THE STORMWATER QUARTERLY

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PERMEABLE PAVEMENT FUNDAMENTALS

Stormwater News

Washington, D.C.— The U.S. EPA announced that $3 million is available through the Centers of Excellence for Stormwater Infrastructure Technologies grant program.

EPA is seeking applications to establish national Centers of Excellence for Stormwater Infrastructure Technologies to help expand stormwater infrastructure solutions across the country. The funding for these Centers of Excellence was made possible by the Bipartisan Infrastructure Law.

Once selected, the Stormwater Centers of Excellence will develop and enhance stormwater best practices by conducting research on new and emerging stormwater control infrastructure technologies and alternative funding approaches; providing technical assistance to state, Tribal and local governments; and collaborating with regional institutions.

Many communities struggle to address stormwater issues because of the costs associated with construction, operation and maintenance of the necessary infrastructure, and because their systems were built for the rain and storm patterns of the last century. In addition, a number of communities across the nation need practical stormwater technologies and the scientific understanding of those technologies to effectively implement stormwater management solutions.

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Permeable pavements are a stormwater control that allows stormwater to infiltrate through the surface of the pavement to the ground below—a green infrastructure alternative to traditional impervious surfaces. Types of permeable pavements include porous asphalt, pervious concrete and permeable interlocking concrete pavement (PICP).

Porous asphalt (sometimes called pervious, permeable, popcorn or open-graded asphalt) and pervious concrete

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NSWC Instructor Honored

It is with great honor that we announce the Harpeth Conservancy has awarded Mr. Paul Davis its 2023 River Steward Award! Paul served Tennessee's Department of Environment and Conservation for 40 years, 24 of which were as its Director of Water Pollution Control. For more than a decade Paul has been a valued instructor for National Stormwater Center.

Grace Stranch, CEO Harspeth Conservancy and Paul Davis, 2023 River Steward

Paul's depth and breadth knowledge of stormwater is unparalleled. His advocacy for Clean Water positively impacts the waters of the great state of Tennessee every day, through Paul's public outreach, and remaining active and involved in organizations such as the National Municipal Stormwater Alliance and the Water Environment Federation.

Join National Stormwater Center in celebrating Paul, his contributions to our nation's water, and his achievement as the 2023 River Steward Award Recipient!

Permeable Pavement Fundamentals

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(sometimes called porous, gap-graded or enhanced porosity concrete) are versions of traditional asphalt or concrete with reduced sand and fines to allow for greater porosity and infiltration. PICP consists of manufactured concrete units (pavers) with small openings between permeable joints that contain highly permeable, small-sized aggregates.

As with traditional pavement or concrete, construction staff install permeable pavements on a crushed stone aggregate bedding layer and base, which can also temporarily detain stormwater that has passed through the permeable surface layer. With proper installation, permeable pavements can serve as durable, low-maintenance and low-cost alternatives to traditional impermeable pavements.

Applicability

Permeable pavements can help achieve multiple benefits since they provide surfaces to move vehicular and pedestrian traffic and reduce stormwater discharges. They are suitable for municipal stormwater management programs and private development applications. For municipal applications, permeable pavements can reduce pavement ponding and local flooding by infiltrating stormwater on-site. Similarly, private development projects can use them to meet post-construction stormwater quantity and quality requirements. Permeable pavements can be especially helpful in developed areas with little open space that cannot accommodate post-construction stormwater controls requiring dedicated surface area. They can also reduce the need for additional expenditures and land use associated with conventional collection, conveyance and stormwater management infrastructure.

Permeable pavements can generally replace traditional impervious pavement in local roadways, pedestrian walkways, sidewalks, driveways, parking lots, and bike path applications. They may not be appropriate for certain high-volume and high-speed roadways, although permeable friction course overlays can reduce road ponding, splash and noise on these types of roadways. Some permeable concrete can handle heavier loads; however, the increased surface abrasion can cause the pavement to deteriorate more quickly than conventional concrete, and the eroded material can create a clogging concern.

