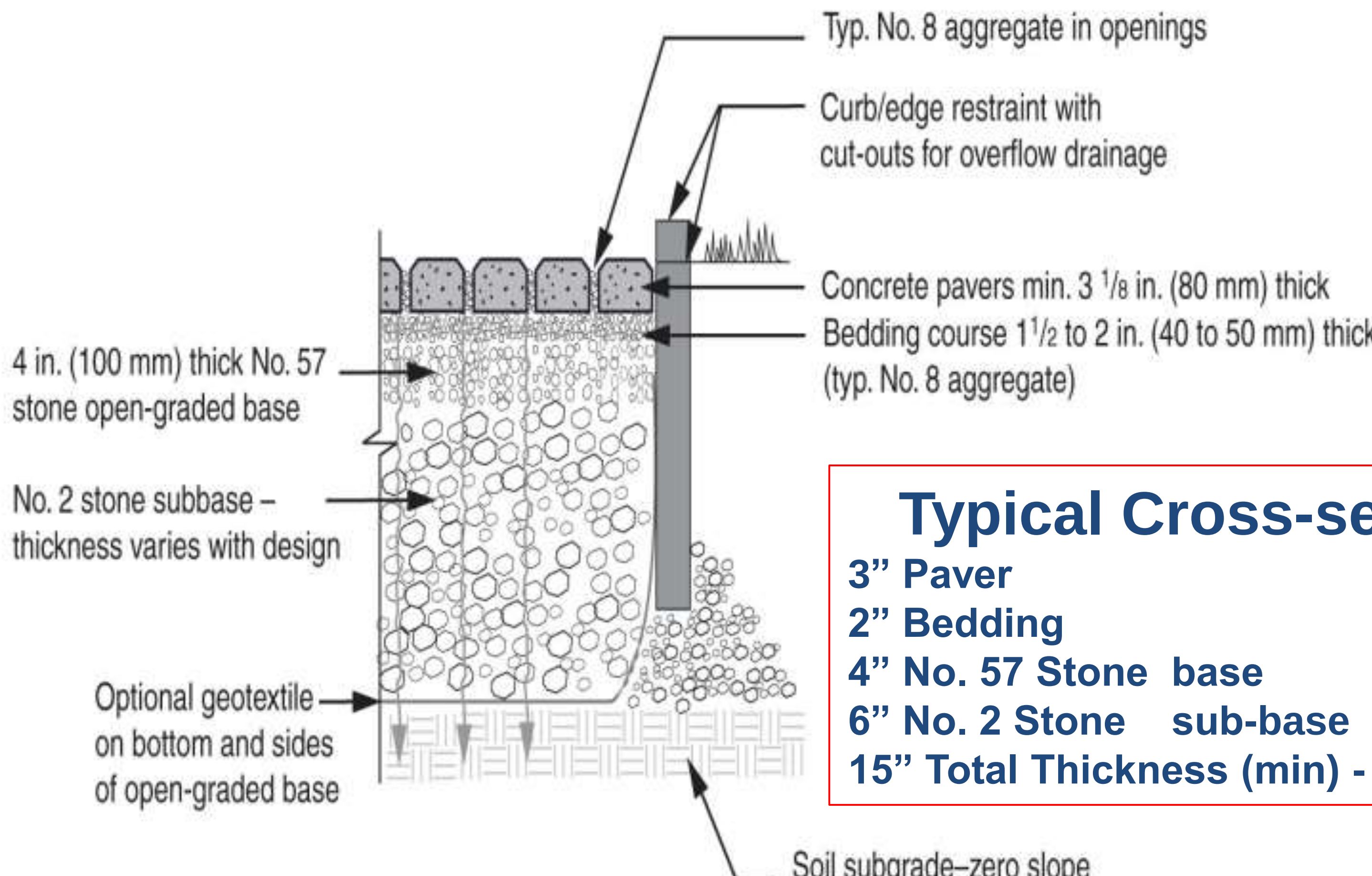
Example of Port's experience with segmental concrete pavement systems

Permeable Interlocking Concrete Pavement (PICP)



2,000 gal/min

Full Infiltration



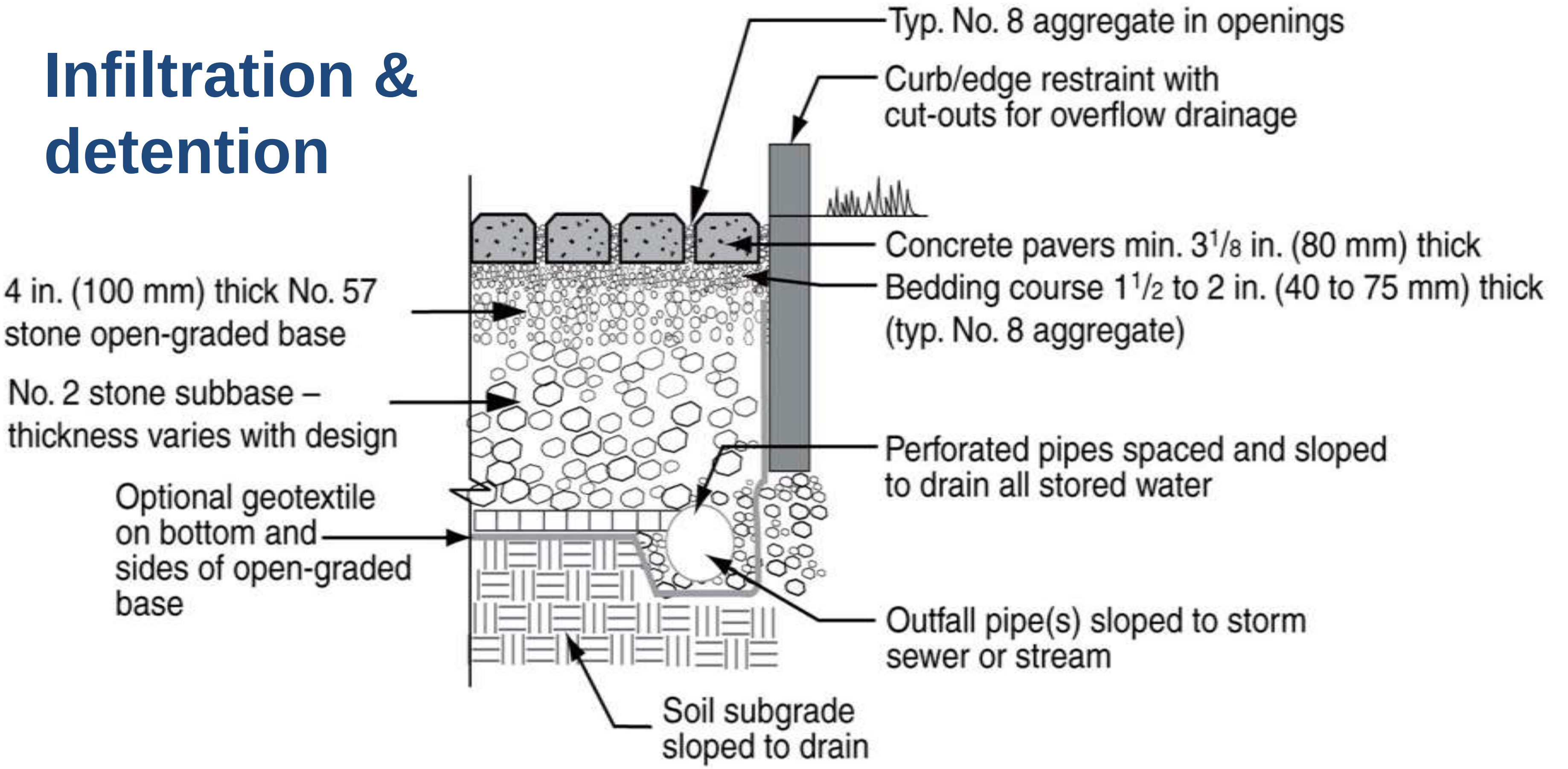
Typical Cross-section

3" Paver
2" Bedding
4" No. 57 Stone base
6" No. 2 Stone sub-base
15" Total Thickness (min) - vehicular

