September/October 2014 | Volume 19 | Number 5

AsphaltPavement.org

ASPHALT PAVEMENT

PUBLISHED BY THE NATIONAL ASPHALT PAVEMENT ASSOCIATION

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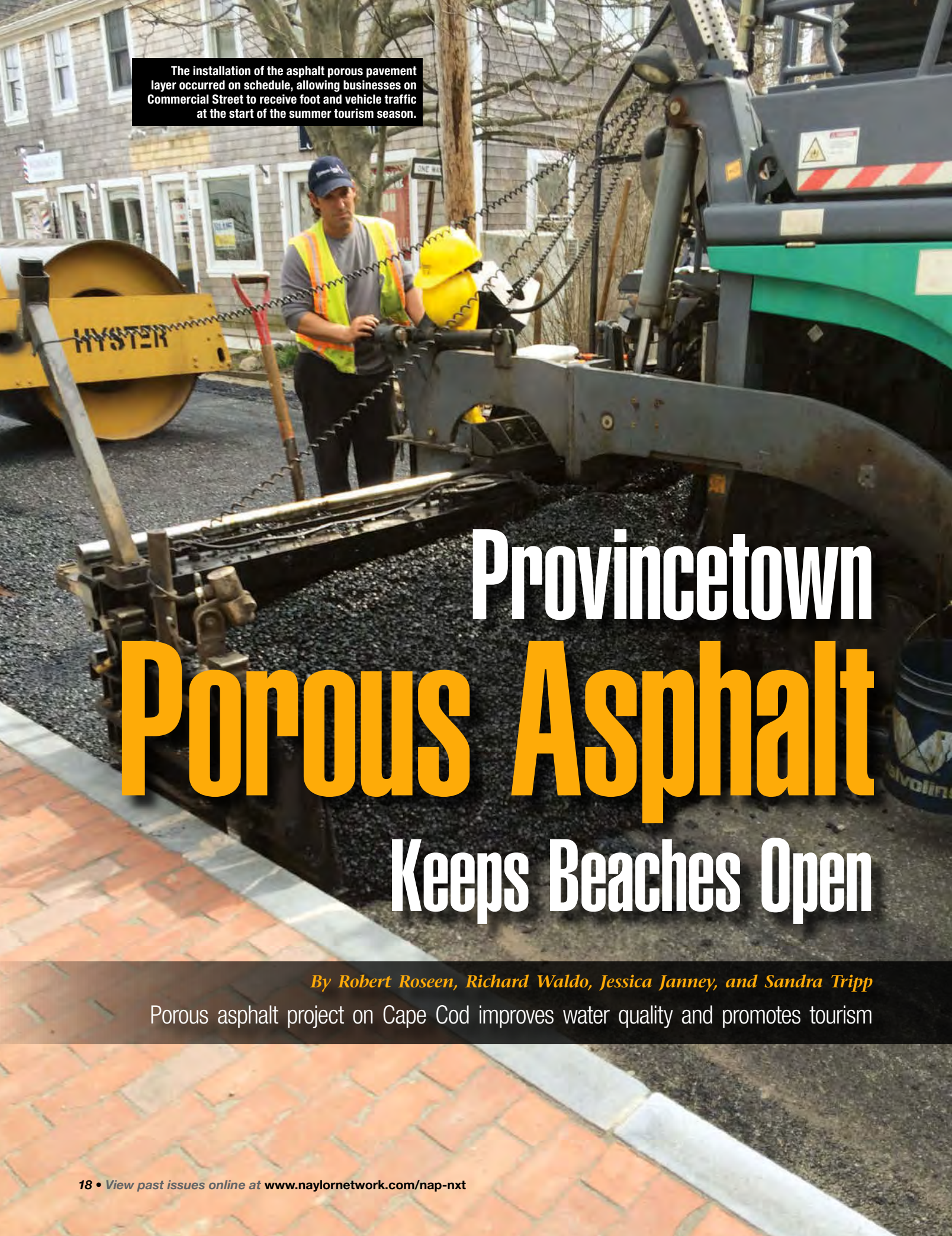

The installation of the asphalt porous pavement layer occurred on schedule, allowing businesses on Commercial Street to receive foot and vehicle traffic at the start of the summer tourism season.

