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Resilient Communities

Stormwater infrastructure helps vulnerable neighborhoods mitigate the effects of climate change

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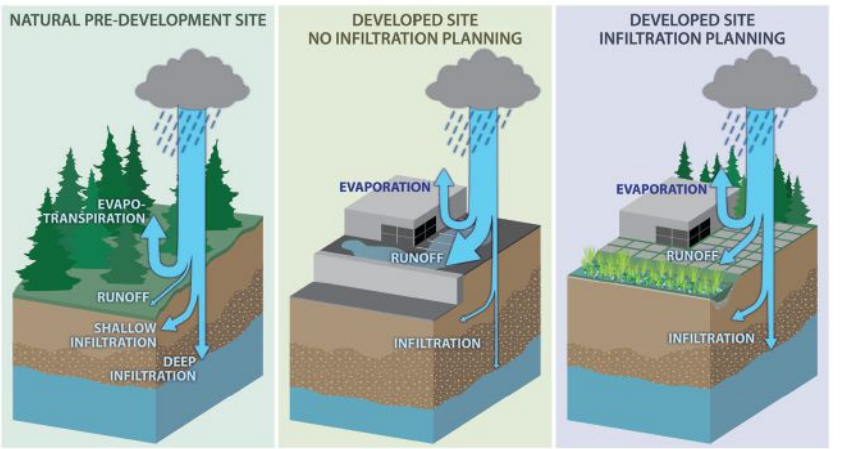
Cover Story

10 Stormwater Management for Resilient Communities

New stormwater infrastructure helps safeguard Massachusetts neighborhood from future impacts of climate change

By Katherine Goyette, Muriel Wixson

Cover photo courtesy Kleinfelder.



14 Infiltration System SOPs

How Deep Does Your Water Go?

By John Knutson

20 Regulatory Compliance as a Design Discipline

Tips for program success

By Emmett Smith, Jeannie Lewis, Robert Horner

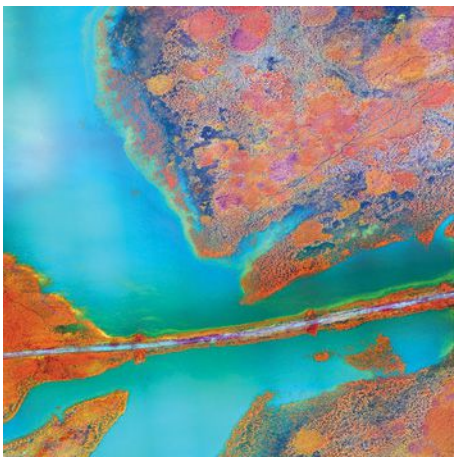
16 Crowdsourcing the Power of the People

Engaging citizens in stormwater management

By Melanie K. Goetz

DEPARTMENTS

IN EVERY ISSUE



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Editor's Comments

BY ALANNA MAYA

Our Time Has Come

Welcome to the Winter 2022 issue of *Stormwater* magazine. Though there are few traditional signs of the season here in Southern California, this time of year is always a good one to take stock of where we are and where we are going. Where we *are* is entering year three of a global pandemic, whose ongoing influence on our everyday lives seems like it might never end. However, updates to CDC guidance and promising reports of the vaccine's effectiveness against new variants means that where we are *going* looks better every day.

Indeed, stormwater's time has come thanks to a spotlight placed on the industry and its projects with the passage of the 2021 Infrastructure Investment and Jobs Act. The $1 trillion bipartisan-backed bill includes new funding streams for the WIFIA program, State Revolving Fund programs, small and disadvantaged utilities, and national lead service line replacements.

Among the bill's provisions are allocations for EPA's Sewer Overflow and Stormwater Reuse Municipal Grants (OSG), funded at $280 million annually for 5 years; for a total of $1.4B overall. Of that funding, 25 percent is reserved for rural and financially distressed communities.

Further bolstering the industry is another key piece of legislation, the House-passed Build Back Better Act, which includes $1.85 billion for stormwater projects, of which $1.35 billion is reserved for financially distressed communities. The Stormwater Centers of Excellence, funded at $5 million annually for five years (amounting to $25 million in overall allocation) will continue to focus on identifying the best technologies and practices for green infrastructure, BMPs and overall stormwater management. These new funding streams represent the largest influx to the sector in 50 years.

The National Municipal Stormwater Alliance (NMSA) has kept track of several other bright lights for the industry. As a nonprofit, NMSA has made significant contributions to the stormwater/MS4 sector through policy leadership, state and regional engagement and support, technical information development and dissemination, and raising the awareness and profile of stormwater overall since its founding in 2018. This month, NMSA Executive Director Seth Brown outlines the top legislative and regulatory issues for the industry in the first of what will be a recurring column from the organization. Read more on page 26 and keep an eye out for the section in future issues of *Stormwater*.

Our cover story this month looks at how stormwater management can create more resilient communities as we face the effects of climate change. Read about how Kleinfelder worked closely with the City of Cambridge's Department of Public Works to design a 390,000-gallon underground stormwater tank in one of the area's oldest neighborhoods while navigating a complex underground utility landscape on page 10.

For project managers considering infiltration and subsurface evaluation for stormwater projects, our BMP Maintenance feature on page 14 covers all you need to know, from pre-planning to design and final evaluations. Building on that advice, on page 20, a case study involving stormwater regulatory compliance throughout the design and construction phase to ensure BMPs are followed; including aspects like site access, stored materials, and more will guide you through one author's process.

Finally, as you plan the coming months, be sure to put StormCon 2022 on your calendars. The program's Call for Abstracts is now open, and we are working diligently to put together the best lineup yet for this year's conference. Join us in person September 26-28 in National Harbor, Md., where speakers from across the nation will present lessons learned, insights and case studies. In the exhibit hall, industry-leading companies will showcase top products and services. I hope to see you there!

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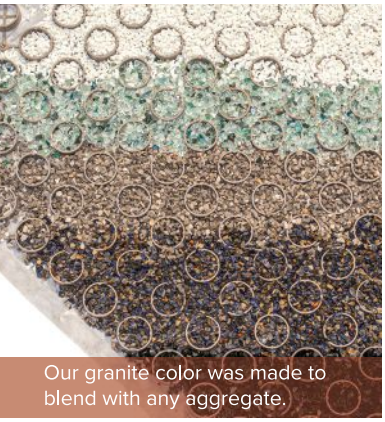

