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Civil Engineering
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Planning

WSU & Puget Sound Partnership Permeable Pavement LID Workshop
Operations and Maintenance

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Introduction

- Maintenance begins during the Planning Phase
- Is it different?
- “The maintenance of LID facilities is essential to ensure that design stormwater management and other benefits continue over the full lifecycle of the installation.”
- What to look for?
  - Drainage
  - Safety
  - Aesthetics
- Training for Maintenance
  - Homeowner, Private vs Public Crews
- Long term infiltration capacity can remain high even with clogging, however……

Inform crews about protecting porous pavements

- Cover pavement with tarp if need to stockpile material
- Maintain cover

Maintain Stabilization of Adjacent Areas

- Proactive vs. reactive
- Address the source

Maintain Adjacent Vegetation

- Ground Cover Migration
  - Where fragaria species (strawberry) or other fast-spreading ground covers are planted adjacent to porous pavement, the ground cover may spread too aggressively and root in the pavement.
  - This migration is of particular concern with porous paving, as the ground cover will establish, collect sediment and reduce the pavement's function.
- Options for Maintenance
  - Modify planting plan and remove invasive plants
  - Maintain adjacent landscaping
  - Weed burners

Ground cover migration happens even with conventional pavement.

Moss Growth

- Be careful with expectations
- Moss is present regardless of pavement type in PNW
- Remove IF it starts to affect performance or safety
- Some is okay
- If severe, options for removal:
  - Pressure washing (concrete)
  - Weed burner
  - Sweeping (during dry periods)
- During planning, consider impacts of shade to maintenance frequency

Above: Pervious Concrete City Sidewalk with moss

Right: Non-Pervious Concrete urban sidewalk with moss

Staining of pavement

Staining from compost spilling onto pervious concrete.

- Applies to pavers, asphalt, cement concrete. Same as conventional pavements.
- During construction, keeping pervious concrete covered for curing & protection can lead to some discoloration but fades with time.
- Avoid placement of organic/compost material on pavement.

Snow Removal

- Avoid sanding since it will clog the system, except in cases of emergencies/ safety issues (vacuum sediment as soon as possible after melt).
- Avoid sanding adjacent streets since tires will track it onto the porous pavement.
- UNH reported up to 75% decrease in salt use but it will depend on site conditions (shade, location etc)
- Design subbase for drainage.
- No salt on pavement in 1st year. (APWA 10-22-08 porous pavement webinar)
- Installed in much colder climates such as Iowa, Pennsylvania, Colorado, Ohio, Lake Tahoe.

Parking Lot, Denver, CO – Next AM Following 12” Snow

Sites directly across street

(Photos: 5 min. differential max)

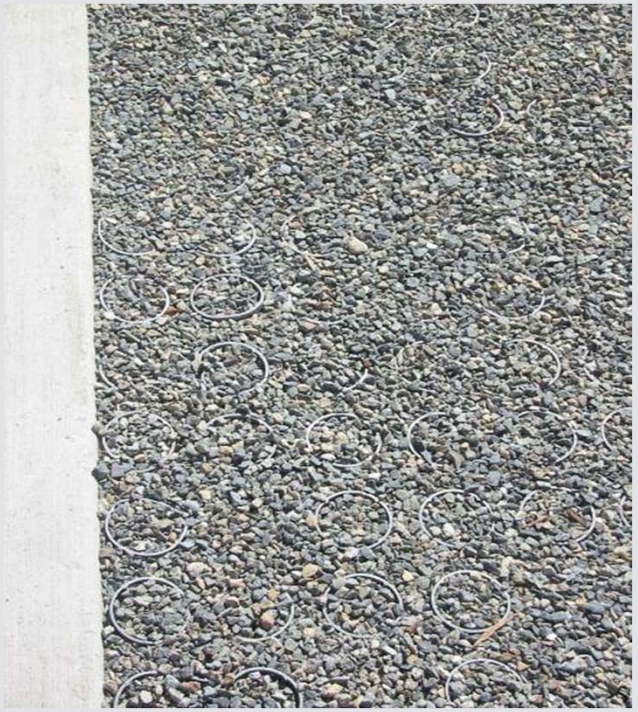
Pervious Concrete

Conventional Asphalt

Heavy snow regions: Modifications required for plow height during snow removal

Photos courtesy of National Ready Mixed Concrete Association and Slide courtesy of Center for Portland Cement Concrete Pavement Technology, 2005 via John Kevern at National Concrete Pavement Technology, Iowa State University