Provincetown Porous Asphalt Keeps Beaches Open

By Robert Roseen, Richard Waldo, Jessica Janney, and Sandra Tripp

Porous asphalt project on Cape Cod improves water quality and promotes tourism

The porous asphalt project featured an infiltration trench and lateral impermeable liner.

The water quality benefits of porous asphalt pavement are well documented. They provide a tremendous reduction in pollutant concentration through filtration and in pollutant load by reducing runoff volume through infiltration.

For more than a decade, officials at the tip of Cape Cod have worked hard to make sure the waters of Provincetown Harbor were safe and swimmable. But despite investing millions in new sewer collection systems, each summer bacteria levels attributed to stormwater runoff would exceed the bathing beach standard and beaches would close sporadically.

For a town whose economy is tied to open beaches and summer fun, a solution had to be found. Provincetown chose to replace the town's main beachfront street with a porous asphalt road — and the benefits were seen right away.

Commercial Street hugs the beaches of Provincetown Harbor and is home to hundreds of tourism-related businesses. On a busy summer day, more than 100,000 people descend upon Provincetown and about 40,000 of them can be found walking along Commercial Street.

For a beach community like Provincetown, water quality is an important issue that affects more than just the marine habitats, it also affects tourism and economic development. Closed beaches due to stormwater waste contamination don't help communities promote tourism.

The U.S. Environmental Protection Agency's Region 1 covering New England began an effort in the early 2000s to improve water quality monitoring and to better notify the public about pollution problems in coastal waters. Ryder Street Beach, intersecting Commercial Street along Provincetown Harbor, was singled out as a flagship project in EPA's New England Clean Beach Initiative.

When a storm would cross the Cape, beaches in Provincetown Harbor would regularly experience beach closures due to high levels of bacteria. Ryder Street Beach experienced high levels of fecal coliform bacteria on these occasions, forcing the town to close the beach. Most of these incidents were attributed to septic system failures, marine sanitary wastes, and pet waste. Working with EPA, Provincetown replaced antiquated septic systems, fixed broken sanitary sewers, and constructed a new waste treatment facility. The town also initiated a public education effort encouraging people to pick up after their pets. The results were noticeable, but the Barnstable County Department of Health and Environment still had to close Ryder Street Beach 16 times in 2011 and seven times in 2012.

A stormwater assessment was completed, which identified the outfalls that discharge untreated stormwater from Commercial Street and other streets into the harbor. Water and sewer installations and repairs made along Commercial Street over the past decade had left the roadway in poor condition. Dense development and large impervious surface areas contributed to runoff into the harbor.

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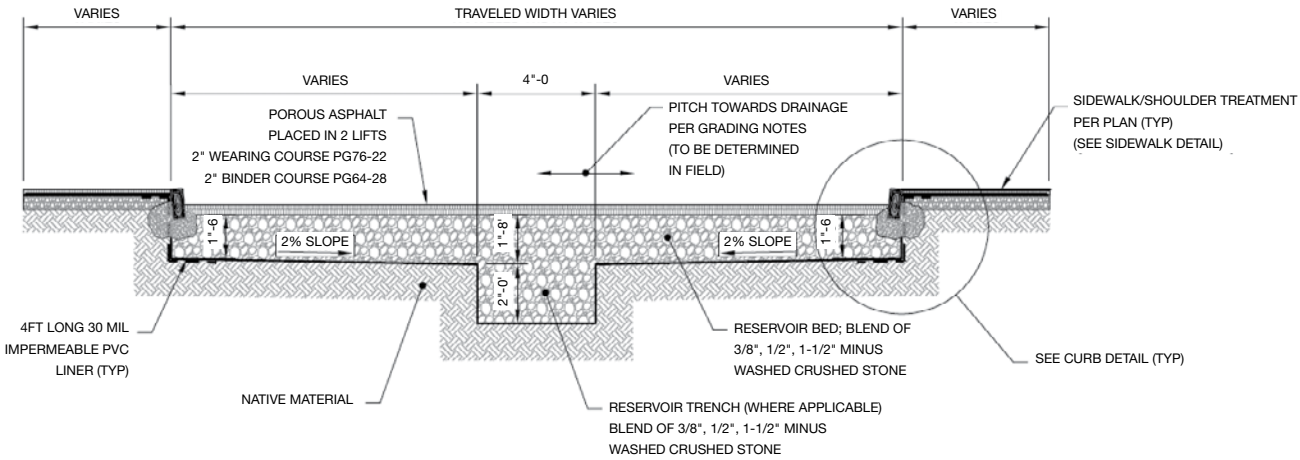
Porous asphalt pavement prevented stormwater runoff onto the beaches and into Provincetown Harbor.