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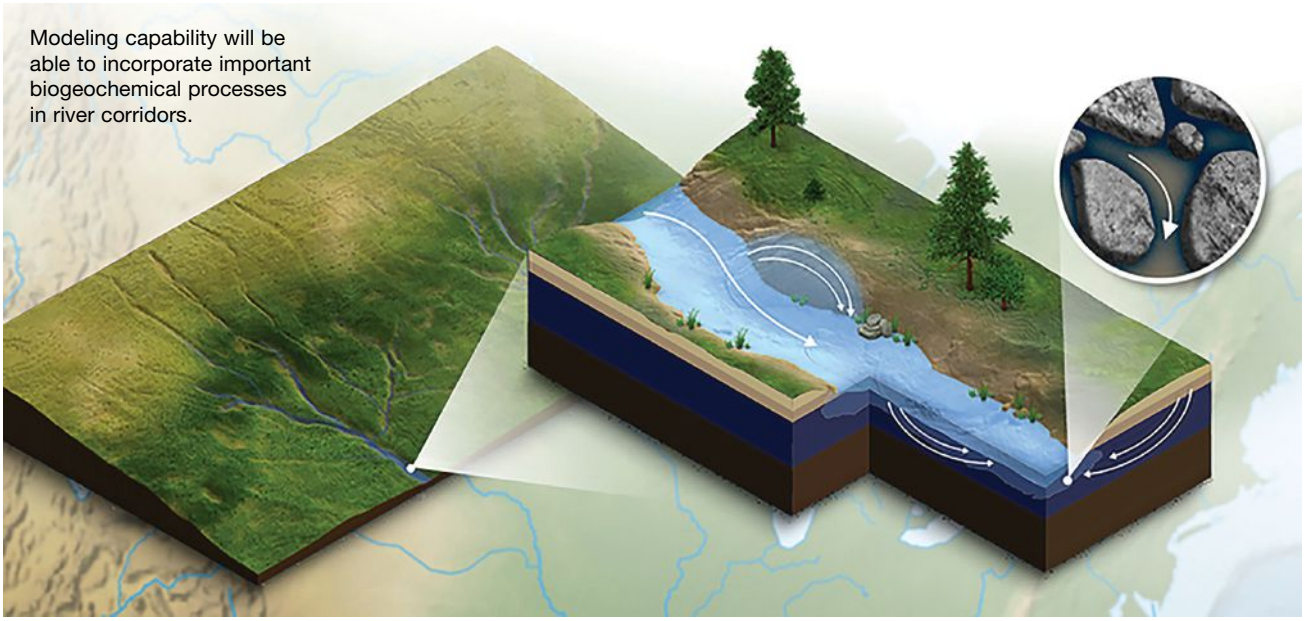


Modeling capability will be able to incorporate important biogeochemical processes in river corridors.

Photo by Andy Sproles/ORNL, US Dept. of Energy.

$1T infrastructure bill passes

> On November 15, 2021, President Biden approved the Infrastructure Investment and Jobs Act. The bipartisan infrastructure bill approves five years' funding of $55 billion to support national water infrastructure.

The new package contains $550 billion in new spending generally, with $55 billion to support clean water nationwide. It also reauthorizes $14.6 billion as part of the Sewer Overflow and Stormwater Reuse Municipal Grants program, and $16 billion to clean up polluted sites such as wells and mines.

Largest constructed wetland completed in FL

> The South Florida Water Management District has completed the largest environmental restoration project in US history, the C-44 Reservoir/Stormwater Treatment Area (STA).

The C-44 Reservoir/STA is a 6,300-acre constructed wetland area designed to restore, protect and preserve water resources in the region. The $100 million project is part of the Comprehensive Everglades Restoration Plan (CERP), designed to create a natural filter capable of cleaning billions of gallons of fresh water before it hits the St. Lucie Estuary and other waterways.

USDA invests $11M in wetland restoration

> The US Department of Agriculture (USDA) announced $11 million in funding for five Wetland Reserve Enhancement Partnership (WREP) projects. In total, the projects will seek to enroll approximately 8,500 acres of wetland.

The group is funding two new projects and providing additional funding to three existing ones. The projects will aim to bring together partners and landowners to voluntarily return critical wetland functions to agricultural landscapes. The funds are also meant to prioritize high-impact projects and provide assistance to historically underserved farmers and ranchers.

New stream modeling includes biogeochemistry

> A new modeling capability will be able to incorporate important biogeochemical processes in river corridors for a clearer understanding of how water quality will be impacted by climate change, land use, or population growth.

Researchers at Oak Ridge National Laboratory used high-performance computing and the Amanzi-ATS software to include biogeochemical reactions in microbially-active zones near streams in models that track the movement of dissolved chemicals in river networks. These reactions have a major influence on the cycling of carbon, nutrients, and contaminants at basin scales. The new multiscale model better tracks water quality indicators such as nitrogen and mercury levels.

Term 'green infrastructure' is growing broader

> A nationwide analysis of the term "green infrastructure" across 122 US cities found that, while stormwater-specific definitions are still most popular, the term is quickly becoming generalized.

The analysis from the Cary Institute of Ecosystem Studies found that many plans fail to explicitly define green infrastructure — and among those that do define the term, it can often deviate from hydrological practices.

The authors promoted a more generalized definition that could apply to most municipalities, stating that a strictly stormwater-based definition might be too narrow for many cities.

Photo courtesy WSP USA.

Improved hydrology for complex lands

> A team of scientists from Oak Ridge National Laboratory and the U.S. Department of Energy (DOE) developed a new mathematical formulation in that enables models to predict water runoff in various landscapes.

The research team's new method may to be able to accurately predict runoff in complex, patterned land cover.

The multi-institutional team had also implemented its method in the DOE's Advanced Terrestrial Simulator (ATS) code. This new feature of ATS will allow scientists to accurately predict how water flows both below and on the surface of landscapes, including how it partitions between groundwater and surface runoff to streams.

Models to predict water runoff in complex landscapes.

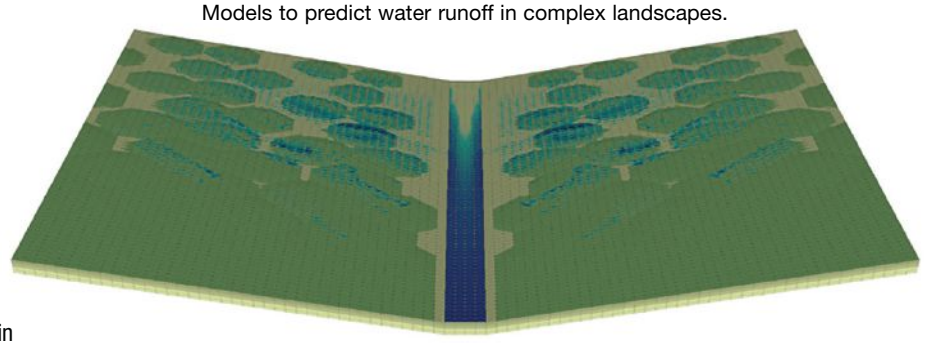
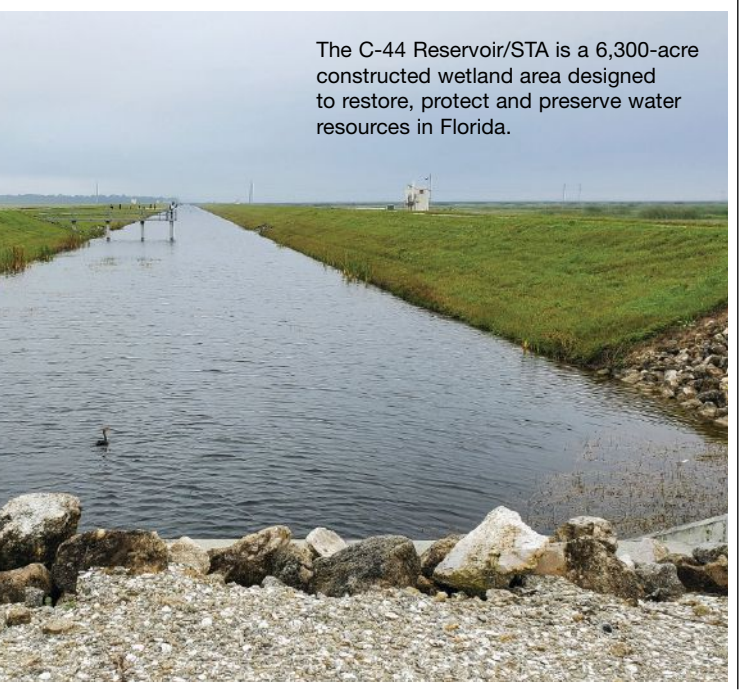


Image courtesy Ethan Coon, Oak Ridge National Laboratory.