Used on Type A and B soils
infiltration rate > 0.52 inches / hour

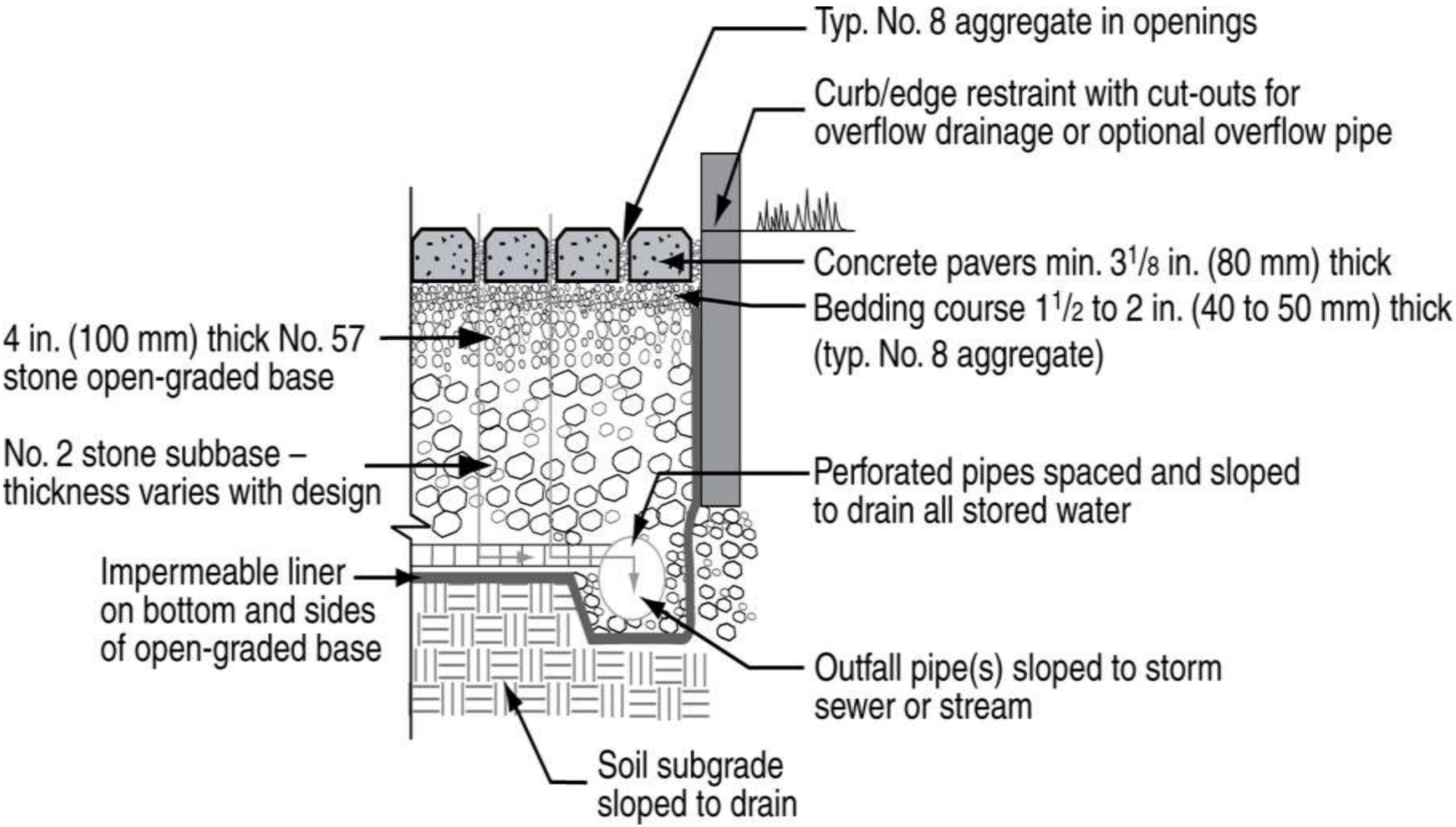
Partial Infiltration

Infiltration & detention



Used on Type C and D soils
Balance between infiltration rate and storage time.

No Infiltration



Land Conservation Improved Land Planning

Underground Detention - Constructability

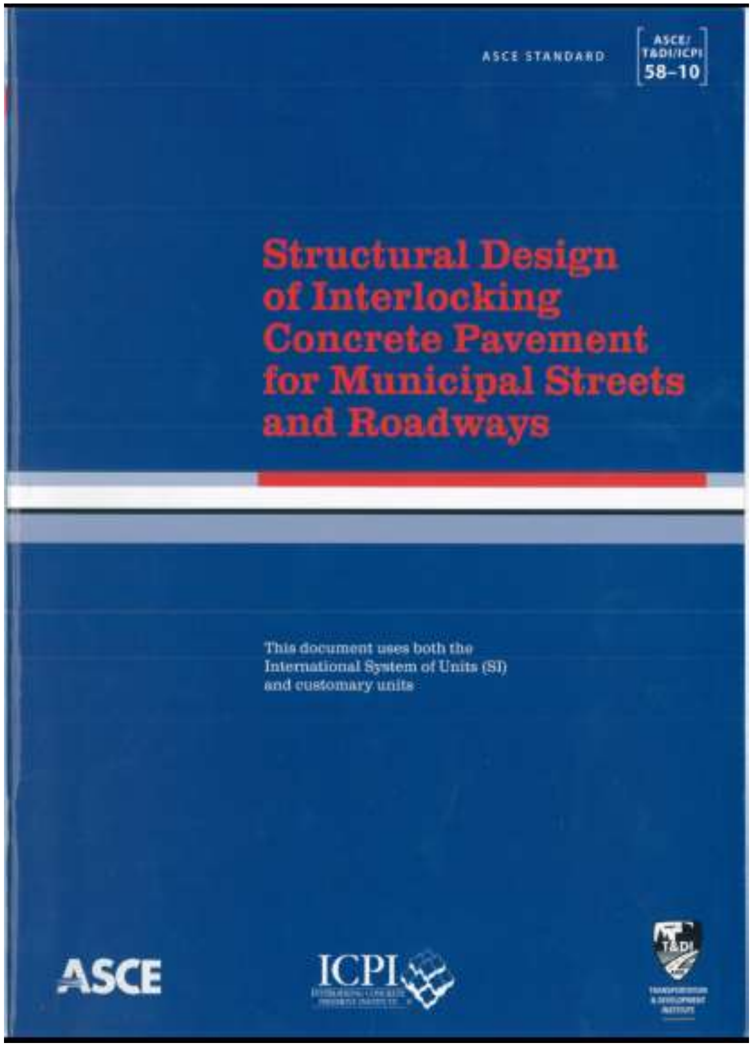
Rainfall / Water Collection Results

Highest rainfall with no water collection:
0.75 in

Lowest rainfall with water collection:
1.38 in

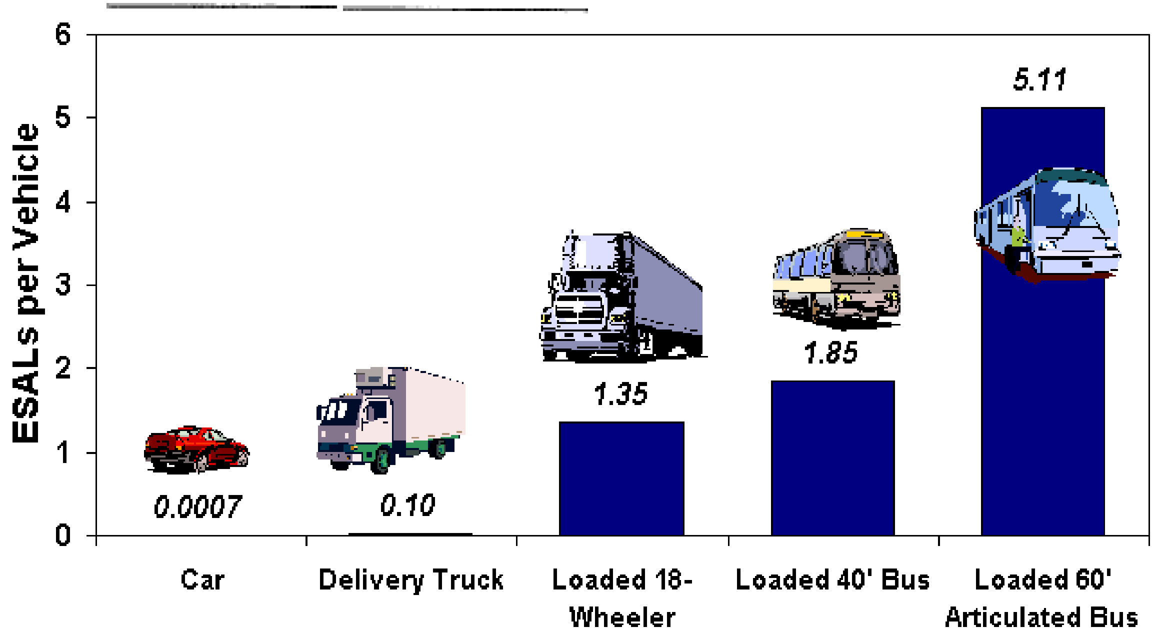
Estimate (0.8in – 1.2in)

ASCE 58-10 Structural Design for ICP



ESALs	Traffic Index
10,000	5.2
20,000	5.7
50,000	6.3
100,000	6.8
200,000	7.4
500,000	8.3
1,000,000	9.0
2,000,000	9.8
5,000,000	10.9
10,000,000	11.8