Commercial Street ready for business, rain or shine.



The construction occurred in stages. After the infiltration trench was excavated, a lateral impermeable liner was set in place to channel water away from sidewalks and building basements.

Provincetown officials decided to address the problems associated with Commercial Street's condition by choosing a pavement option that would also hopefully help with stormwater management — porous asphalt.

Porous Asphalt Overview

The water quality benefits of porous asphalt pavement are well documented. They provide a tremendous reduction in pollutant concentration through filtration and in pollutant load by reducing runoff volume through infiltration. Numerous studies have documented a substantial volume reduction on sites with poor soils and nearly 100-percent recharge for sites with soils that have even modest infiltration capacity.

Using porous pavement for new and redevelopment projects is a watershed-based strategy that can help meet new stormwater management requirements. Porous pavement mitigates the impact of new development and helps to reverse the impact in redeveloping areas because of its ability to cleanse and cool runoff, as well as reduce runoff volumes.

While open-graded surface treatments are widely used to wick water away from the surface of highways, full-depth porous asphalt pavement is less commonly selected for roadways, in part due to concerns about cost and maintenance. Provincetown felt, however, that modern materials and mix designs would provide them a porous pavement well suited to the demands of Commercial Street.

Below the Surface

Commercial Street's porous pavement design included 4 inches of porous asphalt underlain by an 18-inch minimum thickness reservoir bed, atop proof-rolled native sands. Although many porous pavement projects are constructed on soil, the coarse nature of the sand locks well when rolled while still allowing for infiltration.

To focus the water permeating the pavement away from abutting sidewalks and basement walls, the

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Funding the Provincetown Porous Pavement Project

Provincetown knew that it had to improve its water quality, but lining up funding for an ambitious reconstruction of Commercial Street was a challenge. The town chose a multistep funding strategy, tapping multiple funding streams, rather than attempting to gain all the needed funds upfront from one source.

The first step was a stormwater assessment funded by Massachusetts Office of Coastal Zone Management.

Phase I of the Commercial Street Roadway Reconstruction Project was designed and constructed with funding assistance from the MassWorks Infrastructure Grant Program under a Public Works Economic Development Grant. The total construction cost for the project was approximately $1.46 million, and included drainage improvements, sidewalk reconstruction, and installation of porous asphalt.

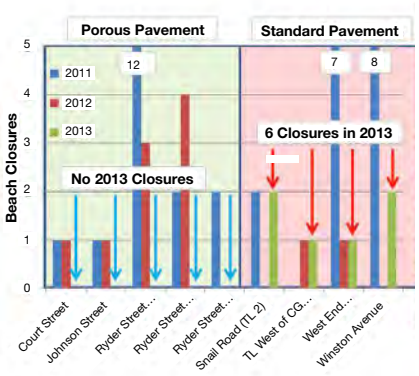
Phase II of the Commercial Street Improvements Project was just completed in May 2014, and was preliminarily designed with funding assistance from a Massachusetts Department of Environmental Protection 604(b) Water Quality Management Planning Program grant with final design and construction funded with assistance from a U.S. EPA Clean Water Act Section 319 Nonpoint Source Program grant. The project bid price was $1.92 million and included drainage and water improvements, sidewalk reconstruction, and installation of porous asphalt.