NOAA, ASCE partner for climate-smart construction

> The US National Oceanic and Atmospheric Administration (NOAA) has announced a partnership with both the University of Maryland (UMD) and the American Society of Civil Engineers (ASCE) to accelerate the development of climate-smart engineering codes and standards. Most building codes in the US and abroad already rely on consensus guidance provided by ASCE.

The collaboration will advance the use of NOAA-produced climate science and understanding within engineering practices for the design and construction of climate-resilient infrastructure, through developing and updating ASCE codes and standards. The partnership calls for a series of exchanges between NOAA and ASCE, which will be facilitated by the UMD Center for Technology and Systems Management.



The C-44 Reservoir/STA is a 6,300-acre constructed wetland area designed to restore, protect and preserve water resources in Florida.

Houston study plants and ranks 'super trees'

> A group of Houston universities' researchers found that live oaks and sycamores were the top-ranking trees to mitigate the effects of stormwater runoff, pollution, and climate change.

The study lays out a three-part framework for deciding which trees to plant, how to identify good locations, and how to engage with community leadership to make the planting project a reality.

Using Houston as a best-case example, the collaborators determined the trees that would work best in the city based on their ability to take in water, stabilize the landscape during floods, soak up carbon dioxide and other pollutants, and provide a canopy to mitigate heat.

Live oaks and sycamores are the top-ranking trees to mitigate the effects of stormwater runoff.

Photo courtesy Houston Wilderness.

Riparian buffer strips rarely harm streambanks

> A new study from Iowa State University suggests that saturated riparian buffer strips, a nutrient control technique common in agriculture, could be installed in more places than previously thought.

Riparian buffer strips are often limited to banks that are not too tall, in hopes that this protects the banks from damage or failure. The researchers tested the assumption about bank height, and also looked at how adding in a new riparian buffer affected streambank stability. They found that most streambanks turned out fine after applying a new riparian buffer. Only in about three percent of the scenarios did the new water's flow through the soil endanger the stability of the bank, and height didn't affect future stability.

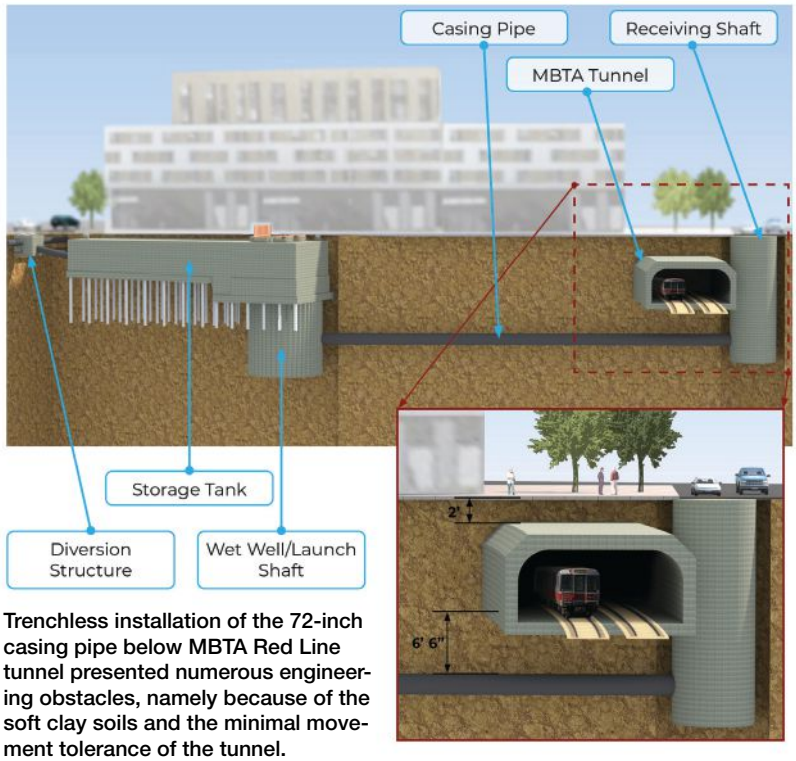
Stormwater Management for Resilient Communities

New stormwater infrastructure helps safeguard Massachusetts neighborhood from future impacts of climate change

BY KATHERINE GOYETTE, MURIEL WIXSON

From rising temperatures to increasing extreme weather events, climate change is affecting the world in which we live. One effect of the changing climate is that it's raining more frequently — and more intensely — than ever before, wreaking havoc on infrastructure and, more specifically, on urban populations and thoroughfares.

In The Port neighborhood in the City of Cambridge, Mass., residential homes and businesses suffer an increased risk of flooding and sanitary sewer backups in residential homes due to these more frequent and intense rain events. This neighborhood comprises a high number of low-income residents and residents who primarily speak a language other than English. Based on the City of Cambridge's recent assessments on climate change vulnerability, these populations tend to be more at risk from the impacts of climate change.



Trenchless installation of the 72-inch casing pipe below MBTA Red Line tunnel presented numerous engineering obstacles, namely because of the soft clay soils and the minimal movement tolerance of the tunnel.

The stormwater within The Port neighborhood historically flowed to the Massachusetts Water Resource Authority's (MWRA) combined sewer system, which has limited capacity to manage flows from today's large storm events. Because of this, the neighborhood has experienced significant surface flooding and sanitary sewer backups in the past, and climate change will only increase flood risk and exacerbate impacts to the neighborhood.

As such, the City of Cambridge constructed the Parking Lot No. 6 Stormwater Tank, drainage infrastructure in Massachusetts Avenue — both a complex utility and urban traffic corridor — that enabled separated stormwater to be directed to the Charles River, rather than to the overburdened MWRA combined sewer, with the intent of reducing future flooding issues in The Port neighborhood.

The tank is Phase 1 of the City's multiphase resiliency plan in The Port. While the tank presented many challenges and innovations in its design and construction, its contributions and value to the community and future engineering endeavors have set a positive tone for the infrastructure improvements that lie ahead for the neighborhood.

Port Flooding Resiliency Project: Parking Lot No. 6 Stormwater Tank

Kleinfelder — an engineering, design, construction management, construction materials inspection and

testing, and environmental services firm — served as the lead consultant for the project and worked closely with the City of Cambridge's Department of Public Works to design a 390,000-gallon, 119-by-36-foot cast-in-place underground stormwater tank, located in the city-owned Parking Lot No. 6 (PL6).

This new tank captures stormwater from The Port neighborhood during wet weather events, pumps it to drainage systems that have available capacity to discharge the flow, and redirects it to the Charles River via an existing 54-inch storm drain in Massachusetts Avenue.

Kleinfelder and subconsultant Stantec needed to apply innovative, creative engineering solutions to overcome multiple challenges associated with crossing the century-old Massachusetts Bay Transportation Authority (MBTA) Red Line subway tunnel, construction of subsurface infrastructure in soft Boston Blue Clay soils, and the simultaneous construction of a commercial development (Market Central) along the east and south sides of PL6, limiting tank construction access.

A rendering illustrates the stormwater tank and other subsurface elements beneath the restored Parking Lot No. 6 in the City of Cambridge, Mass.