Individual permeable pavement types also have unique characteristics and offer additional benefits. Porous asphalt and pervious concrete have slightly rougher surfaces than their traditional counterparts, providing more traction to vehicles and pedestrians. Amending pervious concrete with photocatalytic compounds can help remove harmful air pollutants (Shen et al., 2012). Researchers have also found ways to increase the conductivity of permeable pavement, which not only improves infiltration capacity but also wicks moisture from the ground to improve evaporation. This process, along with the generally lighter colors of permeable pavement compared to asphalt, may help to reduce the urban heat island effect under certain conditions (Yong et al., 2018). The gridded surface texture of PICP also tends to slow traffic and can even provide an aesthetic amenity. Additionally, PICP reduces the risk of ponding on the roadway surface, which in turn reduces the chance of vehicles hydroplaning and reduces splashing of vehicle undercarriages that can release pollutants.

PICP differs from concrete grid pavements (i.e., concrete units with cells that typically contain topsoil and grass). These paving units can infiltrate water but at rates lower than PICP. Unlike PICP, concrete grid pavement designs generally lack a crushed stone base, which limits water storage. Moreover, grids are more typical in areas with intermittent traffic, such as overflow parking areas and emergency fire lanes.

Siting and Design Considerations

The purpose of permeable pavements is to intercept, evaporate, detain, filter and infiltrate stormwater on-site. Site developers can install permeable pavements across an entire street width, across an entire parking area or within a portion of a larger impervious area. For example, designers can use permeable pavements in parking lot lanes or parking spaces to treat stormwater flow from adjacent upgradient impermeable pavements and roofs.

Designers can also incorporate inlets to accommodate overflows from extreme storms. The area of a permeable pavement installation depends on the infiltration capacity of the particular type of pavement

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or paver system (with an appropriate allowance for clogging); its depth or storage capacity; and the stormwater volume that the permeable pavement will need to capture, store or infiltrate.

Permeable pavements consist of surface and sub-surface layers that each have a specific material composition and thickness depending on the desired application (FHWA, 2016). Surface layers are generally less than 4 inches thick. Porous asphalt consists of open-graded coarse aggregate that bituminous asphalt bonds together. Adding polymers to the mix can also increase its strength for heavier load applications. The thickness of porous asphalt ranges from 2 to 4 inches depending on the traffic loads that design engineers expect. Pervious concrete consists of cement, open-graded coarse aggregate and water. Adding admixtures to the concrete mixture can enhance strength, increase setting time or add other properties. The thickness of pervious concrete ranges from 4 to 8 inches depending on the traffic loads that design engineers expect. PICP pavers consist of precast modular units of various shapes and sizes. They are typically 3⅛ inches thick for vehicular areas and 2⅜ inches thick for pedestrian areas.

Proper design of subsurface components is as important as the design of the permeable surface itself. Not every application needs each subsurface layer. In all cases, designers should follow any state or local codes and guidance. Typical subsurface components are described below, from top to bottom (MDE, 2009; NAPA, 2008; UNHSC, 2009).

Layers of pavement (from the bottom up):

- Choker coarse
- Filter Coarse or base reservoir
- Subbase reservoir
- Underdrain (optional)
- Geotextile (optional)
- Subgrade
- Liner

Installation Considerations

For all surface types, proper installation is key to ensuring long-term effectiveness. While construction staff can generally use much of the same equipment to mix and lay permeable and conventional versions of asphalt and concrete, the mixtures are slightly different and have different handling and installation requirements.

During compaction of porous asphalt, contractors should use minimal pressure to avoid closing pore space. They should avoid vehicular traffic for 24 to 48 hours after pavement installation.

Pervious concrete has a lower water content than traditional concrete, greatly reducing its handling time. Contractors should pour pervious concrete within 1 hour of mixing unless using admixtures. A screed—used to level concrete—is a manual or mechanical device typically set ½ inch above the finished height. Staff should not use floating and troweling because these may close the surface pores. Consolidation of the concrete, usually with a non-vibratory steel roller, typically happens within 15 minutes of placement. Designers should take measures to protect these surfaces from high sediment loads. When contributing areas are large, designers should consider pretreatment practices such as filter strips and swales. Preventing sediment from entering the base of permeable pavement during construction is critical for ensuring that permeable pavements retain a high infiltration rate. Staff should divert stormwater flow away from the permeable pavement until stabilization is complete, which can take up to a week for concrete systems.