For Phase III of the project, the town received funding assistance through a second 604(b) Water Quality Management Planning Program grant.

roadbed included a 4-foot-wide by 2-foot-deep infiltration trench below the centerline of the road. The roadbed also incorporated an impermeable liner along the vertical walls of the pavement sub-base to prevent potential lateral migration under sidewalks and into buildings.

Geotechnical investigations were performed at 12 locations along Commercial Street, assessing depth to water and soil characteristics. The soils generally consisted of fine sands with a trace of silt. The depth to groundwater was greater than the depth of the proposed pavement section, and on average was 8.1 feet with a minimum of 4 feet and maximum of 15 feet. Hydraulic loading, groundwater table, and hydraulic mounding were evaluated for the common 1-inch storm and the extreme 100-year storm. Consideration was also given to potential hydraulic routing within pipe bedding to ensure that they would not act as an avenue for water to infiltrate basements.

The porous asphalt mix design chosen was based on the University of New Hampshire Stormwater Center Design Specification for Porous Asphalt Pavement and Infiltration Beds, in accordance with the National Asphalt Pavement Association's *Porous Asphalt Pavements for Stormwater Management: Design, Construction and Maintenance Guide*.



With completion of each phase, the water quality at beaches adjacent to the porous asphalt pavement had noticeably improved water quality, allowing for those beaches to remain open throughout the summer tourism season.

The Provincetown Department of Public Works divided the projects into three segments that could be completed around the summer tourism season.

A PG 76–22 asphalt binder modified with a styrene-butadiene-styrene (SBS) polymer was used, and the pavement was placed in two, 2-inch lifts. This is a very durable pavement suitable for high-traffic environments. A locally available reservoir bed was specified as a blend of 3/8-, 1/2-, and 1.5-inch minus crushed stone, which locks better than a single size of aggregate and allows for more void space. When tested, the bed for Phase I of the Commercial Street project had 38-percent voids.

Reconstruction Project

Commercial Street is a vital part of Provincetown's tourism economy. To minimize disruption for tourists and businesses alike, construction of the porous asphalt pavement was segmented into phases. Construction phasing can be very challenging for permeable pavements and requires special considerations. This was especially true for Provincetown, where it was necessary to schedule all work outside of the busy tourist season. To accomplish this, construction was scheduled mid-May through mid-October.

Phase I limits included Johnson Street to Winthrop Street, which is the section of Commercial Street that provides access to Fisherman's Wharf and MacMillan Wharf in Provincetown Harbor. Construction ran from Fall 2012 to Spring 2013, and included approximately 2,700 linear feet of porous pavement in the busiest downtown area of Commercial Street. Phase II, completed in Spring 2014, began where Phase I ended at Winthrop Street and stretched approximately 2,900 linear feet to the West End parking lot. Phase III, which is only in the design phase, will begin at Howland Street and end where Phase I began (Johnson Street).

On Phase I, the major road base reconstruction work, including installation of approximately 2 feet of washed stone and the binder course of asphalt, was installed by the end of December before winter temperatures would limit construction. The top layer, the porous wearing course, was installed in April and May of 2013. A similar timeline was used for Phase II, which ended in spring 2014.

The town of Provincetown notified residents and businesses in advance that the project would be the most disruptive project they had ever seen, and asked them to make plans according to the project schedule. Many preexisting conditions relating to narrow road width,

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difficulty meeting existing grades, and noncompliant property setbacks required great attention to detail.

In the end even the state's Architectural Access Board was satisfied that the project improved Commercial Street without affecting the character of the area. Construction required close coordination that was overseen by the Provincetown Department of Public Works (DPW), and was assisted by the town's engineering consultant GHD Inc.; Geosyntec; and the General Contractor, Robert B. Our Co. Inc.

Porous Asphalt Benefits

Despite the disruption, community response has been overwhelmingly positive to the project; residents were most delighted by the fact that their main tourism hub was getting a facelift. The reconstruction project provided Commercial Street with new sidewalks, curbing, and a new road surface.

It was not until a brief, yet intense, rainstorm that residents and business owners alike took notice of the special properties of this new asphalt. Merchants noticed that tourists no longer had to jump over standing water to reach their establishments. Similarly, residents commented that they no longer found themselves leaping away from passing vehicles to avoid being splashed as tires went through puddles.