Images courtesy Kleinfelder.

The stormwater tank under construction in Fall 2019. The simultaneous construction of the Market Central towers (building shown on the right), less than 8 feet from the tank, required extensive coordination and geotechnical monitoring.

A Historic Divide

One of the unique aspects of implementing this project was that standing between the PL6 stormwater tank and the existing Massachusetts Avenue storm drain is the MBTA's Red Line subway tunnel. The shallow, 100-year-old tunnel has historically presented a divide for stormwater catchments and subsurface utilities along Massachusetts Avenue, requiring redundant utilities on both the north and south side of the congested corridor.

Constructed in 1910, the Red Line tunnel is 23 feet deep with limited as-built information. Faced with less than 2 feet of cover between the road surface and the roof of the train tunnel and major structural concerns with a tunnel crossing, the Kleinfelder team conducted an extensive alternatives evaluation and devised multiple design iterations.

A Complex Connection

Working in collaboration with the MBTA, Kleinfelder proposed a connection from the new PL6 stormwater tank to the storm drain by microtunneling 200 feet of 72-inch Permalock steel casing pipe — carrying four, 18-inch force mains — beneath the active MBTA Red Line subway tunnel.

Siting an access shaft for the microtunnel boring machine was another complication of this trenchless solution.

Advancing the tunnel within difficult ground conditions due to weight-of-hammer Boston Blue Clay was an added challenge, and the subway tunnel was at high risk of damage from differential movement.

To alleviate these obstacles, the Kleinfelder team performed a geotechnical analysis to evaluate the potential for vertical movement under short-term temporary construction conditions and long-term permanent conditions for the 100-year design life of the final permanent structures. The team incorporated extensive real-time geotechnical monitoring to record soil movement, continuous monitoring of the MBTA subway tracks, and pre- and post-construction structural inspections of the MBTA Red Line tunnel to ensure the specified critically low movement tolerances were met and confirmed the structural

integrity of the portion of MBTA tunnel potentially influenced by the microtunnel operation.

Adding to the challenges during construction was the simultaneous construction of a new Market Central development project — including two towers, 6 and 19 stories high — surrounding PL6. The 20-foot-deep stormwater storage tank would be constructed only 8 feet away from one of the tower's building foundations while the trenchless utility corridor was less than 3 feet away from both towers.

The Kleinfelder team, general contractor Skanska Civil USA, and the tunneling contractor SECA Underground Corporation, worked in collaboration to overcome each challenge with a collective engineering solution and modifications to the tunneling approach, circumnavigating beneath the MBTA Red Line crossing without service disruption.

Community Awareness

Throughout the design and construction process, Kleinfelder and the City engaged with The Port community in defining a plan for the project and garnering interest and enthusiasm. Due to the various languages spoken in the community, as well as the potential for dense technical language, it was necessary to ensure stakeholder materials were clear, translated correctly, and shared in prominent locations — including the multiple churches in the neighborhood, the community arts center, and the Margaret Fuller House, a provider of youth and food services and community advancement.

The team has been able to showcase the project's progress at recent community events, like Port Pride Day and the Port Party, resulting in a sharp increase in enthusiasm and support from stakeholders for future Port infrastructure improvement phases and engineering efforts in general.

Project Success

After the successful completion of the complex design and construction process, the tank became operational in May 2021 and redirected more than 3,480,000 gallons of stormwater from The Port neighborhood during the Boston area's third-wettest summer on record with over 19 inches of rain. The PL6 stormwater tank successfully eliminated the surface flooding that impacted the neighborhood during similar-sized storm events prior to the tank installation.

"This project serves as an example of how municipalities can mitigate the effects of climate change that often harm populations most at risk in our communities, while setting the stage for future improvements, benefiting the community for generations to come," Assistant

Climate change will exacerbate the frequency and severity of storms, which results in flooding from stormwater and sewer overflows.

Commissioner and City Engineer for the City of Cambridge Kathy Watkins said.

The success of the project has generated public interest, allowing for a fruitful and positive transition to other Port neighborhood infrastructure improvement efforts needed to meet the city's goals for flood resiliency. The installed 72-inch casing pipe, for example, includes the piping to connect two additional future tanks to existing stormwater and sanitary sewer infrastructure on Massachusetts Avenue to meet resiliency goals for The Port neighborhood.

The project also received recognition through the American Council of Engineering Companies (ACEC) Massachusetts chapter.

Katherine Goyette *is a senior project manager at Kleinfelder with 24 years of experience in the planning, design, and construction of complex urban wastewater and stormwater infrastructure. She led the planning, design, and construction of the Parking Lot No. 6 Stormwater Tank project and is leading the consequent phases of Cambridge's Flooding Resiliency Project.*

Muriel Wixson *is an outreach and engagement specialist at Kleinfelder, prior to which she served as a news editor and reporter. She is helping to lead the outreach and engagement efforts for Cambridge's Flooding Resiliency Project.*

Infiltration System SOPs

How Deep Does Your Water Go?

BY JOHN KNUTSON

The Pacific Northwest recognized early on the negative effects of urbanization on receiving waters and has been a leader in the stormwater management field for decades. Initially driven by concerns about the impacts of urban runoff on threatened and endangered species in the Puget Sound area, this was later reinforced by the National Pollutant Discharge Elimination System (NPDES) permitting program.

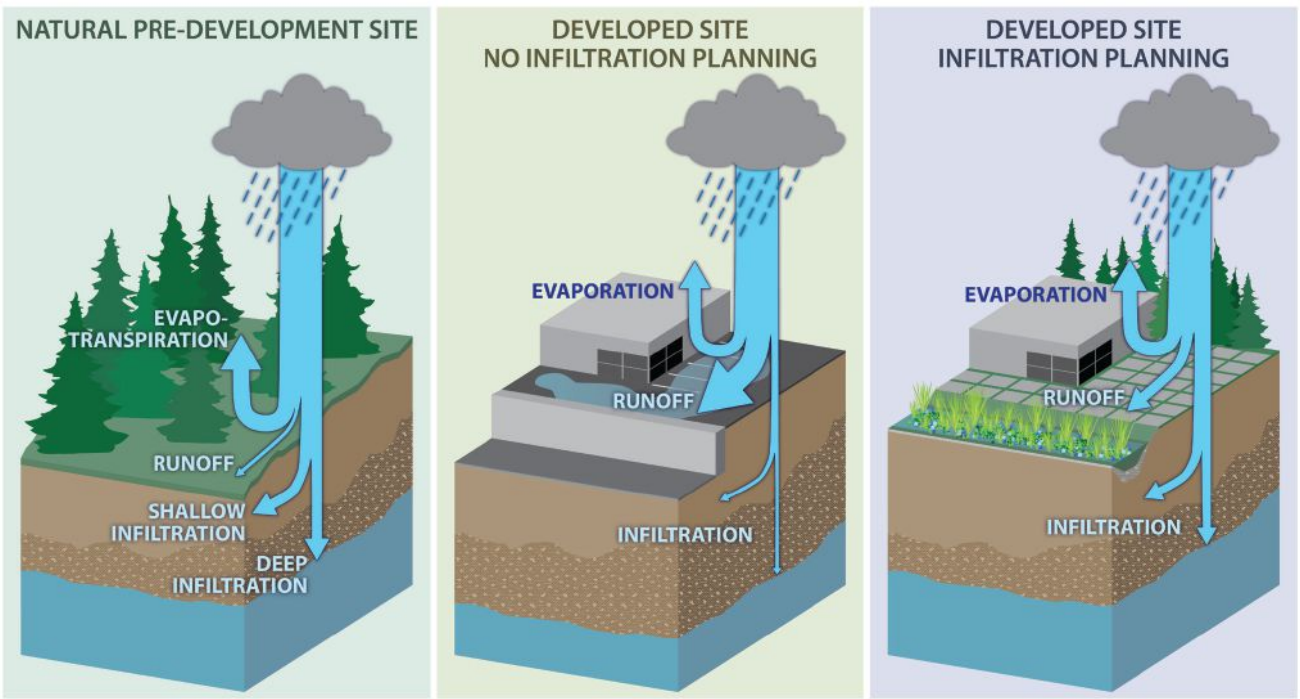
As the science of stormwater management continues to progress, practitioners must learn about and apply the latest techniques. While infiltration is not a new concept, widespread infiltration design is new for some areas and some water quality designers. When infiltration systems fail, the consequences can range from increased pollutant loading and erosion in streams to flooding.