$$TI = 9.0 \times \left(\frac{ESAL}{10^6}\right)^{0.119}$$



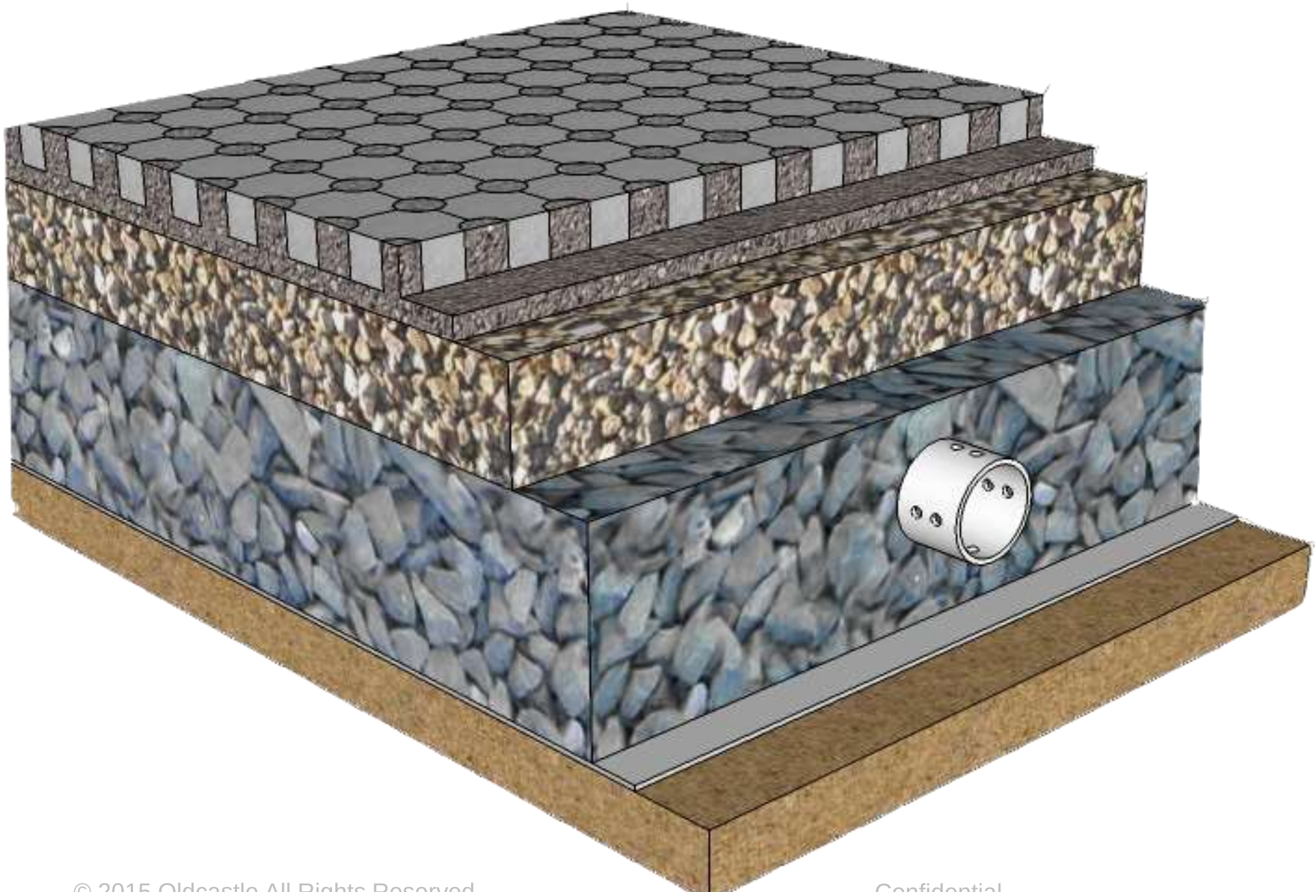
 Confidential

Engineered Pavement Systems

SN = structural number of the pavement, calculated as $\Sigma\, a_i \times d_i$, where

a_i = structural layer coefficient per layer i

d_i = layer thickness per layer i



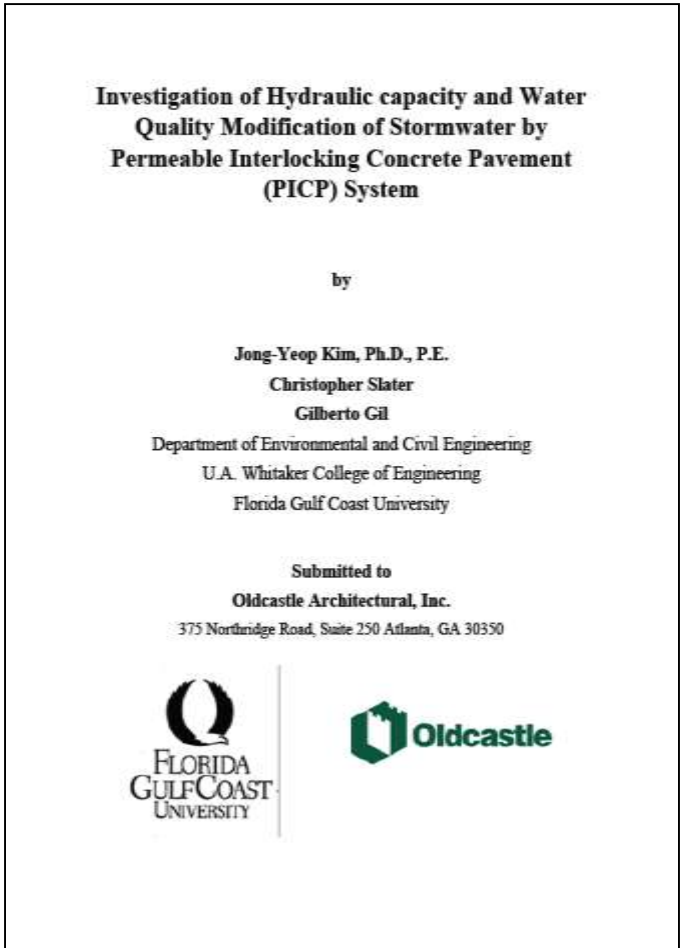
Proven Durability

Proven Performance

Port of Oakland

Mechanical Installation Cost Efficient

Joint Aggregate and Sediment Removal


Investigation of Hydraulic capacity and Water Quality Modification of Stormwater by Permeable Interlocking Concrete Pavement (PICP) System

by

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Two main components:

1. **Investigated the TSS removal efficiency of different jointing material**

2. **Determine the frequency of remedial maintenance based on typical sediment loadings.**

Site Demonstration

Two materials:
1. NJCAT (NJ Corp of Advanced Technology)
2. Winter Sand

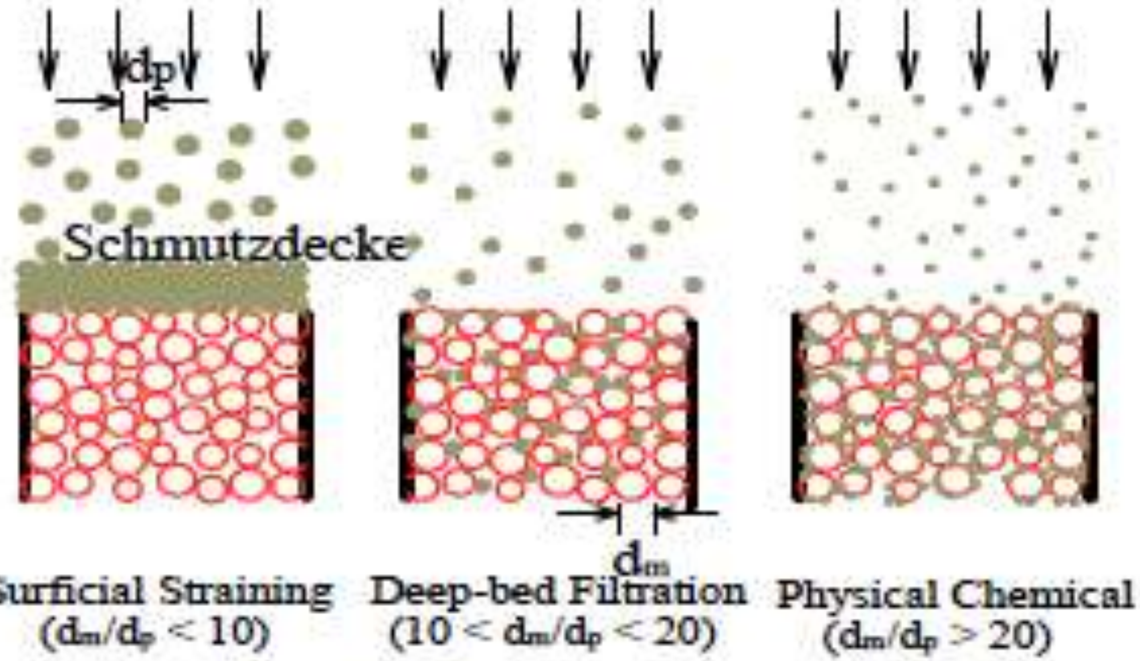
Three concentrations:
1. 100 mg/l
2. 200 mg/l
3. 300 mg/l

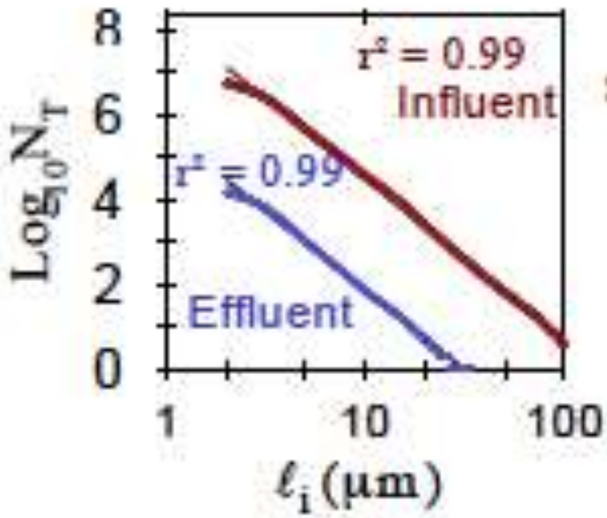
Two scenarios
1. **20 year progressive loading**
2. **Equivalent mass loading**