Routine Maintenance: Plastic Geocells



- Maintenance:
  - Sweep Gravel into stalls 1x/month or as needed
  - Remove and replace gravel if becomes clogged
- Material:
  - GravelPave^2 from Invisible Structures, Inc.
  - Ring and Grid structures filled with ¼” minus with 6” depth of 5/8” minus gravel subbase
  - Mats pinned down per manufacturer installation requirements

Open-Celled Paving Grids

Fire lane/Maintenance road for housing site.
Geoweb® Cellular Confinement system

- Follow manufacturer guidelines for replacing sections of cells
- May have non-uniform vegetation growth if used regularly for parking or driving over where the sun does not shine & water is scarce
- Requires mowing/landscape maintenance
- May need occasional reseeding

Maintenance road using TurfStone® over 1 ½” to 2” sand and 6” of crushed rock w/o fines

Permeable Interlocking Pavers

- Maintenance:
  - Remove and replace paver grids when repairs or utility cuts are needed
  - Replace gravel when needed
- Project Notes:
  - Developer: Lyle Homes
  - Prime: Mithun
  - Private Residential Drive
  - Pavers through Mutual Materials
  - Pavers over 3” Bedding Course and 10” Base Course for this installation
  - Quick Installation 4’x4’ Grids
  - Gap at joints

Permeable Interlocking Pavers/Gravel Filled Geocells

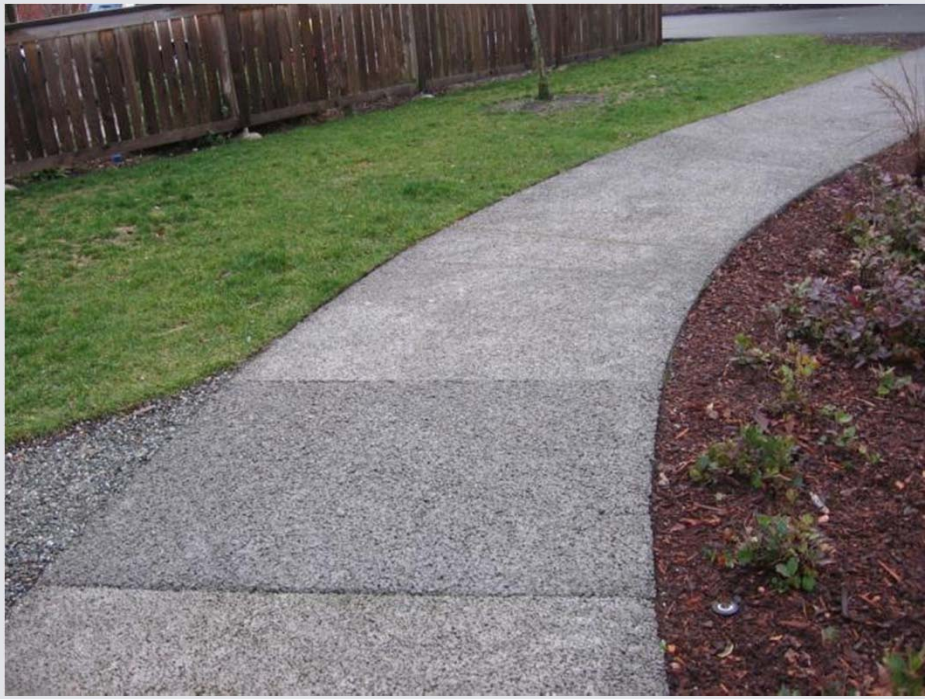
- Remove weeds if they start to affect performance
- Some is okay
- Aesthetics
- Do not use herbicides etc. to remove. WQ facility.
- Hand removal
- Vinegar (small applications)

Porous Asphalt

- No AC overlay/black topping
- Vacuum sweep (annually or more or less frequent depending upon stabilization of adjacent areas)