Maintenance

The most prevalent maintenance concern for permeable pavements is clogging, which can limit infiltration rates. Fine particles that may clog permeable pavements can come from vehicles, the atmosphere and stormwater discharge from adjacent land surfaces—the more frequent (e.g., vehicle use) or large (e.g., drainage area) these sources are, the faster that clogging will occur. Although clogging increases with age and use, it generally does not lead to complete impermeability.

Key Siting and Maintenance Issues:

- Do not install in areas where hazardous material loading, unloading or storage occurs.
- Avoid high sediment loading areas.
- Divert stormwater from disturbed areas until the areas stabilize.
- Do not use sand for snow or ice treatment.
- Perform periodic maintenance to remove fine sediments from paver surface and to optimize permeability.

Source: USEPA Stormwater Management Best Practice: Permeable Pavements, EPA–832-F-21– 031W, December 2021.

CALIFORNIA RELEASES EIR ON DELTA CONVEYANCE PROJECT

California's Department of Water Resources announced the release of its Final Environmental Impact Report (EIR) for the proposed Delta Conveyance Project, which will help capture and store stormwater to bolster water supplies.

The Project was redesigned following public input and Governor Newsom's pledge of rightsizing it to one tunnel to better support both environmental and water supply needs.

By 2040, California is expected to lose 10% of its water supply due to hotter temperatures. During January's atmospheric rivers, the Delta Conveyance Project could've captured enough water for 2.3 million people's annual usage. Recently the state faced its three driest years on record.

Extreme weather whiplash will result in more intense swings between droughts and floods. California's 60-year-old State Water Project infrastructure is not built for these climate effects.

The Delta Conveyance Project will modernize the state's water infrastructure to:

- Capture and move more water during wet seasons
- Minimize future losses from weather extremes;
- Protect against earthquakes disrupting water supplies;
- Continue meeting water quality and fishery requirements; add new operating rules for further fishery protections;
- Include a Community Benefits Program to ensure local communities get the means and resources to achieve tangible and lasting benefits.

Throughout development of the proposed project, DWR heard from local communities and used feedback to address concerns, with some of these recommendations including: avoiding the central Delta, avoiding forebays and barge landings, reducing pile driving, undergrounding power near sandhill crane habitat, minimizing acreage needed to store tunnel material, and minimizing the project footprint.

The proposed project also includes a Community Benefits Program, with the goal to identify and implement local projects that can provide tangible and lasting local benefits.

The environmental review included a 142-day public comment period in which DWR received more than 700 letters and 7,000 individual comments. Outreach began in 2020 and has included a multitude of webinars, workshops, briefings, multi-language informational materials, email updates, videos, animations, tabling at local events, and a comprehensive Delta survey. The Final EIR responds to all substantive comments.

This action signifies the last step DWR is required to take under the California Environmental Quality Act (CEQA) prior to deciding whether to certify the EIR and approve the proposed project. The Final EIR was prepared by DWR as the lead agency to comply with the requirements of CEQA.

STORMWATER NEWS

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Jacksonville, FL - The U.S. Army Corps of Engineers (USACE) Jacksonville District announced that it has awarded a $32.4 million contract for the re-nourishment of approximately 10 miles of the Duval County Atlantic shoreline.

Known as Shore Protection Project, Beach Re-nourishment 2024, Duval Co., Florida, the restoration will re-nourish critically eroded beaches within the municipalities extending from the St. Johns River to the Duval-St. Johns County line.

The district awarded the contract to Great Lakes Dredge & Dock Co. LLC of Houston, Texas. The project will be 100% federally supported through Flood Control and Coastal Emergencies funds.

Beach re-nourishment includes construction of both a dune and beach berm with sand sourced from a federally administered offshore borrow area. Beach restoration work will include beach tilling, vibration control and monitoring, environmental species monitoring and turbidity monitoring.

Olympia, WA - The Washington Department of Ecology announced that it is accepting applications for its fourth round of streamflow restoration grants.