Results

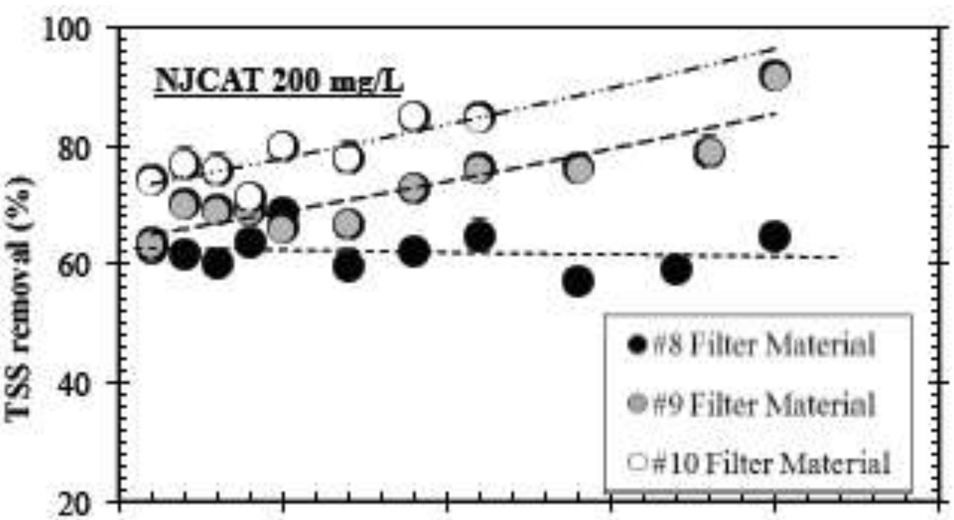
Filtration mechanism

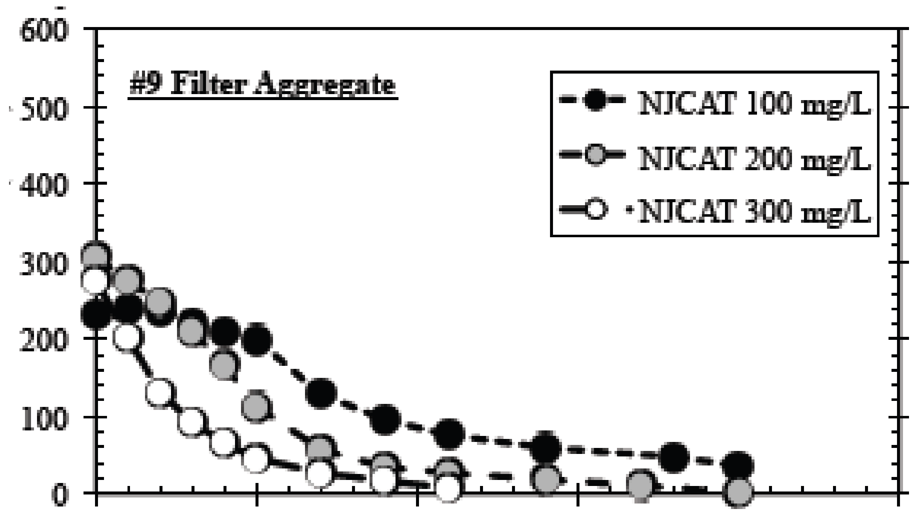
d_m/d_p ratio using mass based d_{50} of media and particulates





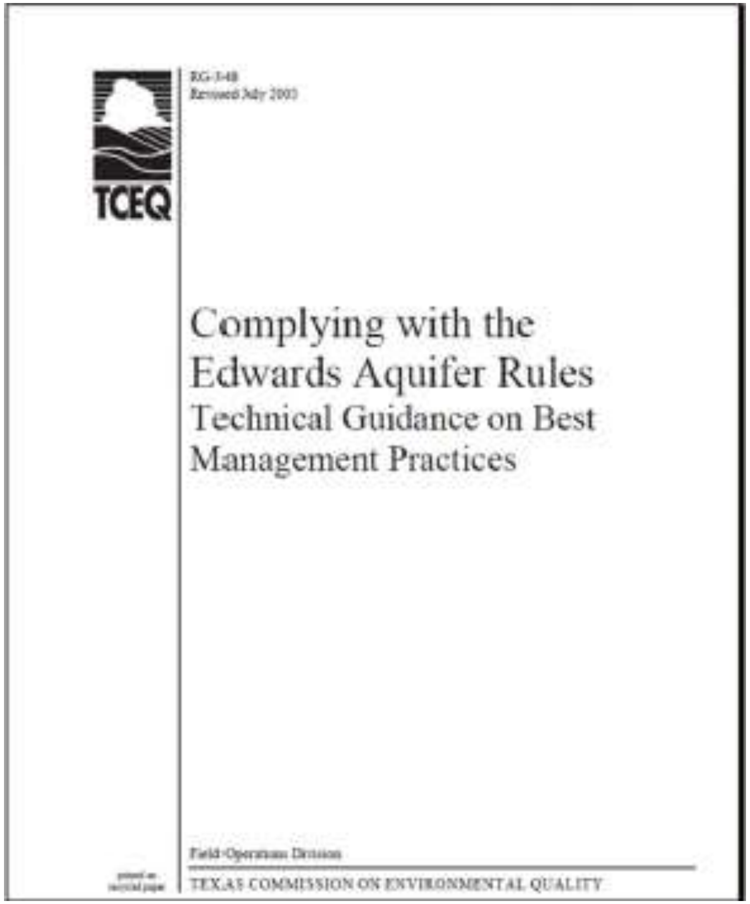
The power law function uses cumulative particle number density (PND) of all particles larger than the reference value R (i.e. 1 μm).





1. **There is an increase in removal efficiency, and a reduction in infiltration, as more TSS materials are trapped in the jointing material.**
2. **Removal efficiency was 60 to 100% based on grain size.**
3. **Remedial maintenance required between 9-20 years.**

Water Quality Approval Process


RG-348
Revised July 2005

TCEQ

Complying with the
Edwards Aquifer Rules
Technical Guidance on Best
Management Practices

Field Operations Division

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

WDNR Study
Costco
Sun Prairie, WI
Roger Bannerman
Summer 2013

Section 3.2.20 – Permeable Pavers are approved by the TCEQ as an addendum to RG-348 on 12/14/12