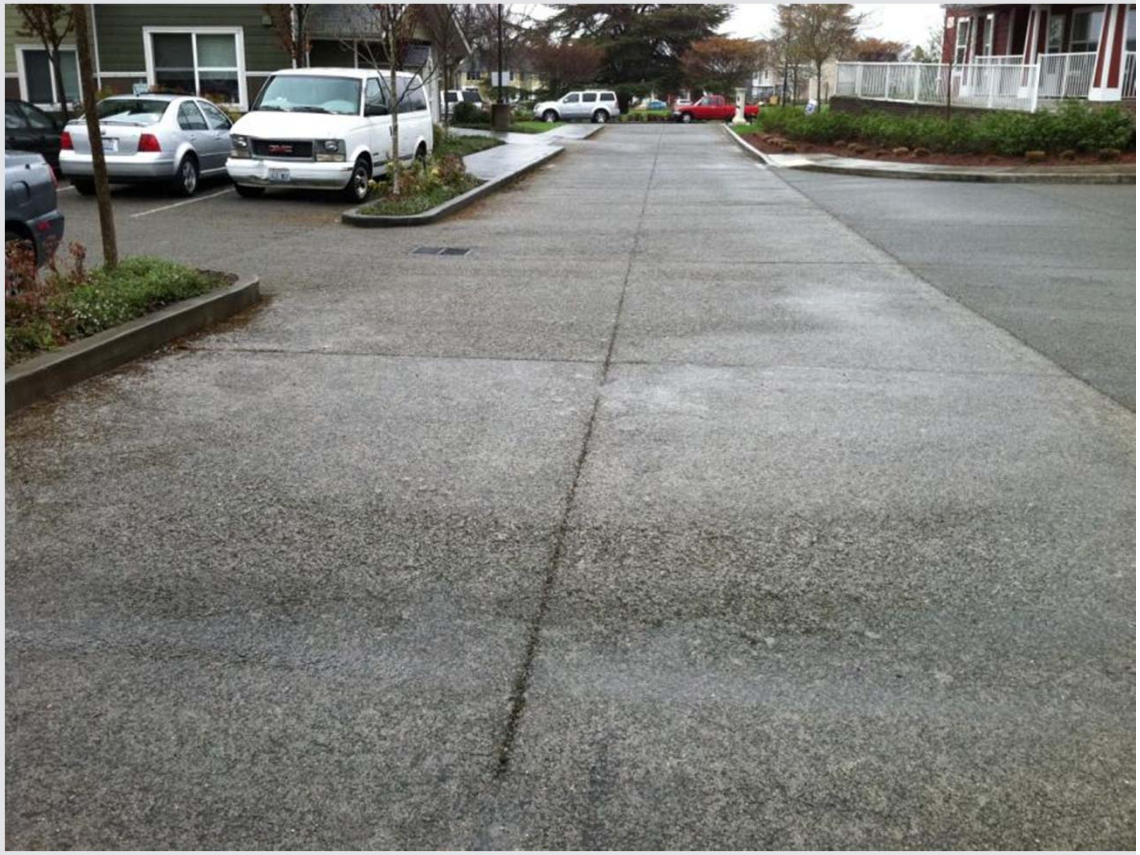
Utility Cut Protocols

- Implement measures to protect adjacent porous facility to remain
- Patch with same porous material
  - Full panel replacement
- Use temporary patch until full panel can be replaced



O&M – Check Overflow/Back-up System

- What is the flow path if water does not infiltrate?
- Verify that overflow system is not plugged



Structural Damage

Higher loading than designed for?

Not installed per manufacturer requirements?

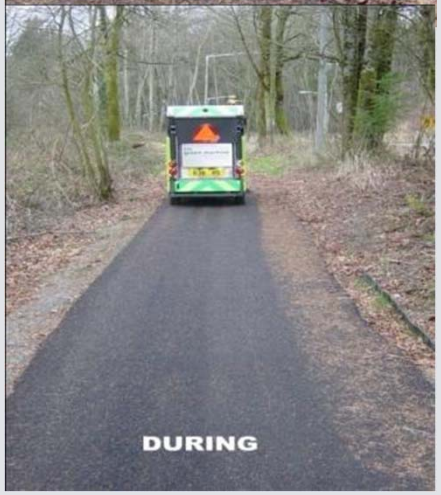
Pedestrian sidewalk driven over by vehicles?

- Determine source of damage and inform others
  - Not used as intended?
  - Installed incorrectly?
  - Other?
- Repair section to nearest joint
- Replace full depth?
- Experience…..Sub work out? or have maintenance crew trained in repairing porous sections?

O&M: Sediment removal for porous asphalt /pervious concrete

- Vacuum sweep annually (Frequency depends on adjacent areas)
- Follow manufacturer guidelines for mechanical equipment. Dry weather.
- Pressure washers. Test small area first.
- Pine needles (sap) are difficult to remove
- Don’t wait. Remove as soon as able if significant unforeseen/accidental sediment loading occurs.

