Sustainability Initiative: 01-02

STORMWATER MANAGEMENT

PERMEABLE PAVEMENT: ADAPTING TO STORMWATER MANAGEMENT CHALLENGES

Drake University

The Greater Des Moines Partnership

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Impermeable surfaces, such as streets, parking lots, and sidewalks, prevent stormwater from seeping into the ground, and force it into a city's storm sewers and eventually into streams, rivers, and lakes. This leads to flooding, pollution, and increased water treatment and maintenance costs. By replacing impermeable surfaces with permeable ones, these negative effects can be mitigated, saving money and improving local environmental conditions.

WHAT ARE PERMEABLE PAVEMENTS?

Permeable pavements include surfaces such as pervious concrete, porous asphalt, and paving stones. Permeable pavements are an economically and environmentally beneficial alternative to conventional pavements. While conventional pavements collect stormwater on their surface and drain it to storm sewers, permeable pavements allow stormwater to seep through their surface and into the soil beneath, taking advantage of the natural filtration process.

Permeable surfaces serve the dual purposes of reducing costs and environmental harms—all while lowering the risk of flooding.

COST OF PERMEABLE PAVEMENTS

As detailed further at the end of this document, the cost of permeable pavements - especially in the long-term - can be comparable to or even less expensive than traditional pavements. While the current research indicates that the short-term, initial cost of permeable pavement may, in some cases, be more expensive than impervious pavement, that same research suggests that permeable pavement may last longer and has fewer costs associated with maintenance, resulting in an overall decrease in costs over the life of the pavement. Importantly, these studies do not calculate the added savings in having less water flow through municipal systems.

BENEFIT OF PERMEABLE PAVEMENTS

Permeable pavements reduce runoff volumes from intense rain events by 70 to 90 percent, making flooding less likely, reducing incidents of hydroplaning, generating cost savings in infrastructure sizing, construction, and maintenance, and reducing stormwater utility fees. Pollutants in the water are filtered through the underlying soil, reducing costs associated with water treatment. And because permeable pavements drain directly through the surface, they are less susceptible to the freeze/thaw cycle. This means there is less need for salting, frost heave and the need for patching is greatly reduced, and dangerous black ice is far less prevalent.

WHAT IS OUR PROPOSAL?

Our proposal seeks to address many of the challenges above by requiring some permeable surface coverage in new parking lots that are built over the minimum parking requirements. Included in the code changes are a definition of permeable surfaces, a standard for maintenance of permeable surfaces, and a waiver of the permeable surface requirement if the site's soil-type does not support permeable surfaces.

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MODEL ORDINANCE NO. _______________ (Permeable Surfaces)

AN ORDINANCE to amend the Municipal Code of the City of ___________, Section XXX-XXX [applicable code pertaining to water drainage on parking lot surfaces], by requiring permeable surfaces to be used in the construction of parking lots of a certain size, creating a definition of permeable surface, and allowing the [*APPROPRIATE CITY OFFICIAL OR OFFICE*] to approve site plans which replace retention ponds with permeable surfaces.

Be It Ordained by the City Council of the City of _____________:

Section 1. That the Municipal Code of the City of ___________, Section YYY-YYY [applicable definitions section], is hereby amended by adding the following definition:

> *"Permeable Surface" means an area paved with porous asphalt, pervious concrete, open jointed blocks, or other materials designed to allow infiltration of at least 50 percent of surface runoff during a typical rain event into an underlying stone reservoir that temporarily stores surface runoff before it infiltrates into the subsoil.*

Section 2. That the Municipal Code of the City of ___________, Section ZZZ-ZZZ [applicable section relating to paving], is hereby amended by adding a new Section AAA-AAA with language set forth as follows:

> *Section AAA-AAA Paving. Any off-street parking area designed to accommodate four or more vehicles shall comply with the permeable surface requirements set forth in Section CCC-CCC.*

Section 3. That the Municipal Code of the City of ___________, Section WWW-WWW [applicable section to retention ponds], is hereby amended by adding a new Section BBB-BBB with language set forth as follows:

> *Section BBB-BBB Parking lots, retention ponds, and permeable surfaces. Parking lot and retention pond drains shall be installed as directed by the* [*APPROPRIATE CITY OFFICIAL*] *and in accordance with the approved site plan, a copy of which shall be available on the job site. The* [*APPROPRIATE CITY OFFICIAL*] *may approve a site plan that substitutes a retention pond with a permeable surface that accommodates the same or a greater volume of stormwater.*

Section 4. That the Municipal Code of the City of ___________, Section UUU-UUU [applicable section pertaining to parking lot construction], is hereby amended by adding a new Section CCC-CCC with language set forth as follows:

> *Section CCC-CCC Permeable Surfaces.*

(a) At least 25 percent of the surface area of a parking lot that exceeds the required parking minimum by 25 percent or less shall be a permeable surface.