Water Harvesting – Water Quality

Old Woman Creek

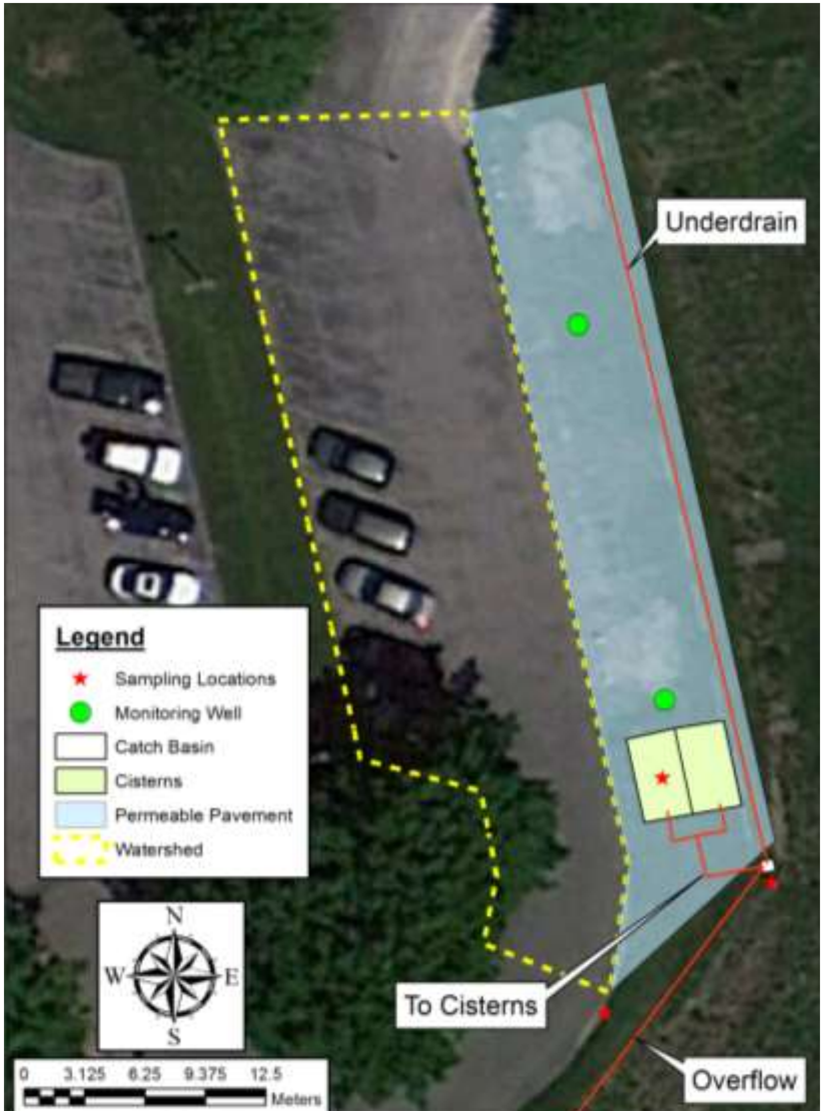
- Huron, OH - NCSU

Street Division East Office

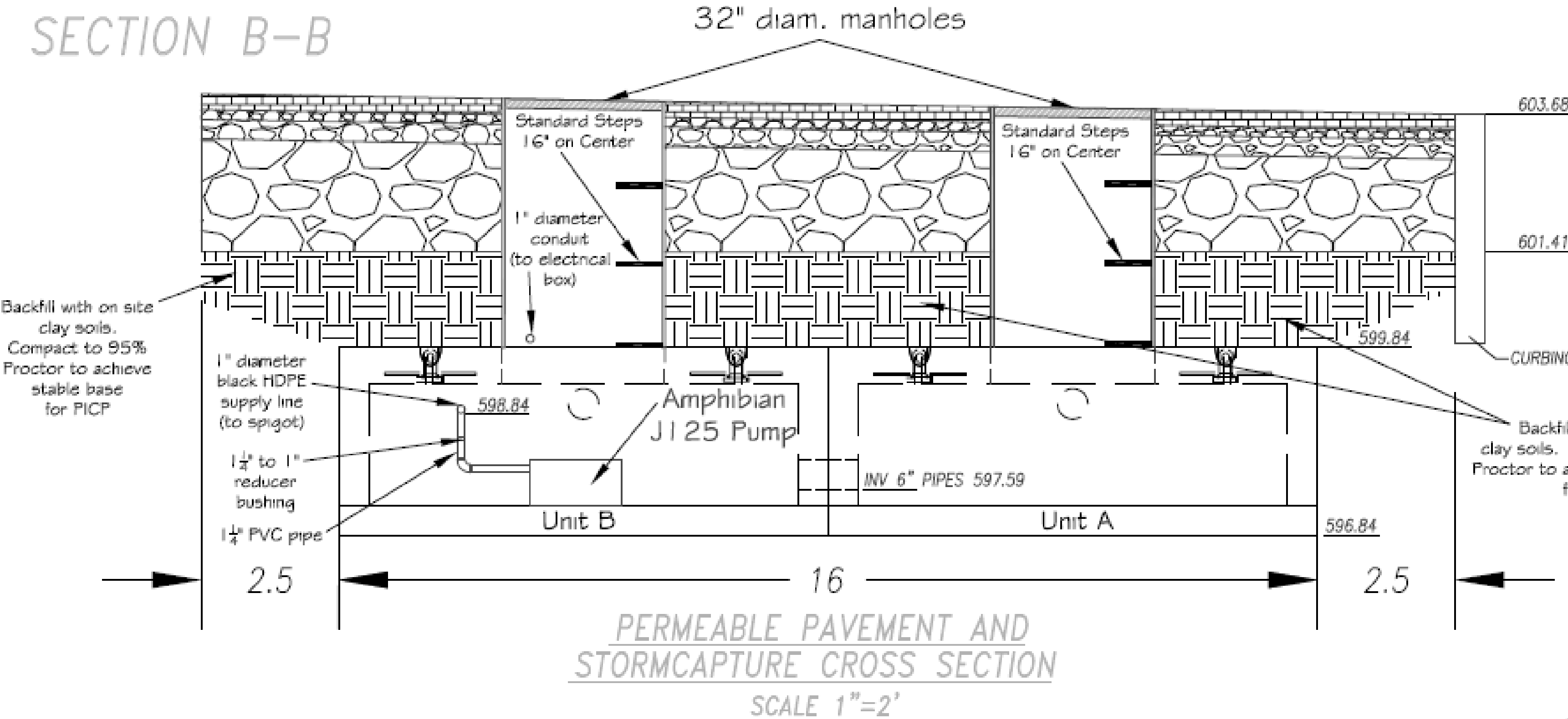
- Madison, WI - WI DNR

http://wi.water.usgs.gov/non-point/permpave/index.html

Old Woman Creek Parking Area



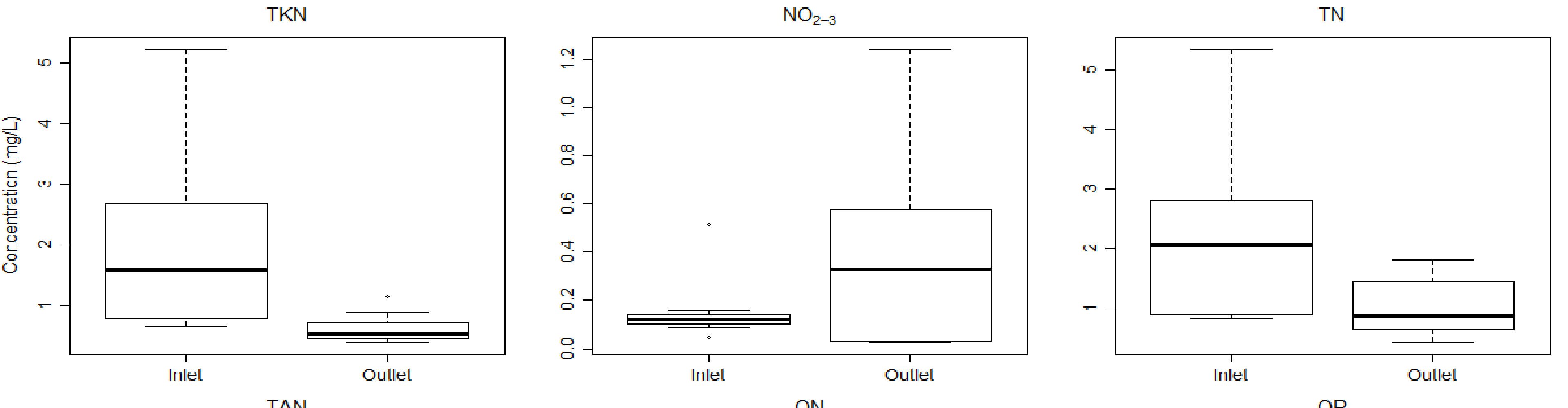
StormCapture Cross-Section



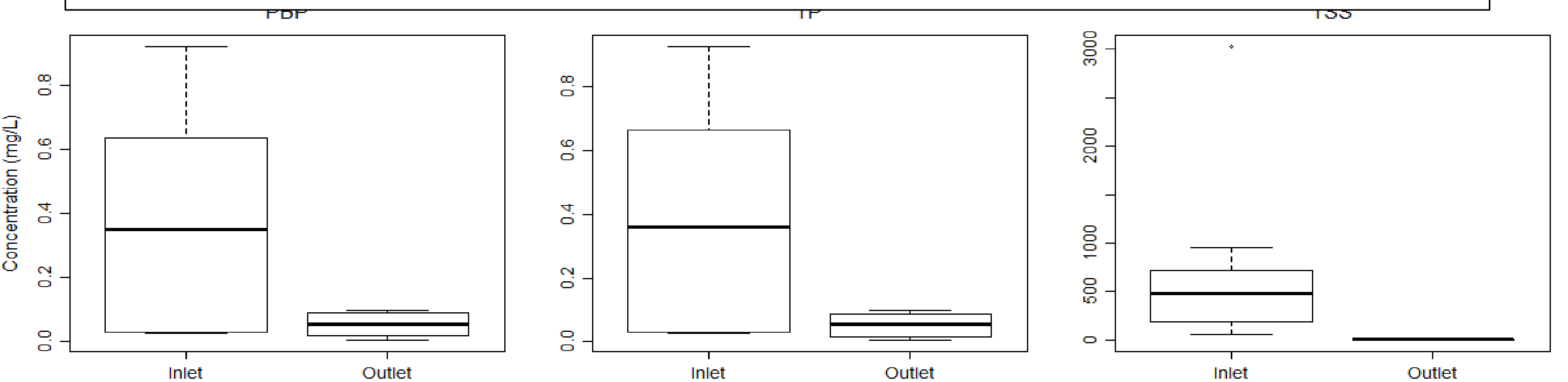
Not to Standard Scale

System Performance: Nutrients and Sediment

Pollutant	Location	$\bar{x}$ (mg/L)	$\tilde{x}$ (mg/L)	ER	RE_{median}
TKN	Inlet	2.06	1.59	0.69	0.66
	Outlet	0.64	0.54		
NO_{2-3}	Inlet	0.17	0.12	-1.42	-1.75
	Outlet	0.40	0.33		
TN	Inlet	2.23	2.05	0.53	0.58
	Outlet	1.04	0.87		
TAN	Inlet	0.05	0.04	0.37	0.19
	Outlet	0.03	0.03		
ON	Inlet	1.76	0.81	0.68	0.42
	Outlet	0.57	0.47		
OP	Inlet	0.011	0.0046	0.90	0.85
	Outlet	0.001	0.0007		
PBP	Inlet	0.38	0.35	0.87	0.85
	Outlet	0.05	0.05		
TP	Inlet	0.39	0.36	0.87	0.85
	Outlet	0.05	0.05		
TSS	Inlet	766	483	0.99	0.99
	Outlet	[illegible]	[illegible]		



- Excellent treatment of both dissolved and sediment-bound nutrients
- Ammonification->nitrification (aerobic process) responsible for $NO_{2\text{-}3}$ export
- Load reduction >60% except $NO_{2\text{-}3}$



Comparison Against Past Studies: Effluent

Pollutant (mg/L)	Cistern (OWC)	Wilson et al. (2014)	DeBusk and Hunt (2014)
TAN	0.03	0.32	0.2
TKN	0.54	0.63	0.47
NOx	0.4	0.29	0.28
TN	0.87	0.92	0.78
TP	0.05	0.03	0.02
PO_4	0.001	0.01	-
TSS	4	2.4	2.7