Up to $40 million in grants will be available for projects intended to protect and enhance stream flows while providing water for rural homes in Washington.

The grants are intended to fund water storage projects, fish habitat improvements, water right acquisitions or improvements in water management and infrastructure. Eligible applicants include tribal governments, public entities and non-profit organizations within Washington.

In previous years, these grants have funded a range of projects around the state. One project in central Washington purchased a 2,524-acre Antoine Valley Ranch in the Okanogan watershed, dedicating its senior water rights to remain in streams, with plans to restore instream and stream-side habitat on the property for steelhead recovery.

These projects increase stream flows to help support robust, healthy and sustainable salmon populations while also helping to meet the water needs for local residents, communities and farms.

ASCE Issues Standard Covering Sustainable Infrastructure

The American Society of Civil Engineers issued its "Standard Practice for Sustainable Infrastructure" in 2023, and cited as ASCE 73-23. The standard is intended to guide sustainable infrastructure development throughout the life-cycle process. The standard describes the minimum requirements for a sustainable infrastructure. It is a non-mandatory standard to be used to develop and implement sustainable infrastructure solutions. The standard defines sustainability as the ability to meet the needs of the present without compromising the ability of future generations to meet their needs.

Sustainable leadership shall encourage transformative development of the infrastructure solution from the earliest stages, consider and analyze all reasonable alternatives, and consider natural, no-constructed project solutions. The standard requires leadership to address owner, community, and stakeholder needs and to balance the economic, environmental and social impacts throughout the life cycle of sustainable infrastructure solutions.

The standard is intended to:

- Allow for implementing sustainability strategies on a project-by-project basis.
- Involve the project owner in establishing the "triple bottom line."
- Facilitate the use of rating systems or other tools to measure the sustainability of the project.
- Encourage creativity and innovation in the design and construction community.
- Allow for optimizing any conflicting environmental, social, and economic requirements of the project.

The standard covers 19 different outcomes covering the following areas:

- Sustainability leadership;
- Quality of life;
- Resource allocation;
- The natural world;
- Greenhouse gas emissions;
- Resilience;
- Life-cycle cost analyses.

The types of infrastructure covered include:

- Transportation
- Wastewater
- Parks and recreation
- Water
- Stormwater, etc.

The standard covers two specific principles:

1. Do the right project; and
2. Do the project right.

The standard also addresses reducing net embodied carbon. It complements existing ASCE standards and policies and the Institute for Sustainable Infrastructure's Envision tools.

THE SOCIAL IMPACTS OF STORMWATER MANAGEMENT

From reducing flooding to lessening demand on public stormwater drainage systems; supporting healthy streams and rivers; and creating healthier, more sustainable communities, a lot of work goes into managing stormwater to meet project goals and objectives. To achieve these goals, communities are opting for green infrastructure improvements to enhance or replace grey infrastructure. Green infrastructure improvements aim to perform ecological services and be an engineered enhancement that draws the community together. In many cities, residents of low-income communities as well as communities of color have long been excluded from land use decisions, resulting in neighborhoods that are often paved over and lacking in green spaces that could absorb stormwater, filter contaminated urban runoff, and draw the community together.

By connecting people to their environments with urban installations of green infrastructure, neighborhoods can be transformed. Communicating the value of green infrastructure, placing stormwater management goals front and center in planning efforts, as well as listening, engaging, and building trust among community stakeholders are all keys to success.

The Ecological Service

As city neighborhoods were built, the combined sewer system was engineered to carry sewage and stormwater away as quickly as possible. In many cities, both stormwater and sanitary sewage flow into the same pipe. In dry weather, all sewage is conveyed to the wastewater treatment plant and treated before being released. During wet weather, however, a combination of stormwater and sewage enter the sewer and many wastewater treatment plants cannot handle the deluge. As a result, untreated wastewater can overflow into our creeks, rivers and lakes, resulting in a combined sewer overflow (CSO).