Failing infiltration systems caused street flooding in Yakima, Wash.

Photos courtesy Aspect Consulting.

Infiltration Design

Over the last decade, MS4 Permits have started requiring the use of infiltration BMPs to mitigate the hydrologic and water quality impacts of development. From a surface water perspective, infiltrated runoff does not cause stream erosion, has no pollutant loading, and helps recharge groundwater.



A proper implementation of infiltration BMPs can drastically reduce the hydrologic and water quality impacts of land development.

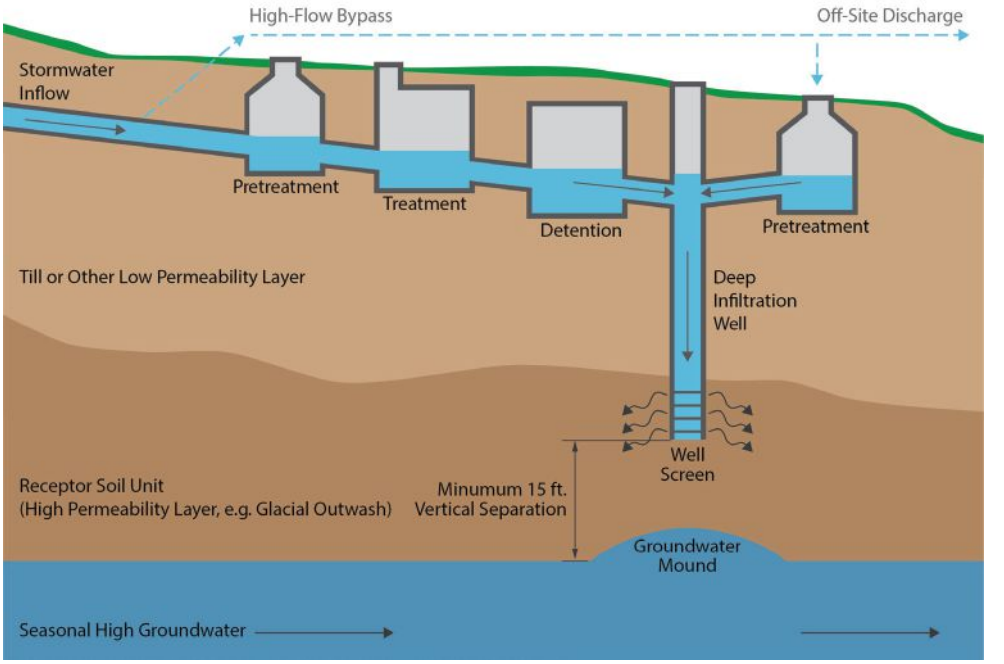
Much like the early application of other stormwater BMPs, some designers don't have a technical background in infiltration. Numerical models, simplifying assumptions, and step-by-step procedures make applying infiltration feasible for generalists, but there are some key issues to consider.

Estimating Infiltration Rates

The starting point for designing an infiltration BMP is determining the infiltration rate your BMP is expected to have. Allowable methods have changed over the years, with some agencies requiring in-situ infiltration testing for all infiltration BMPs, and some allowing "grain size methods" to estimate rates in certain cases.

However, grain size methods for screening purposes should be avoided unless the soils meet all criteria for application of the equation being used. Reliance on grain size method results can backfire, which is why in-situ infiltration testing must be done to support the design process, with knowledgeable analysis of testing results.

The number of infiltration tests should scale with the size, complexity, and soil heterogeneity of the project site. Thoughtful testing and analysis methods can also indicate if groundwater was mounding during the test, and whether a formal mounding analysis is needed.



Thoughtful testing and analysis methods can identify groundwater mounding and whether a formal mounding analysis is needed.

Once correction (safety) factors are applied, there are generally two ways an infiltration rate is used to help model and design infiltration BMPs: assume the infiltration rate is constant during BMP filling and emptying; or assume the infiltration rate varies (typically linearly) with water depth (pressure head) above the infiltration surface.

Knowing how the infiltration BMP will be sized is important when analyzing test data because the resulting constant infiltration rate will not necessarily be the same value as the variable rate.

Plan to Manage Plugging

Infiltration BMPs are susceptible to the same plugging by sediments and biofouling that stormwater filters are. Stormwater filters plug up; and infiltrating into soil is much like infiltrating into a filter. Therefore, pretreatment to remove sediment is necessary to prolong the life of infiltration BMPs.

Plugging of the infiltration surface is the main reason that safety factors are used when sizing infiltration BMPs. Stormwater manuals often prescribe safety factors, but the safety factor really should scale based on the soil being infiltrated into.

For instance, when infiltrating slowly into a fine soil with a permeability not much higher than stormwater sediment, reducing the measured rate by a factor of 2-4 is acceptable. But, when infiltrating into coarser soil with a permeability much greater than stormwater sediment, a larger safety factor is warranted (some jurisdictions do set a maximum design infiltration rate). The level of treatment for sediment removal prior to infiltration should affect the safety factor, too.

Check and Address Groundwater Mounding

Infiltrating runoff sometimes causes groundwater mounding. As mounding increases, it can reduce the infiltration rate, cause seepage problems, and raise regulatory compliance concerns. Monitor groundwater during infiltration testing to see if it rises in response to the test. If so, the data can be used to help calibrate a mounding model.

In cases where mounding is an issue, a formal analysis and modeling (such as USGS's MODFLOW) of the receptor soil/aquifer combination, as well as a fine-

Continued on page 31

Crowdsourcing the Power of the People

Engaging citizens in stormwater management

BY MELANIE K. GOETZ

In 1968, at the height of the Cold War, an attack class nuclear submarine, the U.S.S. Scorpion was lost at sea. The submarine went missing just five days before it would have arrived at the dock in Newport News, Va.

For nine days, the Navy searched with no success. Coordinating with the ongoing search, Navy scientist John Craven assembled a diverse team of civilian experts to track down the submarine. Although the term itself wasn't widely used at the time, he enacted a form of "crowdsourcing" — a practice that could be immensely valuable for stormwater outreach.

By definition, crowdsourcing is a process of organizing and coordinating the labor, knowledge, and intuition of a crowd. Crowdsourcing can serve for anything from simply collecting large amounts of data for later analysis, to solving an incredibly difficult problem — like finding a submarine presumed to be lost in the middle of a vast ocean.