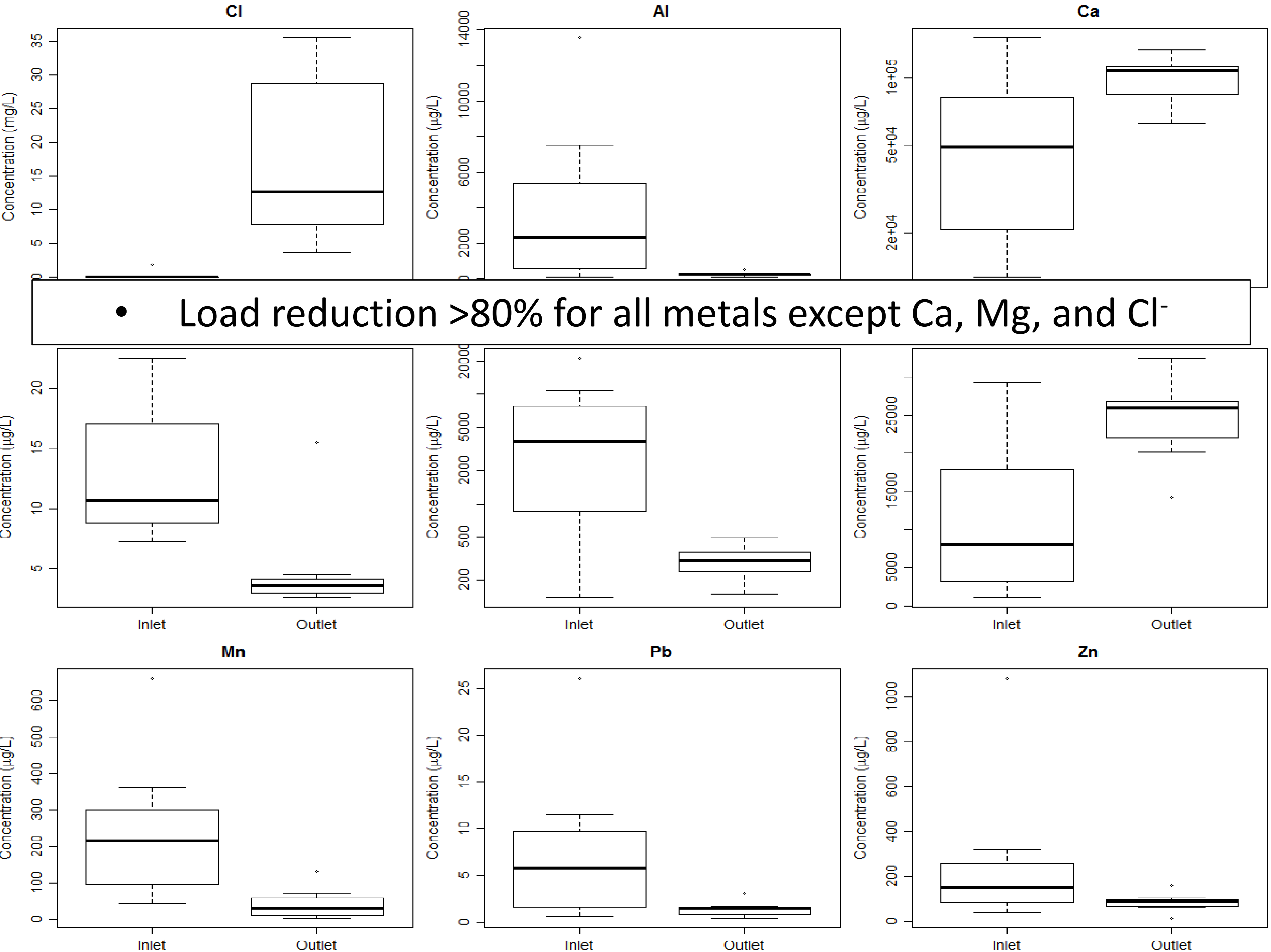
Blue shading – belowground, concrete cistern
Green shading – aboveground, plastic cistern

System Performance: Metals and Chloride

Pollutant	Location	$\bar{x}$ (µg/L)	$\tilde{x}$ (µg/L)	ER	RE_{median}
Cl	Inlet	0.3	0	-65	N/A
	Outlet	18	13		
Al	Inlet	3959	2308	0.94	0.90
	Outlet	247	231		
Ca	Inlet	59811	48910	-0.66	-1.22
Cu					0.66
Fe					0.92
Mg	Inlet	11534	8068	-1.11	-2.21
	Outlet	24300	25930		
Mn	Inlet	245	217	0.82	0.86
	Outlet	43	31		
Pb	Inlet	7.84	5.81	0.83	0.75
	Outlet	1.37	1.48		
Zn	Inlet	278	151	0.70	0.43
	Outlet	84	86		

Excellent treatment of all metals except Ca and Mg. Leaching of Cl^-

Ca and Mg leaching from dolomitic limestone aggregate used beneath the PICP

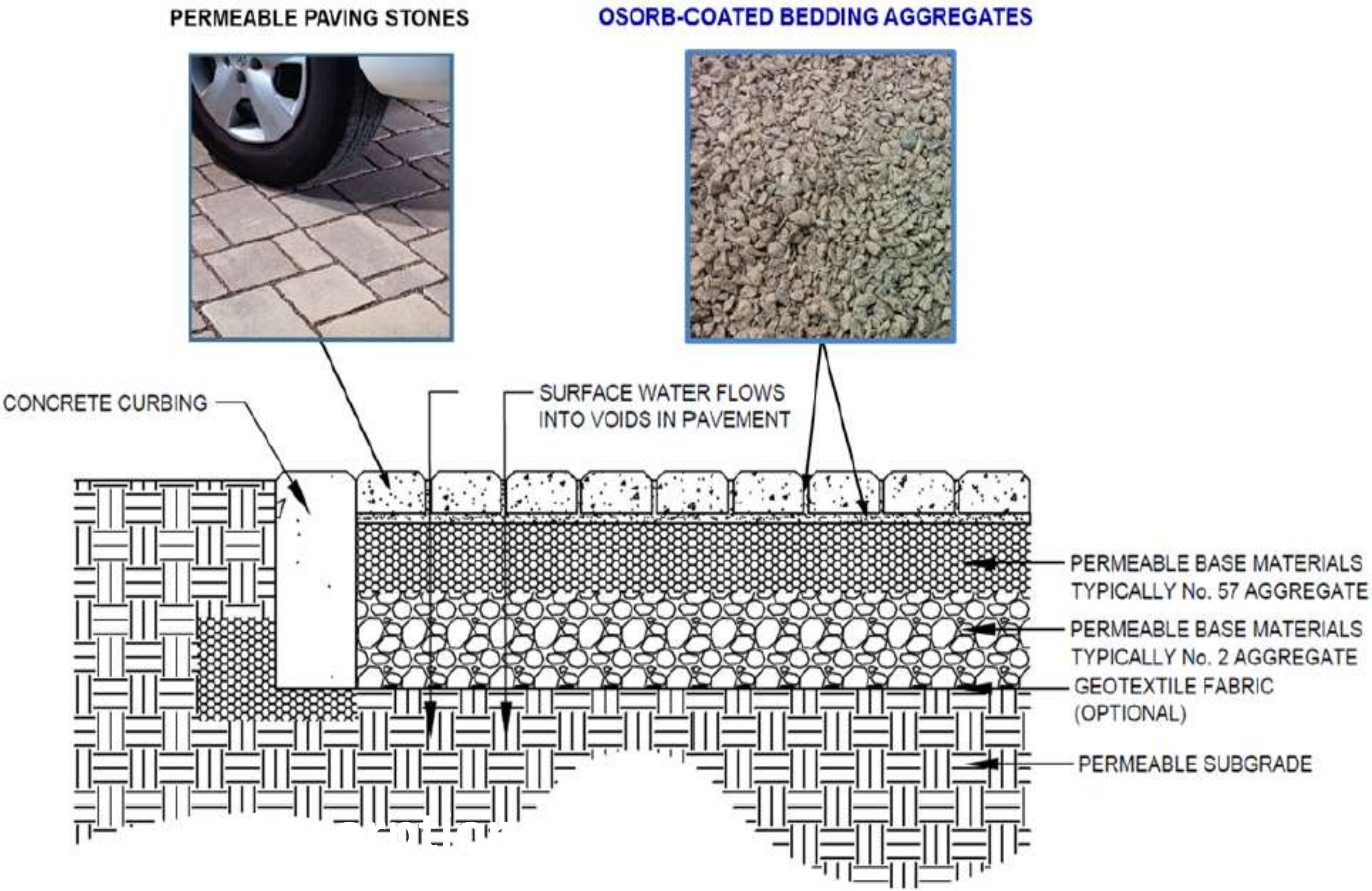


- Load reduction >80% for all metals except Ca, Mg, and Cl^-

Summary

- Generally excellent treatment of nutrients, sediment, and metals from treatment train
  - Filtration by PICP
  - Settling within PICP aggregate and cistern
- Only 16% volume reduction due to lack of water use – leak to native soils
- 2015 – continue monitoring
- 2016 – bring water indoors for toilet flushing & continue monitoring (pending funding)