When the final layer of the porous pavement for Phase I was placed, many pedestrians were confused as to whether or not the road was finished. The larger, open pores of the porous pavement were not what they were used to seeing. They questioned whether or not the rough appearance would affect the overall durability. With average daily summer foot-traffic reaching 40,000 tourists and several large delivery trucks, residents were concerned. However, after repeated exposure to sharp turning trucks and numerous parades, the durability concerns were answered. The pavement proved to be very durable and did not show any unusual signs of wear.

Open Beaches, Open for Business

The driver of Provincetown's economic vitality is the ongoing health of its harbor. The early indications are that this porous pavement installation has contributed to a tremendous reduction in beach closures.

In the years prior to the porous pavement installation, beaches at the five outfalls associated with Phase I of the Commercial Street project were closed 18 times in 2011 and nine times in 2012. Following the completion of Phase I, there were *no beach closures during 2013 at the beaches running parallel to the sections of Commercial Street rebuilt with porous pavement.* Outfalls adjacent to the beaches in the yet to be improved parts of Commercial Street had 15 beach closures in 2013.

Although the results were preliminary and other factors may have contributed to the drastic decline in beach closures, the project area results were impressive. Having a summer with zero beach closures has the residents jumping for joy and extending gratitude to town staff and engineers.

The 18-month installation was complicated, requiring a highly skilled contractor to work with narrow roadways, old building foundations, dense placement of utilities, and a tight construction calendar. A strong project team ensured a successful application of a permeable pavement with a focus on quality controls and a plan for long-term operations and maintenance.

Pavement durability has been exceptional with no visible pavement distress, as identified by raveling or rutting, despite regular heavy truck traffic supplying the businesses and routine bus traffic accessing the public pier. Provincetown employs nightly street vacuuming during summer months for trash and debris, which will contribute to the long-term hydrologic functionality of the permeable pavement. AP

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Tips for Porous Pavement Success

Porous asphalt pavement is an important stormwater management tool; however, its use does require careful planning. Specifically, successful installation generally requires four critical elements: 1) proper design including appropriate specification of pavement mix and sub-base construction; 2) strict quality control during pavement production; 3) proper engineering oversight during construction and pavement placement; and 4) long-term operations and maintenance plans.