Using crowdsourcing very much in the form of a contest, each member of Craven's chosen crowd was instructed to work independently, each assessing the Scorpion's fate without the influence of other crowd members. Each worked, initially, from the Navy's existing database of information; however, they were free to draw upon other theoretical, scientific, and mathematical information if they believed those resources might be useful.

CrowdHydrology allows citizens to use their smartphones to text data regarding stream levels at various gauging stations along water bodies.

Photo courtesy CrowdHydrology.

On a preset deadline, using a probability methodology called Bayes Theorem, Craven's entrants came up with one collaborative estimate of its location — essentially, the statistically most-likely resting place of the ill-fated Scorpion.

Five months later, the Navy finally located the Scorpion lying on the ocean floor. Although no one individual among Craven's theoreticians came up with the precise location of that submarine, the team's collective average pinpointed a location that was a mere 220 yards off from where the missing submarine was ultimately found.

How Craven's group of people, working independently under a naval scientist's guidance, could have collectively been so accurate is a phenomenon that still amazes many.

Denver, Colo.'s Stormwater Education and Outreach program has helped to engage and educate the public about stormwater issues and concerns.

Photo courtesy City and County of Denver, Colo.

Yet, the fact remains that a group average, even when it is derived from something as simple as broad, crowdsourced data collection, tends to be relatively accurate in ways that may be of enormous positive impact to various communities. Enter crowdsourcing and what it can mean to stormwater public outreach and education.

Crowdsourcing Stormwater Outreach and Education

For over a century, the U.S. Geological Survey (USGS) has actively encouraged Americans to get involved in local projects designed to map the entire country.

While the USGS produced the US topographic map through its own expertise, it has also benefited from crowdsourcing to improve and refine the accuracy of that map. Today, there are thousands of volunteers participating in the USGS' mapping challenge by submitting data points collected from all areas of the country.

Today, crowdsourcing continues to be enticing as a cost-efficient way to not just gather important flood potential data but also to engage and educate the public about stormwater issues and concerns. For example, it potentially engages and educates the very non-point pollution sources that are the hardest to regulate — the ones generated by the general public itself.

Collecting data that can reveal stormwater runoff changes is a relatively new type of crowdsourcing gaining momentum. One example that began in 2010, CrowdHydrology, allows citizen scientists to use smartphone technology to text data regarding stream levels at various gauging stations placed along rivers and aquifers, which is then collected and analyzed.

The idea of enlisting citizen scientists to collect stream level readings in their communities was the brainchild of Dr. Christopher Lowry, a professor of hydrogeology at the University of Buffalo, and Dr. Michael Fienen, a research hydrologist at the U.S. Geological Survey Wisconsin Water Science Center.

Participation in the program is simple, with a relatively low cost to non-profit organizations. The only cost of entry is limited to the cost of each meter and its signage, which is typically less than $100 each. All the data collection and resulting analysis for the program is free.

Once the gauge and sign have been properly installed, anyone with a smartphone can text the stream level to the number on the sign. According to Lowry, the group averages obtained against all of the texted stream level reports are often found to be surprisingly accurate. Generally, it is best for the gauge to be located on a busy trail along a stream with good visibility and where the water levels are most likely to fluctuate due to precipitation and water runoff.

Another example of successful data crowdsourcing can be found with the Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS). This program encourages its participants to take measurements of the amount of precipitation after each time a rain, hail, or snowfall crosses through their community.

Here again, the program is both voluntary and free; however, each citizen must purchase their own high-capacity 4-inch-diameter rain gauge. Then, the volunteer-reported precipitation data is used by the National Weather Service and other agencies. The data collected is shown on CoCoRaHS' website, where it has been organized and presented to apply to daily situations ranging from vital water resource analysis and severe storm

warnings to something as simple as neighbors comparing how much rain fell in their respective backyards.

Equally important to data collection is the ongoing success in using crowdsourcing for stormwater education and public outreach, which is revealed by the positive comments and reviews that the participants have left on the website.

Stormwater entities are also using crowdsourcing to gain funding, hold contests, and even change public perceptions and behaviors by getting people to take the pledge to protect waterways.

Yet, like anything else, there are instances in which crowdsourcing can be misused. In such cases, crowdsourcing can backfire, quickly revealing why certain things should never rely on crowd participation. And while no rules are ever absolute, there are some guidelines to consider to avoid crowdsourcing disasters.

How to Avoid Crowdsourcing Disasters

What makes crowdsourcing such a powerful tool for engaging the public is also what can make it so dangerous — loss of control. There is no quality control over each and every participant.

When using crowdsourcing, the control offered to the public should never involve anything that could be harmful. That's why it is important that public engagement does not affect anything essential to the organization such as its mission, vision, or brand.

For example, when NASA decided to promote a popular vote to name a new section of the International Space Station, they made sure to start with a few of their own suggestions. Unfortunately, they also decided to include a write-in option.

By the end of the voting process, a comedian's fans gave his name six times more votes than any of the pre-approved name suggestions. NASA was obliged to reject the winning name. Had NASA not offered up a "write-in" name, the public relations disaster might have been avoided.

A group asking for public input can never know what response they might get. The following six crowdsourcing guidelines can avoid such disasters.

- **Not Critical.** It's important that crowdsourcing requests are not critical to the organization's mission.
- **Definable Task.** It is essential to make the task easily definable when requiring either answers to difficult questions or information. Several stormwater organizations have realized success with easy-to-understand requests to gain funding, collect data, and education. For example, the Washington State Department of Ecology is engaging its residents by asking them to take the "Protect Our Waters Pledge," providing residents with ten things they can do to make a difference in protecting the waterways.
- **Minimum Skills.** When engaging the general public, it is best to ask for tasks which require minimum skills. For a stormwater organization, this means simple tasks, like collecting water level or precipitation data, would be better than anything technical.
- **Visible Outputs/Results.** By making the outputs visible, participants tend to feel valued and more engaged. It also works as a way to gain more volunteers or to generate more funding. For example, when going for funding, organizations should show the monetary goals and their progress in achieving them. When collecting data, the results should be easy to access and understand. Successful campaigns, like CrowdHydrology, organize and post all their crowdsourced data on their websites for easy review.
- **Recognition.** It is important to recognize individuals, even publicly when appropriate, for anything from their funding support to their volunteer efforts. Recognizing people publicly for their involvement, no matter how small the time or monetary investment, continues to be something that stormwater organizations attribute to the ongoing success of their crowdsourcing programs.
- **Launch Failure.** Even a perfectly-planned crowdsourced campaign cannot become a success if nobody participates. While the initial launch can start with a social media campaign and a website, sometimes a successful outcome starts with a few key individuals. When designing a program using crowdsourcing for

public outreach, organizations should consider how to get the word out initially — especially if it's a first effort. Successful campaigns may require inviting specific, high-profile people to start the engagement. This list can be made up of stakeholders, elected officials, community leaders, influencers, or school administrators. The idea is that, in order to attract a crowd, it's best to start with prominent individuals in the community. While a strategic selection of influential people can get your efforts off the ground, it will take continued effort and dedication to keep a movement's momentum.

The Takeaway

When it comes to solving large-scale problems like finding the U.S.S. Scorpion or collecting data to protect waterways, crowdsourcing has been proven to provide accuracy, cost-efficiency, and public engagement and education. Today, stormwater organizations continue to use crowdsourcing very successfully in a wide array of applications, all while engaging and educating the public.