- Preventive Maintenance can reduce frequency of vacuuming



Above photos from City of Bellevue

Equipment

- Porous Pavement Equipment – vacuum sweeper or vacuum sweeper & pressure washer
- Other Equipment used by others :
  - Dry broom and other hand tools for removing debris
  - Power Lawn Vacuum
  - Specialty Items
    - Flame weeders, Hot water weeders
    - Scrubbers (not as common)

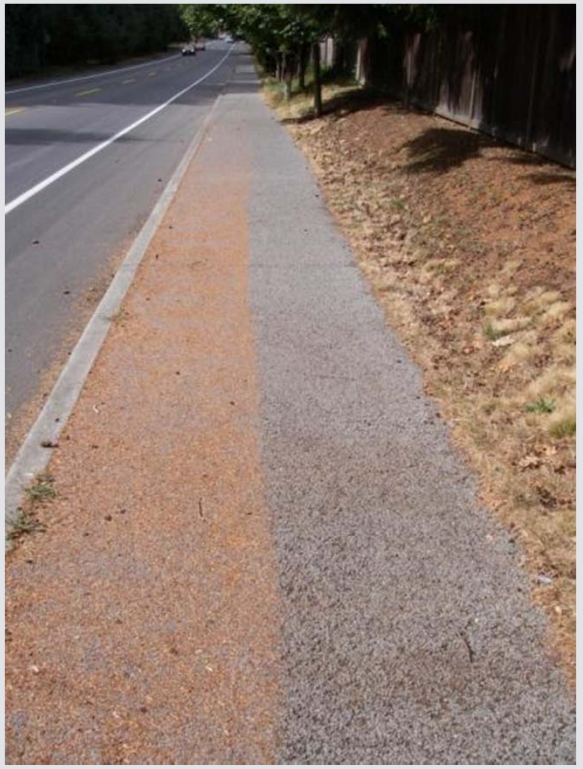
Before | During | After cleaning

Photos from City of Olympia

Equipment for cleaning porous pavements

Local studies: City of Olympia, pervious concrete & percocrete

- Some findings in report from Craig Tosomeen, Sept 2006:
  - "Leaf/Litter vacuums are more effective than sweepers with dust control vacuum systems"
  - Vacuum machine had difficulty removing leaf piles when they were more than 2 to 3 inches thick



Photos from Maintenance Memo from Craig Tosomeen, City of Olympia Photos from Maintenance Memo from Craig Tosomeen, City of Olympia using Leaf/Litter Vacuum (Minuteman Parker Vac-35) September 2006 to clean pervious concrete sidewalk installed in 1999.

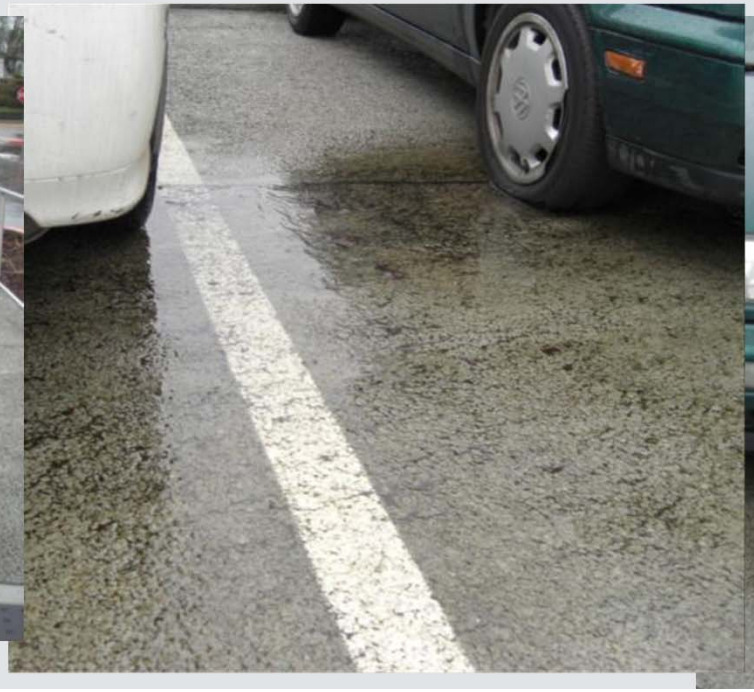
Example of Maintenance Equipment from Portland OR

- N. Gay Avenue & Westmoreland projects, Portland OR
- Pavers, porous asphalt and pervious concrete public streets
- 1 to 2x / year - Vacuum sweepers used to collect fines:
  - Tymco's 500x
  - Schwarze's A7000
  - Elgin's Crosswind J-Plus
- Infiltration test of porous asphalt, pervious concrete and pavers
  - Flusher truck spray water over pavement (calculate rate & area)
- "vegetation growth in pavers did not appear to hinder infiltration on Rex St." (~63 in/hr)
- Source: Brett Kesterson, Portland, OR at APWA porous pavement webinar (10-22-08)