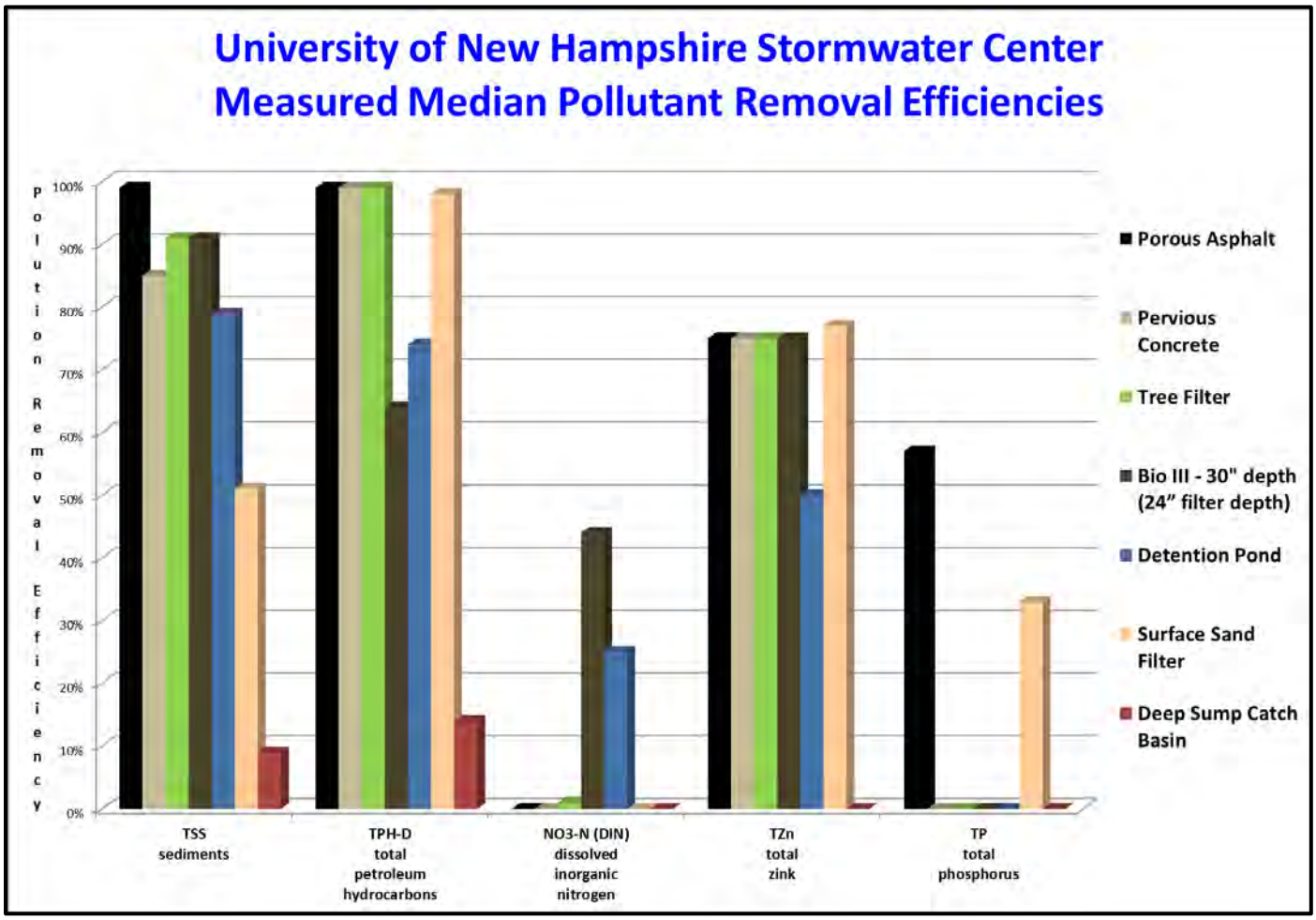
University of New Hampshire Stormwater Center

The University of New Hampshire Stormwater Center (UNHSC) is dedicated to the protection of water resources through effective stormwater management. The Center has four main focus areas:

- BMP Performance Testing
- Targeted Research
- Outreach and Education
- Design and Implementation

Center researchers examine and refine the performance of stormwater treatment systems to treat the pollution in stormwater runoff and reduce the flooding that it can cause. Targeted research examines cold climate performance, cost, design, maintenance, and other information needed to advance the practice and understanding of stormwater science. This research provides information which is then integrated into an outreach program for stormwater managers and professionals who seek to build programs that protect water quality, preserve environmental values, and reduce the impact of stormwater runoff. The Center receives funding and program support from the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), a partnership of UNH and the National Oceanic and Atmospheric Administration (NOAA), and other federal, state, and private sources. It is housed within the University's Environmental Research Group, a division of the College of Engineering and Physical Sciences.

The following graphic is taken from its 2012 biennial report. It compares the removal efficiencies of various types of BMP:



Asphalt - America's #1 Recycled Product

Maryland factoids:

Most new Maryland roadways incorporate at least 18% recycled aggregate and even higher amounts of binder.

The Maryland asphalt industry frequently recycles glass, newspapers, roofing shingles, tires, asphalt roadways, plastics, waste oil and other products often destined for landfills.

Major portions of the Inter County Connector (ICC) asphalt pavement used over forty percent recycled materials.

Premium asphalt mixes such as SMA and porous asphalts can now contain recycled materials.

Materials from local roadways can be incorporated into local highway projects. This eliminates the transportation of roughly 66,000 tractor trailer loads of aggregate and 3,000 tanker loads of asphalt binder. This reduces congestion on the roads, reduces consumption of diesel fuel and the related emissions, and saves valuable natural resources for future generations.

Ocean City recycles their glass during peak vacation periods by incorporating it into local asphalt roadways.

Reclaimed asphalt materials and Warm Mix technology saved US taxpayers more than $2.2 billion dollars in 2011 & even more today.