When implemented correctly, crowdsourcing can offer up much-needed data collection, answers to difficult questions, funding, and, equally important, the ability to engage all the non-point pollution sources that are not always easy to identify and regulate.

Crowdsourcing can educate people, indirectly or directly, about how simple things — like not littering, not using stormwater drains as trashcans, limiting the use of pesticides and herbicides, or picking up after their dogs — can make a huge difference in protecting waterways. Each person's volunteer efforts, whether large or small, can make a difference.

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Maintaining the construction entrance for stormwater projects and keeping the surrounding area clean is important for compliance, public confidence, and safety.

Photos courtesy Weston & Sampson.

Regulatory Compliance as a Design Discipline

Tips for program success

BY EMMETT SMITH, JEANNIE LEWIS, ROBERT HORNER

Today's complex construction-related projects often involve multi-jurisdictional permitting, wetland and cultural resource accommodations, cross-disciplinary teams, and environmental compliance inspections. The ability of a project team to design, permit, construct, and reliably conduct self-inspection throughout the lifecycle of the project can often spell the difference between failure and success.

Proper advance planning during the infrastructure design process typically leads to a significant reduction of risk in stormwater compliance when the project reaches the construction phase. With increased federal infrastructure funding due to the American Rescue Plan Act and the Infrastructure Investment and Jobs Act, there will be higher spending in the municipal and infrastructure construction arena, as well as an increased need for shovel-ready projects.

In order to execute more on-time construction projects while maintaining regulatory compliance, it's becoming more important than ever to have an established, robust, consistent, and highly regarded regulatory compliance program. This is especially true when projects include or are adjacent to sensitive resources like water bodies, wetlands, cultural resources, salt marshes, significant trees, and other valuable community assets.

It is counterproductive, inefficient and costly to have a project — after years of planning, design, and permitting — be further delayed due to a misunderstanding about wetlands impacts and suffer a stop work order, a notice of violation, or, even worse, fines. Not only can this situation cost valuable time and money, but it can have collateral damage to the community's confidence.

Erosion controls and secondary containment prevent impacts and can easily be inspected and maintained.

One way to significantly reduce a risk of noncompliance, while also making more successful projects generally, is to create a mindset that enables the design team to look at a project and its impacts holistically through an environmental regulatory lens. This means considering not only the actual physical assets constructed but also the impacts of construction, including staging, material and equipment storage, stringing pipe, stockpiling excavated materials, parking for construction team members, and maintenance.

As the regulatory community tries to keep pace with an ever-increasing number of projects, it has become even more essential to keep these projects on track. It is critical on several levels for a linear, site, earthwork, or environmentally sensitive project to go through a regulatory review at key milestones to ensure that it can be constructed as the design team has envisioned, with all impacts properly recognized, accounted for, and mitigated. This can be accomplished in multiple ways.

Collaborative Design Reviews

Designing a project to avoid or minimize impacts from the outset is the most effective. The farther into a project timeline that an impact is encountered, the more costly it will be to correct or mitigate. Minor design changes that are recognized when moving a project from conceptual to a 30 percent phase can always help facilitate a more efficient design process. This is the time to add a "Collaborative Review" milestone.

At this point in the design life, it is beneficial to bring in team members with expertise in construction techniques, materials handling, logistics, operations, site work, and regulatory compliance to review and brainstorm collectively. Envisioning the completed construction and operational implementations can significantly improve the project delivery process while also building team confidence and trust.

Lifecycle costs can be significantly lowered as well when operational and maintenance aspects are assigned a high priority during the design process. After all, even though the design and permitting process may take several years to complete, operational terms can take decades.

Having the end user of a project represented throughout the entire planning and construction process creates a feedback loop that will necessarily improve the design.

Effective Communication Plans

Environmental permitting is also an essential process for maintaining environmental and regulatory compliance. As an example, a natural gas transmission main can often traverse multiple county and municipal jurisdictions. Most projects of this type include various terrains, property owners, permitting jurisdictions, and interactions with the public, as well as crossings of other transportation and utility assets and sensitive environments.

The constructability of a project can raise dramatically when the design and construction team self-regulate throughout the project to monitor, maintain, report, and close out. It can also build confidence among the regulatory community and the general public. The designation of roles and responsibilities associated with compliance is essential, as is placing authority with the compliance team members.

In the example of the gas transmission main, the project included multiple wetland crossings, encroachment permits, and easements; each of which had associated special conditions. In addition, each municipal stormwater jurisdiction had special permit conditions to prevent adverse impacts to adjacent resources and water quality.

The project was designed with significant staging areas that allowed ample space for materials, storage, equipment maintenance, office and management, parking, and communication facilities. There were access locations along the route and there were several nearby cultural resources where special care was afforded.

Many special provisions of the various permits were addressed using specific best management practices (BMPs) such as erosion control devices, access facilitation devices, temporary bridges, and signage to designate sensitive areas such as wetlands.

The environmental compliance team, armed with a clear plan in hand, was able to constantly monitor all aspects of the regulatory compliance program through the construction cycle. This enabled effective communication with the range of jurisdictional inspectors and created important trust-based relationships as the project progressed. It also clearly demonstrated the dedication to environmental compliance of the owners, engineers, and contractors.

As is the case with all projects, developing an effective communication plan is essential. In this case, a weekly progress meeting was initiated during the design process that covered all aspects of the project, including permitting and compliance.

Proper signage at areas such as this wetland crossing can improve awareness and assist with permit special provision compliance.

Designating the meetings as a specific project category assisted in driving progress while establishing a very close working relationship with the members of the environmental compliance team who ultimately became responsible for implementing and enforcing the project plans and requirements as the project transitioned to construction.

That transition was a specific point in time marked by an environmental permit transition conference. This conference included the actual personnel responsible for installing, monitoring, and reporting all aspects related to environmental compliance. Each member of the team was able to learn their exact roles, which helped them coalesce and become an effective unit. As the project progressed, any challenges that arose during construction were quickly and effectively addressed in a collaborative manner, enabling completion with no anomalies associated with environmental permitting.

This practice of engaging the environmental compliance team members early and throughout the design process clearly served to reduce risk, resulting in a project that was completed with none of the delays or cost increases created by regulatory compliance challenges.

Clearly, permitting and compliance can and should be incorporated with a high level of importance early in the design process in order to save time, gain regulatory trust, and to help prevent additional costs during construction.

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Pipe Outfall Protection

Is It Really 'Rock'et Science?

BY VINCENT DAVIS

The Delaware Department of Transportation (DelDOT) was recently tasked with developing a design guidance document for pipe outfall protection to aid its designers for use on their design projects.

Photos courtesy Vincent Davis.

The Delaware Department of Transportation (DelDOT) was recently tasked with developing a design guidance document for pipe outfall protection to aid its designers for use on their design projects.

The concentration for this guidance focuses on pipes less than or equal to 60-inch round diameter (or equivalent). Anything larger than this size is considered a bridge; hence, it would require additional coordination with a Bridge Design section. In Delaware, most of the state is located in the coastal plain region except for a small portion of the upper part, which is in the piedmont region.

In layman's terms, Delaware is very flat, and DelDOT designers usually have more problems with trying to get enough slope on a pipe system to reach minimum clean out velocity.

Even with the mostly flat slopes, scour at pipe outfalls is still prevalent. In practice, most pipe outfalls (and intersecting swales) exhibit some type of scour even if the velocities and amount of flow are small.