(b) A parking lot that exceeds the required parking minimum by more than 25 percent shall be paved with a permeable surface over an area of the lot equivalent to the percentage of excess parking in the lot.

(c) Maintenance. Permeable surfaces shall be swept with a high-efficiency vacuum sweeper at least once a year. If the permeable surface used is porous asphalt or porous concrete, then the surface shall be cleaned with a high-pressure hose following a high-efficiency vacuum sweeping at least once every other year.

(d) Records. The owner of a parking lot shall keep at least five (5) years of written documentation of all cleaning and make them available to [*APPROPRIATE CITY OFFICE*] *upon request.*

(e) Waiver. The requirements of this section may be waived by [*APPROPRIATE CITY OFFICE*] *if a Certified Professional Soil Scientist's inspection of an intended parking area concludes it is unsuitable for a permeable surface.*

Section 5. This Ordinance shall be in full force and effect from and after the later of its passage and publication as provided by law.

Section 6. That the City Clerk is hereby authorized and directed to cause certified copies of this ordinance and proof of publication of this ordinance to be properly filed in the office of the [County Recorder]:

FORM APPROVED:

Citations and References

Drake Law Students Eric Schultz, Krissa LeLaSheur, Katelyn Bries,
Stormwater Management: Sustainable Best Practices for Improving Des Moines Parking Lots, available at, http://www.law.drake.edu/newsEvents/docs/2012-sustainability-report.pdf.

Frequently Asked Questions, Pervious Pavement, available at, http://perviouspavement.org/faqs.html.

Kenneth Justice, Pervious Concrete: The Concrete that Drinks (2011), available at, http://water.rutgers.edu/Conference2011/JusticePresentation.pdf.

Northwestern Connecticut Council of Governments. Model Zoning Regulations for Parking for Northwestern Connecticut, Fitzgerald & Halliday, Inc. (Sept. 2003).

Porous Pavement Fact Sheet – US EPA, available at, http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=137&minmeasure=5.

Stephen J. Gaffield, Robert L. Goo, Lynn L. Richards & Richard J. Jackson, Public Health Effects of Inadequately Managed Stormwater Runoff, American Journal of Public Health 93:9 (Sept. 2003).

U.S. EPA, Green Parking Lot Resource Guide, EPA-510-B-08-001(Feb. 2008).

USGS, Earth's Water: Runoff, available at, http://ga.water.usgs.gov/edu/runoff.html.

For an example of permeable paving streets, parkway bioretention, and cobble infiltration beds, see
Charles City, IA Downtown Permeable Streetscape, Green Infrastructure & Stormwater Management,
Case Study, American Society of Landscape Architects, http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20191%20Charles%20City%20Downtown%20Permeable%20Streetscape,%20Charles%20City,%20IA.pdf.

Examples of relevant codes:

City of San Francisco Planning Department, Guide to San Francisco Landscaping Ordinance (2010), available at, http://www.sf-planning.org/ftp/files/publications_reports/Guide_to_SF_Green_Landscaping_Ordinance.pdf.
Hernando Cty., FL, Ordinance 2001-11(G).
Kansas City, MO, Zoning and Development Code, § 88-420.
Metropolitan Council, MN, Urban Small Sites BMP Manual, available at, http://www.pca.state.mn.us/water/pubs/sw-bmpmanual.html.
Model Zoning Regulations for Parking for Northwestern Connecticut (2003), available at, http://www.nwctplanning.org/ParkingStudyPhase2.pdf.
Navassa, NC, Zoning Ordinance, Art. 10.
New Jersey Stormwater Best Management Practices Manual (2004), available at, http://www.njstormwater.org/bmp_manual/NJ_SWBMP_9.7.pdf.

Analysis of Off-street Parking Requirements

Summary

The following is a summary of existing studies concerning the short-term and long-term costs associated with permeable pavement. As the studies cited and discussed below indicate, permeable pavement provides a long-term cost savings over comparable impervious pavement options. The current research indicates that the short-term, initial cost of permeable pavement may, in some cases, be more expensive than impervious pavement. However, that same research suggests that permeable pavement may last longer and has fewer costs associated with maintenance, inlets, pipes, and detention pools, resulting in an overall decrease in costs over the life of the pavement. Importantly, we were unable to find a study that factored in or considered cost savings stemming from a reduced flow of stormwater when using permeable pavement. If water flows through permeable pavement are accurate, local governments stand to save additional costs by reducing the volume of water entering the municipal stormwater system, potentially resulting in less maintenance and associated costs.