Photos from Portland OR at http://www.apwa.net/cll/docs/HandoutsPP.pdf

Monitoring

- Annually check infiltration vs. clean when no longer infiltrating
- Some have put off maintenance until surface ponding is observed
- Annually check overflow subsurface drains to make sure functioning and not blocked
- Check water level in observation ports (if used – cleanout with perforated/slotted pipe extending to native subgrade) in pavement section subbase during dry weather or 24 hours after rain event
- Have an annual inspection checklist in the maintenance manual.



Replacement

- If routine maintenance and cleaning not done and unable to restore infiltration rates, partial or full reconstruction may be required
- Assess % of area impacted

Above photo from http://www.lcrep.org/fieldguide/examples/permeablepavers.htm

Develop Maintenance Schedule & Manual for Crews & Implement

High Point Natural Drainage Maintenance Schedule At-A-Glance

	Applies to All Landscaped Areas [Natural Drainage System (NDS) and Non-NDS]												NDS Areas					Non-NDS Areas ONLY		Pond
	Remove Trash	Remove Leaf and Branch Debris	Mow Lawn	Redefine Lawn Edge	Trim Lawn	Weed Lawn Areas Including Swales	Aerate, Overseed and Topdress Lawn	Trim Planted Areas Along Paved Edges	Weed Planted Areas	Groom Perennials and Grasses	Prune Trees and Shrubs	Irrigation System	Apply Compost Mulch and Compost Tea	Sweep Porous Cement Concrete Walks	Vacuum Porous Cement Concrete Walks	Sweep Gravel Back into Gravel Pave Areas	Vacuum Sediment, Refill Gravel Pave	Add Medium Bark Mulch	Fertilize	Pond Maintenance
January	1 time/ week	1 time/ month								See grooming schedule, High Point Maintenance Manual, Section 2.4e				1 time/ week		1 time/ month				See Pond Operations and Maintenance Manual in Pond section of binder
February	1 time/ week	1 time/ month	1 time						swales 1 time		late dormant season			1 time/ week		1 time/ month				
March	1 time/ week	1 time/ month	2 times	1 time	1 time	1 time			beds 1 time pond 1 time		late dormant season		tea- 1 time March thru...	1 time/ week		1 time/ month		after 1st weeding	mixed plantings 1 time early spring	
April	1 time/ week	1 time/ month	3 times		2 times	1 time	1/3 spring and/or fall				post bloom season			1 time/ week		1 time/ month			lawn - 1 time late spring	
May	1 time/ week	1 time/ month	3 times	1 time	2 times	1 time		1 time			post bloom season	system start up		1 time/ week		1 time/ month				
June	1 time/ week	1 time/ month	weekly		3 times	1 time			beds, swales and pond 1 time			manual walk-thru.		1 time/ week		1 time/ month				
July	1 time/ week	1 time/ month	weekly	1 time	3 times	1 time					prune suckers in summer	manual walk-thru.		1 time/ week		1 time/ month	1 time/ 3 years		mixed plantings 1 time mid grw. seas.	
August	1 time/ week	1 time/ month	weekly		3 times	1 time			beds 1 time			manual walk-thru.		1 time/ week	1 time	1 time/ month				
September	1 time/ week	1 time/ week	weekly	1 time late Sept. OR...	3 times	1 time		1 time	swales 1 time pond 1 time			manual walk-thru.		1 time/ week		1 time/ month		after last weeding	lawn - 1 time early fall	
October	1 time/ week	1 time/ week	3 times	... early Oct.	2 times	1 time	1/3 spring and/or fall				bleeding sap pruning season			1 time/ week		1 time/ month				
November	1 time/ week	1 time/ week	2 times		1 time									1 time/ week		1 time/ month				
December	1 time/ week	1 time/ month												1 time/ week		1 time/ month				

Maintenance Inspection Sample Check List

- ✓ Is emergency overflow clear?
- ✓ Structural damage?
- ✓ Is gravel filled to the surface in the geocells or between pavers?
- ✓ Is system draining? (next slide)
- ✓ Other
  - ✓ Weed, moss growth not excessive ?
  - ✓ Have issues previously noted been addressed?
  - ✓ Other?