Industrial Water Quality Treatment

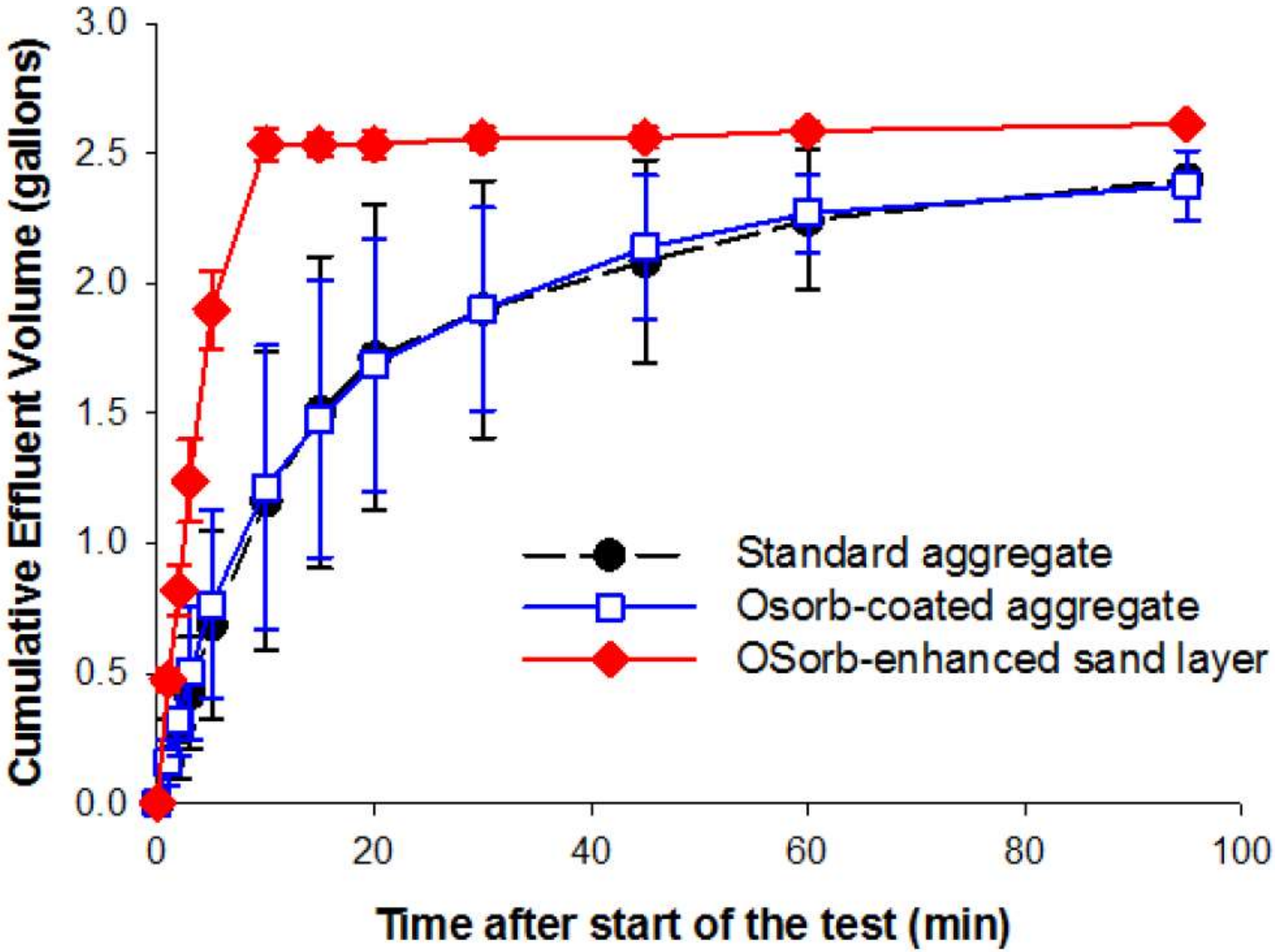


Pollutant Loading

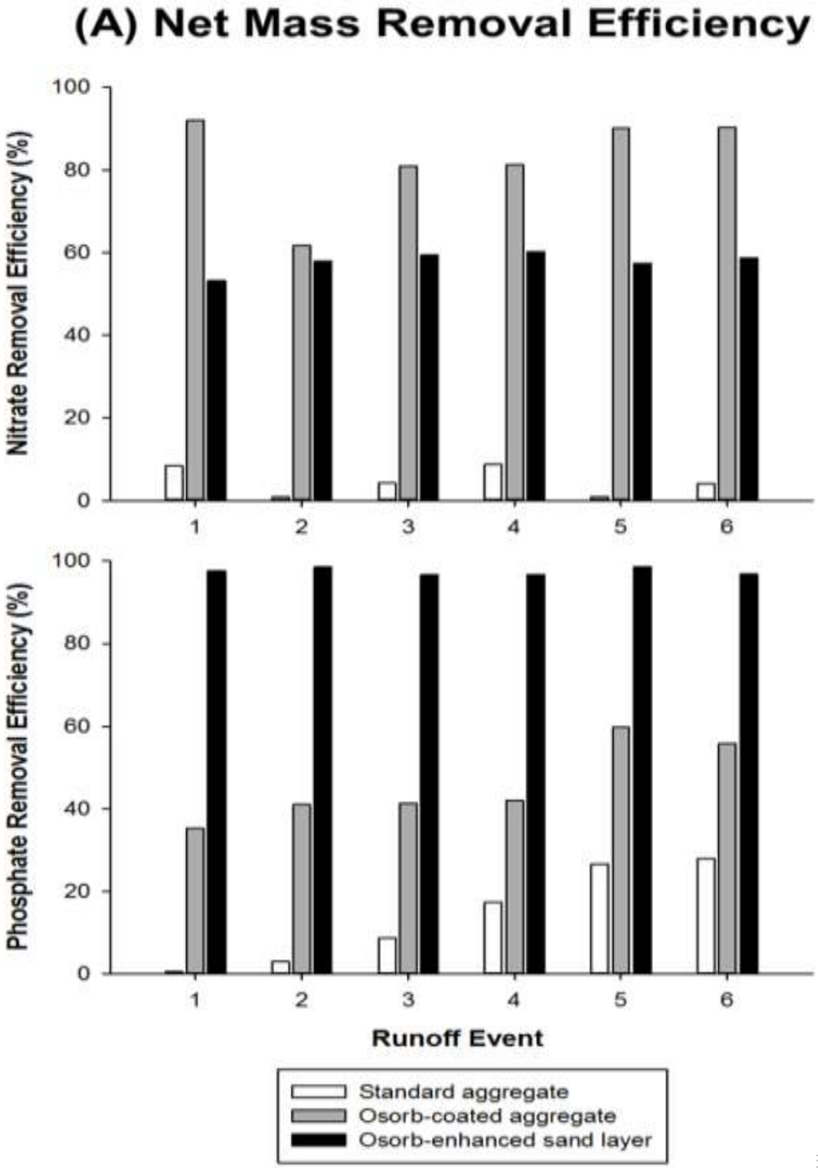
Table 1. Spiked solution pollutants and concentrations

Pollutant	Concentration (ppm)	Reagent
Copper (Cu)	2	$CuSO_4$
Lead (Pb)	1	$PbCl_2$
Zinc (Zn)	2	$ZnCl_2$
Nitrate-N (NO_3-N)	2	$NaNO_3$
Phosphate-P (PO_4-P)	1	$NaH_2PO_4H_2O$
Naphthalene	0.1	$C_{10}H_8$

Hydraulic Performance

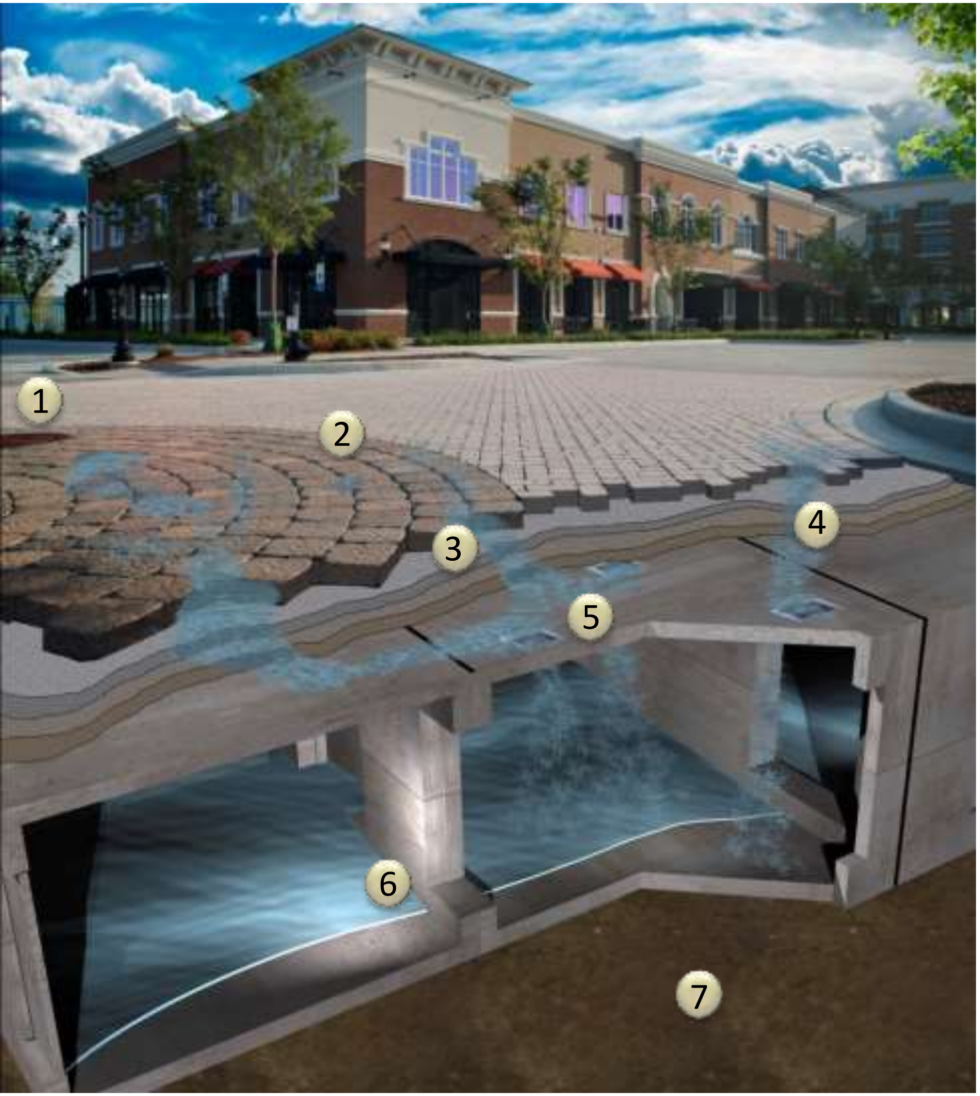


Pollutant Removal



Nutrient Treatment
Metals Treatment
VOC Treatment

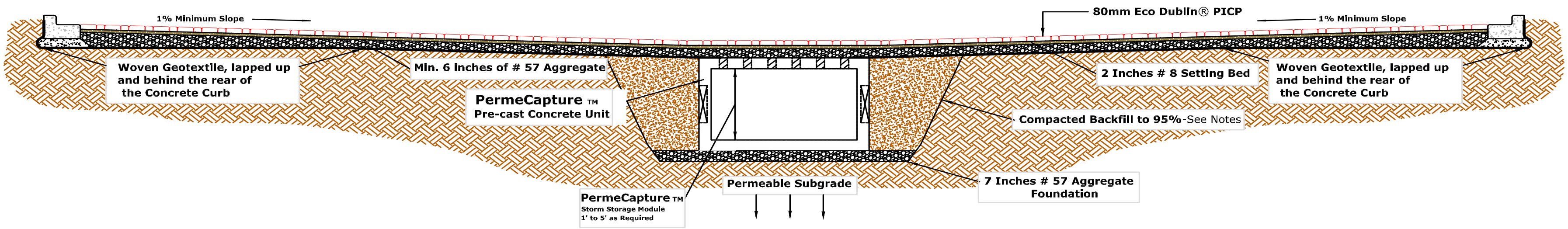
PermeCapture™ Stormwater Management System