Analysis

The current research indicates the initial, upfront cost of permeable pavement to be, in some cases, more expensive than impervious pavement. A paper from the U.S. Department of Transportation, Federal Highway Administration (FHA) found the cost of permeable asphalt is approximately 10 to 15 percent higher than the cost of traditional asphalt, and the cost of permeable concrete is about 25 percent higher than the cost of traditional concrete.[1] Similarly, the University of Minnesota found the comparable upfront costs associated with different permeable pavement types to be (per square foot, installed):

- $0.50-1.00 for permeable asphalt,
- $2-6.50 for porous concrete,

[1] U.S. Department of Transportation, Federal Highway Administration, *Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring,* available at http://environment.fhwa.dot.gov/ecosystems/ultraurb/3fs15.asp.

- $1.50-5.75 for a grass reinforcing system, and
- $5-10 for interlocking concrete paving blocks.[2]

The Virginia Department of Environmental Quality also found the cost for various permeable pavement types to vary from $.50 to $10.00 per square foot,[3] and the University of Maryland citing an EPA study found the following costs per square yard: $23.01 for hot mix asphalt, $31.00 for porous asphalt, $60.75 for porous concrete, and $104.32 for porous pavers.[4]

While the upfront costs may be higher when using permeable pavement, a fact sheet from Rutgers University, The State University of New Jersey, suggests that permeable pavement has fewer costs associated with inlets, pipes, and detention pools.[5] The Rutgers fact sheet notes that permeable pavement provides economic benefits by increasing the utilization of property (i.e. area used for detention ponds can be used for another function) and by lowering life cycle costs due to its increased durability and better freeze-thaw performance.[6] As set forth in the Rutgers paper, Table 1, below, demonstrates potential expenditures associated with permeable versus traditional pavements.

[2] Peter Moe, *Permeable Paving,* Minnesota Landscape Arboretum (2009), *available at* http://www.arboretum.umn.edu/porouspaving.aspx.
[3] Virginia Department of Environmental Quality*, Virginia DEQ Stormwater Design Specification No. 7, Permeable Pavement, Version 2.0* (2013), *available at* http://chesapeakestormwater.net/download/3284/.
[4] University of Maryland Extension, *Permeable Pavement Fact Sheet, available at* https://extension.umd.edu/sites/default/files/_docs/programs/master-gardeners/Howardcounty/Baywise/PermeablePavingHowardCountyMasterGardeners10_5_11%20Final.pdf, (*citing,* U.S. EPA, *Permeable Pavement Research*, EPA National Risk Management Research Laboratory, Edison New Jersey (Amy Rowe 2010)).
[5] Amy Rowe, *Green Infrastructure Practices: An Introduction to Permeable Pavement,* Rutgers, The State University of New Jersey (February 2012), *available at* http://njaes.rutgers.edu/pubs/publication.asp?pid=FS1177.
[6] *Id*.

Table 1[7]

Expenditure	**Permeable pavement**	**Traditional pavement**
Surface material	✓	✓
Aggregate	✓	✓
Installation	✓	✓
Inlets	NA	✓
Conveyance pipes	NA	✓
Detention pond	NA	✓
Acreage for detention pond	NA	✓

The FHA paper mentioned above also notes that the higher cost of permeable pavement can be offset by the elimination of other costs associated with traditional pavement projects, such as curbs, gutters, and storm drains.[8] A paper from Kitsap County Public Works in Kitsap County, Washington on the cost of permeable pavement contains similar findings, stating:

> Permeable pavement may cost a bit more than conventional pavement to install. However, the total infrastructure cost will be less, because fewer stormwater pipes and catch basins will need to be constructed, making permeable pavement a cost-effective way to manage stormwater.[9]

Finally, a fact sheet from the Interlocking Concrete Pavement Institute and the Low Impact Development Center notes that projects using permeable interlocking concrete pavers (a kind of permeable pavement) have less replacement, detention/retention, and storm sewer system costs associated with them, making those projects cost-competitive with traditional pavement projects.[10] As an illustration, the Interlocking Concrete Pavement Institute set forth the following table:

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[7] *Id*.
[8] *See* FHA, *supra* note 1.
[9] Kitsap County Public Works, *Permeable Pavement Fact Sheet* (2012), available at http://www.kitsapgov.com/sswm/pdf/Permeable_Pavement.pdf.
[10] Interlocking Concrete Pavement Institute, *Permeable Interlocking Concrete Pavement (PICP): Residential and Commercial Developers Fact Sheet* (2008), *available at* http://ncsu.edu/picp/FactSheets/Developers-PICP.pdf.