Many older cities have a combined sewer system that continues to function similarly today. By diverting stormwater from the sewers, capturing and retaining it onsite, green infrastructure reduces the amount of stormwater entering the sewers and reduces the number of CSO events, protecting public health and the environment. The Community Service Through transparency, public awareness, open and honest communication, and prompt and respectful customer service, stormwater management and green infrastructure improvements can also be a series of enhancements that draw the community together. Through providing open green space with these enhancements, relationships and trust with communities grow— interaction by interaction, meeting by meeting, and project by project. When developing a green infrastructure plan, you should also be asking:

- How can we best engage the community so that they tell us what they want and need?
- Can the design options we are suggesting include additional benefits that help advance social equity, promote racial and environmental justice, and improve community well-being?
- How do we find out what they want and need? First and foremost, unless you live in the community, you do not intimately know the wants and needs of the residents. It is your job to ask questions to know how to best address their wants and needs.

Engagement Plan

Develop an engagement plan that establishes multiple channels of communication for residents to share the latest study findings, provide feedback and input, and participate in developing solutions throughout the planning process. When developing stormwater management plans for the cities of Buffalo, New York, and Pittsburgh, Pennsylvania and coastal management plans for Boston, Massachusetts, Arcadis used open house events, online surveys, community presentations, stakeholder interviews, outdoor postings, and online engagements to involve the community. Arcadis also found conversations with members of local religious communities helpful thus enlisted their support to identify advisory board members and to communicate the value and importance of getting involved.

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The Social Impacts of Stormwater Management

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In Boston, the project team directly engaged with more than 550 community members from one neighborhood. The results of a strong engagement process will be felt for years to come. Stakeholders help shape the development of the stormwater management and green infrastructure solutions and priorities, which help to secure additional benefits for each neighborhood and community resident. With this information, the focus turned to identifying design decisions for additional benefits that help advance social equity, promote racial and environmental justice, and improve community well-being. Aside from protecting the environment, reducing flooding, and creating healthier water bodies for more sustainable communities, the green design options suggested have other benefits for the community. Examples include design options that provide new recreational and cultural amenities; design options that include a community gardening program to reduce food insecurity; and design options that include trails and walkways to connect people to neighboring communities.

According to the National Socio- Economic Development Center, community gardens as a form of green infrastructure are often overlooked. For instance, they reduce urban heat islands, provide ecosystem services, and increase stormwater retention. They also support sociological goals of trust-building, participation and food security. These garden spaces sometimes spring up on contested, abandoned or brownscape properties with toxic residues and, historically, have been challenged by other urban priorities such as development and privatization. The National Recreation and Park Administration developed a resource guide for planning, developing and implementing green infrastructure for stormwater management in parks. With a goal of increasing social equity, they suggest combining green stormwater infrastructure into park retrofits and new park development. This can help ensure that open space is used to its full potential by providing multiple environmental and social benefits while helping cities grow or revitalize more equitably.

During the selection process, it is important to ensure parks contribute to social equity and will prioritize underserved communities. Truly engaged community members actively participate in the design process and provide meaningful feedback, not just initial ideas or general desires. Equity must also be addressed at a system-, city- or county-wide scale to ensure resources are allocated fairly and investments target the area of greatest need. Some strategies that can be employed to ensure equity are to:

- Develop and incorporate levels of service standards that encourage equitable access to parks when siting projects.
- Ensure that community outreach efforts involve all stakeholders, making efforts to include groups that have historically been underrepresented and underserved.
- Create a participatory process as much as possible.
- Accommodate as many ages, abilities, activity levels, and amenities as possible.
- Use equitable employment practices.
- Make efforts to recruit and hire parks and recreation employees that reflect the demographics of the communities in which they work.
- Utilize tools to help incorporate equity considerations into the decision making process.
- Keep the design adaptive and remain responsive to community feedback.

Not only are stormwater management goals created to protect the environment and reduce flooding but also to ensure healthier and sustainable communities. The voices of all community members, regardless of socioeconomic background, race, ability or gender, are important in the decision making for these improvements. They bring necessary perspective to the design options that can then better prioritize social equity, racial and environmental justice and community well-being holistically. Stormwater management and green infrastructure projects can have social impacts that go beyond the natural environment.

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