1. Maintenance Access
2. Permeable Pavers
3. Drainage Aggregate
4. Permeable Base
5. HydraPorts™
6. Storm Capture Modules
7. Subgrade Soils

Patent Pending

Villas Altazoa- Scottsdale, AZ



OLDCASTLE ARCHITECTURAL, INC.
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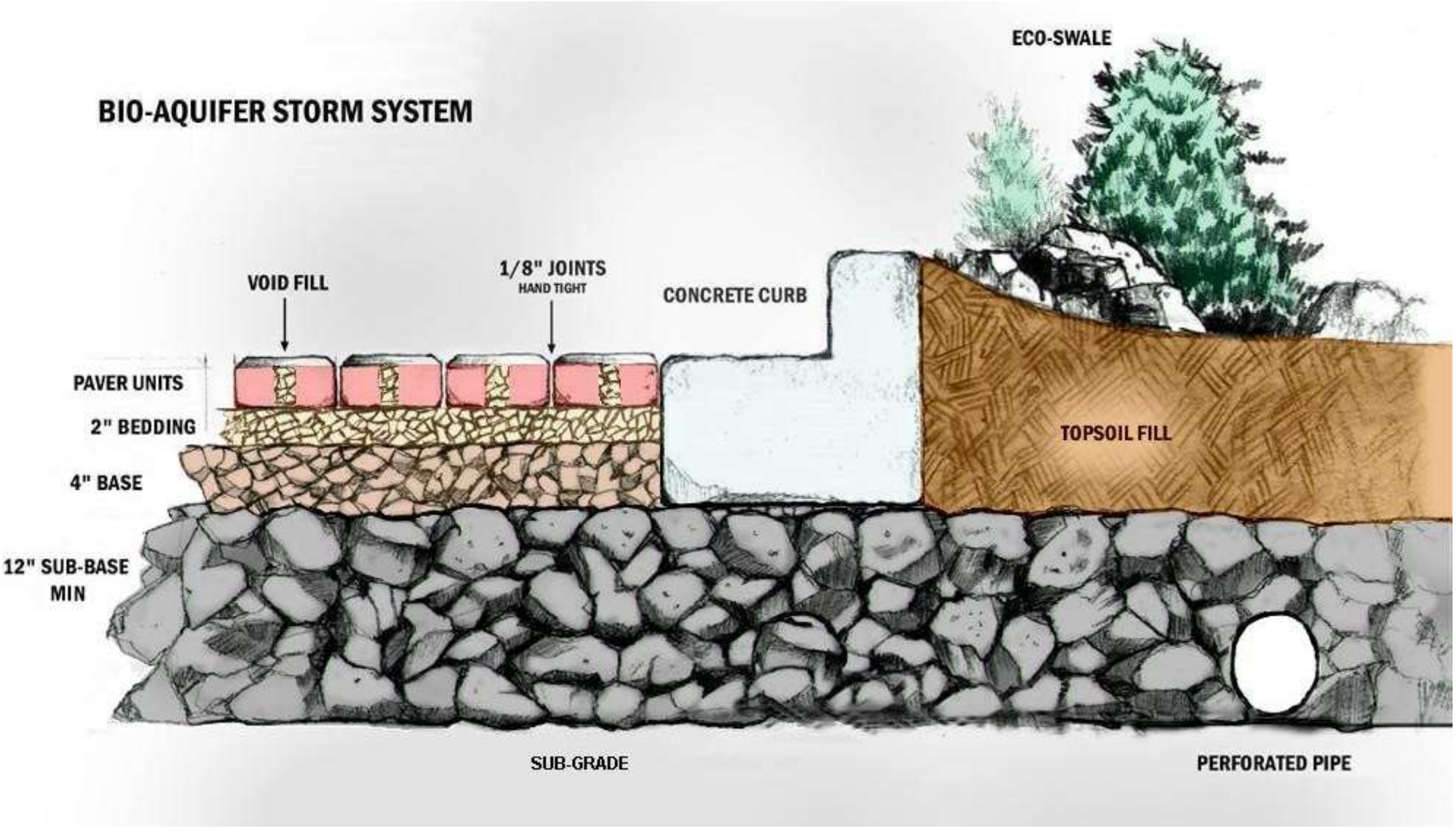
PermeCapture TM Pre-cast Storm Storage Module w/ 80mm Eco Dublin® PICP Pavement Surface Cross Section Detail

This cross section drawing is intended for preliminary design purposes only. The actual structural design and site evaluation shall be performed by a qualified Professional Engineer. Oldcastle accepts no liability for the improper use of this detail.

Stormwater Management



Remedial Maintenance

Estimated 15-20 year cycles

Vacuum Type Sweeper

Schmutzedecke

Morton Arboretum Workshop
Dr. Wm. Hunt-NCSU 2009

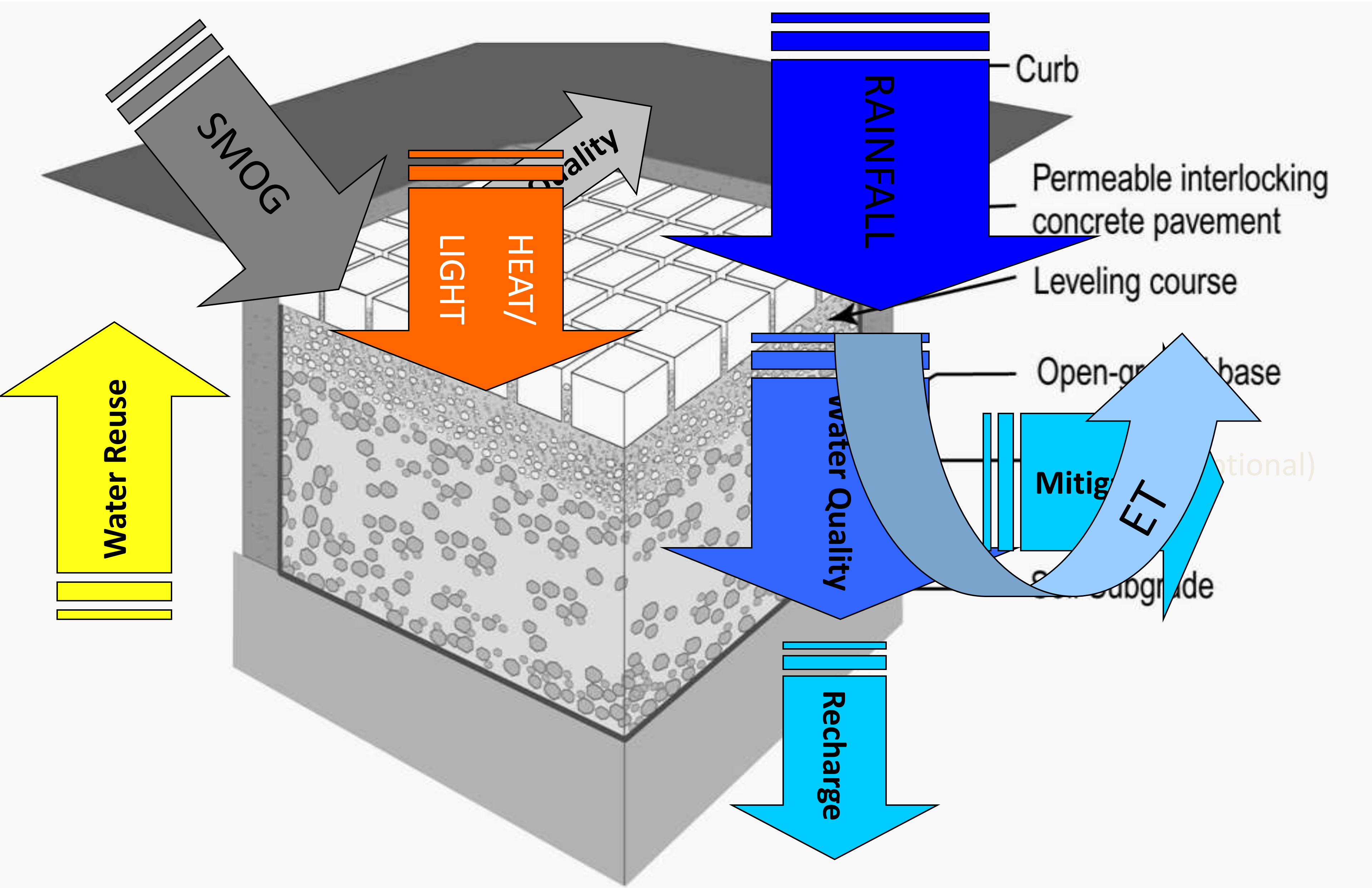
Sediment travel limited to 1”-1 ½”

Sedimentation Travel

Forensic Documentation

CA-16 **Seven Years** **CA-7**

BEST Multi-Tasking Eco-Machine



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This concludes The American Institute of Architects
Continuing Education Systems Program

For more information contact:

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