Table 2

Item (2006 prices)	**PICP (permeable interlocking concrete pavers)**	**Concrete**	**Asphalt**
Paving/ft^2 (/m²)	2.25 (24.21)	8.00 (86.08)	3.00 (32.28)
Excavating/ft^2 (/m²)	1.00 (10.76)	1.00 (10.76)	1.00 (10.76)
Stone/ft^2 (/m²)	2.00 (21.52)	1.50 (16.14)	1.50 (16.14)
Installation/ft^2 (/m²)	4.00 (43.04)	(in paving cost)	1.50 (16.14)
Curbs/ft^2 (/m²)	1.50 (16.14)	1.50 (16.14)	1.50 (16.14)
Maintenance/ft^2 (/m²)	0.20 (2.15)	0	Not known
Replacement/ft^2 (/m²)	None	None	Every 12 years
Detention/Retention required	None	Yes	Yes
Storm Sewer System/ft^2 paving	None	3.00	3.00
Total/ft^2 (Total/m²)	**10.95 (117.82)**	**15.00 (161.40)**	**11.50 (123.74)**

A presentation given at Rutgers University in 2011 illustrates the potential cost savings that can be realized in permeable pavement projects.[11] The presentation outlined the costs for a 100,000 square foot parking lot paved with permeable concrete and an identical lot paved with asphalt. [12] The presentation noted that while traditional asphalt may have less upfront costs than permeable concrete ($355,000 for pervious concrete versus $285,000 for asphalt), an asphalt project results in longer-term higher costs ($355,000 for pervious concrete versus $530,000 for asphalt):[13]

[11] Kenneth Justice, *Pervious Concrete,* PCA Northeast Cement Shippers Association (2011), *available at* http://www.water.rutgers.edu/Conference2011/JusticePresentation.pdf.
[12] *Id*.
[13] *Id*.

Material	Cost
6" **pervious concrete** + 12" aggregate recharge bed (installed)	**$355,000**

Material	Cost
4" **traditional asphalt** + 8" aggregate base	$285,000
Inlets	$25,000
18" pipe	$85,000
One acre detention pond with land cost	$135,000
	Total: $530,000

A number of case studies also outline the cost savings permeable pavement projects offer. A case study by Clean Water Services, a public utility in Oregon that installed a permeable pavement parking lot at its Field Operations Center, notes the cost of that project was offset in part by the elimination of catch basins and pipe conveyance systems, as well as by the longer lifespan as compared to traditional pavement.[14] The University of Rhode Island and Rhode Island Department of Health in 2008 completed a case study on two permeable parking lots at the university, concluding the construction costs of those projects were comparable to equivalent-sized conventional parking lots: [15]

> The costs of porous asphalt and conventional asphalt are approximately equal. The crushed rock, the material used for the recharge bed in the porous pavement system, usually costs more than a conventional lot's compacted subbase, but this expense is typically offset by the significant reduction in stormwater pipes and inlets. The topsoil that is removed for the stone recharge bed can be used elsewhere on site for landscaping, which diminishes the need for purchasing additional soil. Furthermore, because detention basins are not required for porous parking lots, as they are for their

[14] Clean Water Services, *Slow the Flow: Designing the built environment to protect urban watersheds* (2004), *available at* http://www.cleanwaterservices.org/Content/Documents/Permit/Slow%20the%20Flow%20brochure.pdf.
[15] The University of Rhode Island Cooperative Extension in partnership with the Rhode Island Department of Health Source Water Protection program, *The University of Rhode Island's Permeable Parking Lots: A Case Study of Alternative Pavement Materials* (updated Feb. 2008), *available at* http://www.uri.edu/ce/wq/nemo/Publications/PDFs/PP.URI.updatedversion.Feb2008.pdf.