Bring: camera, measuring tape, as-builts, previous reports, checklist, equipment to conduct infiltration test, tools to remove cleanouts, etc

✓Is system draining?

- ✓ Observe during rain to check overall
- ✓ Is there runoff from the surface?
- ✓ Is water still ponding on the surface 1 hour after rain has stopped?
- ✓ If inspecting during dry weather, run cylinder infiltration tests over multiple areas or run hose over surface

- ✓ Is there ponding water in the observation port 24 hours after the rain has stopped?


Photo taken 4/6/2013, Built 2008


Photo taken 4/6/2013, Built 6/2005

Interdepartmental & Interagency Agreements

- Determine WHO will do maintenance during planning/design phase. Transportation? Utilities? Private Developer? Varies with jurisdiction.
- Inform staff and document location in records for maintenance, future improvements in vicinity and utility cuts.
  - GIS mapping of infiltration facilities?
  - Continuously inform with staff turnover
- Schedule staff accordingly: Inspection of systems is preferred during rain events but maintenance equipment more effective during dry periods
- Document what materials are required for repair (no white/black topping, use clean subbase)
- Develop agency annual inspection checklist (examples on web)
- Inform public of its location.

QUESTIONS?







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Resources (1 of 2)

- American Concrete Institute's Specification for Pervious Concrete Pavement ACI 522.1-08 www.concrete.org
- National Ready Mixed Concrete Association Pervious Concrete Publications www.nrmca.org
- "Freeze Thaw Resistance of Pervious Concrete," National Ready Mixed Concrete Association, May 2004. www.nrmca.org
- "Pervious Concrete Contractor Certification," National Ready Mixed Concrete Association, August 2005. www.nrmca.org
- City of Seattle Department of Planning and Development Client Assistance Memo #515. http://www.ci.seattle.wa.us/dclu/Publications/cam/CAM515.pdf
- LID Technical Guidance Manual for Puget Sound, http://www.psat.wa.gov/Publications/LID_tech_manual05/lid_index.htm
- Lower Columbia River Field Guide to Water Quality Friendly Development http://www.lcrep.org/fieldguide/examples/permeablepavers.htm
- City of Olympia www.olympiawa.gov/cityutilities/stormwater/scienceandinnovations/porouspavement.htm
- City of Portland 2008 Stormwater Management Manual, http://www.portlandonline.com/bes/index.cfm?c=47952&
- Delatte, Norbert, Dan Miller of Cleveland State University "Portland Cement Pervious Concrete Pavement: Field performance Investigation on Parking Lot and Roadway pavements, Final Report" to RMC Research & Education, December 1, 2007.
- Dierkes, Carsten, Lothar Kuhlmann, Jaya Kandasamy, George Angelis. Abstract: "Pollution Retention Capability and Maintenance of Permeable Pavements". Presented at Global Solutions for Urban Drainage: 9th International Conference on Urban Drainage. Portland, OR. September 2002.

Resources (2 of 2)

- Dietz, Michael E. “Low-Impact Development Practices: A Review of Current Research and Recommendations for Future Directions”. Springer Science + Business Media B.V. 2007.
- “Porous Pavements,” by Bruce K. Ferguson, Taylor & Francis Group, 2005.
- “Pervious Concrete Pavement” by Paul D. Tennis, Michael L. Leming and David J. Akers and Portland Cement Association and National Ready Mixed Concrete Association, 2004.
- “NC State University Permeable Pavement Research: Water Quality, Water Quantity, and Clogging,” Eban Z. Bean, EL, PhD Candidate and William F. Hunt, PhD, PE, NWQEP Notes, North Carolina State University, Number 119, November 2005.
- “Long-Term Stormwater Quantity and Quality Performance of Permeable Pavement Systems,” by Benjamin O. Brattebo and Derek B. Booth, July 1, 2003, Center for Water and Watershed Studies, Department of Civil and Environmental Engineering, University of Washington at http://depts.washington.edu/cwws/Research/Reports/permeableparking.pdf
- Pervious pavement in cold climates: http://www.perviouspavement.org/asphalt%20vs.concrete.htm
- “Maintenance Guidelines for Porous Pavements” University of New Hampshire, Stormwater Center http://www.unh.edu/erg/cstev/pubs_specs_info/winter_maintenance_fact_sheet.pdf
- City of Bellevue Natural Drainage Practices Maintenance Guidelines & Checklists www.bellevuewa.gov/pdf/Utilities/Natural_Drainage_Practices.pdf http://www.bellevuewa.gov/preventing_water_pollution.htm
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