> conventional counterparts, porous pavement systems can be a viable economic option.[16]

Permeable pavements save money in other ways as well.[17] Because they are less susceptible to surface freezing, there is less need for salting, plowing, and patching, and they have been found to be safer than traditional pavements.[18] Permeable pavements also alleviate many other economic costs associated with traditional pavements, including storm sewer maintenance, flooding, water pollution and treatment, drought, urban heat, and air pollution.[19]

Kitsap County has found permeable pavement projects can work well for over 20 years, due in part to being less prone to ice buildup.[20] A report from the U.S. Environmental Protection Agency found the lifespan for permeable pavements to be even greater, and more than double that of conventional pavements in northern climates:

> [permeable pavements] tend to develop fewer cracks and potholes than conventional asphalt pavement. When cracking and potholes do occur, a conventional patching mix can be used. Freeze/thaw cycling is a major cause of pavement breakdown, especially for parking lots in northern climates. The lifespan of a northern parking lot is typically 15 years for conventional pavements; porous asphalt parking lots can have a lifespan of more than 30 years because of the reduced freeze/thaw stress.[21]

Local governments stand to avoid significant costs through permeable pavement projects by reducing the volume of water entering the municipal stormwater system. The Interlocking Concrete Pavement Institute notes permeable pavements can reduce runoff volumes from intense rain events by 70 to 90 percent, making flooding less likely, generating cost savings in infrastructure sizing and construction, and reducing stormwater utility fees by reducing peak flows.[22] And the EPA notes that "permeable pavement transforms areas that

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[16] *Id*.
[17] *See* Rowe, *supra* note 5.
[18] *Id*.
[19] *Id*.
[20] Kitsap County Public Works, *supra* note 9, at 2.
[21] EPA, *Porous Asphalt Pavement,* (last updated September 10, 2009), *available at* http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm.
[22] Interlocking Concrete Pavement Institute, *supra* note 10 at 4.

were a source of stormwater to a treatment system and can effectively reduce or eliminate runoff that would have been generated from an impervious paved area."[23]

In 2010, Charles City, Iowa replaced streets in a 17-block area of the town with permeable pavement to address nuisance flooding, improve water quality, and reduce runoff volumes.[24] The project, which included bioswales, reduced peak discharges for a 10-year storm event by over 90 percent, and reduced the need for replacement of existing storm sewers.[25] Along with these benefits, the project also reinforced the city's "green" image.[26] The city has since approved two similar permeable pavement projects covering 15 more blocks.[27]

It is generally accepted that permeable pavement must be cleaned at least twice a year in Northern climates, or permeability will decrease.[28] A report prepared for the Wisconsin Department of Transportation estimates the cost of vacuum sweeping a half-acre parking lot three to four times a year is $400.00 to $500.00.[29] Other charges associated with permeable pavement that should be taken into account include using appropriate deicers instead of sand and salt, and learning how to adjust snowplows accordingly.[30]

Conclusion

A survey of current research on permeable pavement indicates that permeable pavement projects may have a higher upfront cost than traditional pavement projects.

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[23] EPA, *supra* note 21.

[24] American Society of Landscape Architects, *Green Infrastructure & Stormwater Management Case Study: Charles City Downtown Permeable Streetscape, available at* http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20191%20Charles%20City%20Downtown%20Permeable%20Streetscape,%20Charles%20City,%20IA.pdf.

[25] *Id*.

[26] *Id*.

[27] Cedar Rapids Globe Gazette, *Charles City OKs another permeable paving project, available at* http://globegazette.com/news/local/charles-city-oks-another-permeable-paving-project/article_6eb018e2-99f0-11e1-8654-001a4bcf887a.html.

[28] Rowe, *supra* note 5, at 4.

[29] CTC & Associates LLC, WisDOT Research & Library Unit, *Comparison of Permeable Pavement Types: Hydrology, Design, Installation, Maintenance and Cost* (2012), available at http://socwisconsin.org/wp-content/uploads/2012/10/TSR-2011-permeable-pavements.pdf.

[30] University of Rhode Island and Rhode Island Department of Health, *Permeable Pavement: What's It Doing On My Street?* (November 2005), *available at* http://www.uri.edu/ce/wq/NEMO/Publications/PDFs/PP.WhatsItDoingOnMySt.pdf.

However, that same research suggests that permeable pavement lasts longer, has fewer associated infrastructure costs, requires less maintenance, is safer than traditional pavement and does not require detention ponds. When those avoided costs are taken into account, the research indicates the cost of permeable pavement projects – especially in the long-term - can be comparable to or even less expensive than traditional pavement projects.

This document is the product of a collaboration between the Greater Des Moines Partnership and Drake University Law School. The document was drafted by the Partnership's Senior Vice President Meg Fitz, Professor Jonathan Rosenbloom and Drake Law students Andrew Duffelmeyer, Kelsey Knight ('14) and Derek Moran ('12). If you have any questions, please contact us at: jonathan.rosenbloom@drake.edu or mfitz@desmoinesmetro.com