Exploring Pipe Outfall Protection

Channel lining selections are fine for when the flow is at a steady state position, but what about that small area next to the pipe outfall? With the main function of outfall protection being to disrupt the concentrated energy, how best and easily can that area be secured to mitigate erosion?

In order to be useful for maintenance personnel in the field, preliminary research on the background of outfall protection and other states practices in this area were conducted and a multitude of studies based on different research projects were consulted.

Many states and municipalities encapsulate their approach differently. The two main design criteria that most areas follow are the processes found in Hydraulic Engineering Circular 14 (HEC 14) and two charts created by the Soil Conservation Service — now known as the National Resources Conservation Service (NRCS). There are also different states and agencies that use a mixture of the two, as well as other criteria.

HEC 14 Processes

HEC 14 is an excellent resource and, for the purposes stated above, the document's discussion of culverts contains the most relevant subject matter. The discussion of riprap aprons was also fairly succinct, but the riprap basin calculations were more involved in the documentation. Also, the Federal Highway Administration (FHWA) HY 8 Culvert Hydraulic Analysis Program is based on HEC 14, so, for situations that include only a straight pipe run open on both ends, that program could be used for sizing a riprap basin.

From a designer perspective, HEC 14 and HY 8 are good options. However, if the field engineer or maintenance personnel wanted a simpler procedure that could be done quickly in the field, the riprap apron could be calculated fairly easily, but the riprap basin calculations would be too complicated. Plus, the HEC 14 length and width apron dimensions often seem to be larger than what is needed in real-world applications.

With the perceived larger than needed size, right of way concerns come into play. Again, is there potentially a simpler way to calculate a length and width, which would work for DelDOT and still be viable from an engineering aspect?

NRCS Charts

The NRCS charts give different dimensions than HEC 14, — plus, the individual charts appear to be a combination of two charts imposed on one another, created sometime in the 1970s or 1980s.

While the origin of the charts is unknown, Appendix D in HEC 14 states the charts appear to be based on J.P. Bohan's research report, *H-70-2, Erosion and Riprap Requirements at Culvert and Storm-Drain Outlets*, conducted in 1970.

From a designer standpoint, sizing riprap aprons with the charts is simple and quick. For personnel out in the field, it could be a little cumbersome carrying those around. And those charts are only good for riprap aprons, not riprap basins.

Even with the mostly flat slopes typical of the area, scour at pipe outfalls is still prevalent.

Riprap Alternatives

For most pipe outfall protections, riprap is the standard. But, for the thousands of pipes, road crossing culverts, driveway culverts, and more that have lower velocity and total flow values, what about using a more flexible armoring application? How would that sizing be accomplished? There are quite a few products on the market that should work, according to the manufacturer's literature.

But with no independent testing of these products — at least, not in the way that the National Transportation Product Evaluation Program (NTPEP) does for flexible channel linings such as erosion control blankets (ECB) and turf reinforcement matting (TRM), it can be hard to determine feasibility.

For outfall pipes that have lower velocity and total flow values, a more flexible armoring application might be best.

DelDOT has tried a few test cases using TRM at a pipe outfall for scour protection but, in almost all cases — it wasn't as successful as hoped.

There is a strong promise for some of the other more robust products that could do a good job of preventing scour and promoting a greener approach to Delaware's pipe outfall protection needs. This would help tremendously with cost, installation, long term maintenance, and appearance. Yes, rock is about as natural as it can get and engineers really like it, but homeowners and maintenance personnel — who have to cut around it and spray herbicides — may have a different opinion.

Perhaps a happy medium can be reached by simplifying the formulas used while still maintaining an engineered functional approach; at least for Delaware's needs. What works here may not be the best solution for other states and municipalities, so stormwater managers are encouraged to take a step back and evaluate their pipe outfall protection design process.

Vince Davis *is a professional engineer in Delaware and has been with the Delaware Department of Transportation for over 26 years, mostly working in the fields of stormwater management and erosion and sediment control.*

Federal Stormwater Regulations and Policies

The current landscape

BY SETH BROWN

The most contentious policy issue currently in the water sector is the Waters of the U.S. (or WOTUS) rulemaking, with its constant back-and-forth dynamics. While the 2015 version of the WOTUS regulations under the Obama administration expanded the jurisdictional universe of waters defined as a WOTUS, the 2020 version under the Trump administration reduced this coverage significantly, including eliminating ephemeral streams from inclusion under the legislation. In the stormwater sector, the most significant WOTUS issue is the exclusion of stormwater management infrastructure from being considered under the rule.

The specific concern relates to scenarios where a stormwater practice — such as a stormwater pond — that was originally constructed to meet regulatory requirements may be viewed as a natural body of water to those unaware of the original intent of the practice. As such, further definition is required. Considering that there are well over a million stormwater control measures across the U.S. by one estimate, the burden to regulators to address confusion over these scenarios would be overwhelming and a strain on limited resources. Also, the focus on nature-based practices — namely green stormwater infrastructure — makes these scenarios all the more likely to arise.

The currently proposed rule out for comment rolls the definition back to the pre-1986 WOTUS ruling — which does not include an exclusion for such stormwater control features. The National Municipal Stormwater Alliance (NMSA) and other groups have voiced the need for this exclusion, so it is hoped that this uncontentious issue is resolved in the final rulemaking.

Another regulatory program that MS4s should keep their eye on is the Electronic Reporting (or E-Reporting) Rule. The first phase of this rule has been completed, so EPA is currently engaged in the second phase, which includes MS4s with the premise that all MS4 permit compliance documentation will be required to be provided in a digital format by December 21, 2025 (note that "digital format" means data in a spreadsheet or database as opposed to simply transitioning paper reports to PDF documents). While this is four years away, the process of shifting regulatory documentation for entire states or municipalities is not quickly or easily done, so this is a relatively short period of time in this context. Also, this date was initially set for December 21, 2020, so an additional extension is not likely.

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A final topic to consider tracking is the Clean Watersheds Needs Survey (CWNS), an effort led by EPA and state regulatory programs periodically to capture the capital investment needs in the Clean Water sector.

EPA has developed a costing tool that enables a community to provide basic information about a stormwater practice (such as the size of the stormwater control measure (SCM) footprint and the type of SCM) to generate an estimated cost.

Also, EPA has developed a list of accepted documents that can be used to estimate capital needs for stormwater, which include watershed plans, stormwater utility feasibility studies, capital improvement plans, climate resilience evaluations, and many other similar types of documents. EPA is also allowing states to develop their own approaches to estimating stormwater needs. Each state has an assigned state CWNS coordinator, who is the point of contact for communities and utilities in their state. This coordinator leads efforts to develop these "state approaches" along with other support in their state. This flexibility reflects EPA's recognition that states vary in their approaches to tracking stormwater infrastructure needs.

With the significant increases in funding authorized in the Infrastructure Investment and Jobs Act of 2021 for the SRF and OSG programs, the incentive for states and communities to report stormwater needs is more urgent than ever. NMSA is working with EPA staff to perform outreach and engagement with states and MS4s to ensure that stormwater needs are identified and captured in the CWNS.

Seth Brown *is Executive Director of the National Municipal Stormwater Alliance (NMSA). Since forming in 2018, NMSA has made significant contributions to the stormwater/MS4 sector through policy leadership, state and regional engagement and support, technical information development and dissemination, and raising the awareness and profile of stormwater overall. Learn more at www.nationalstormwateralliance.org.*

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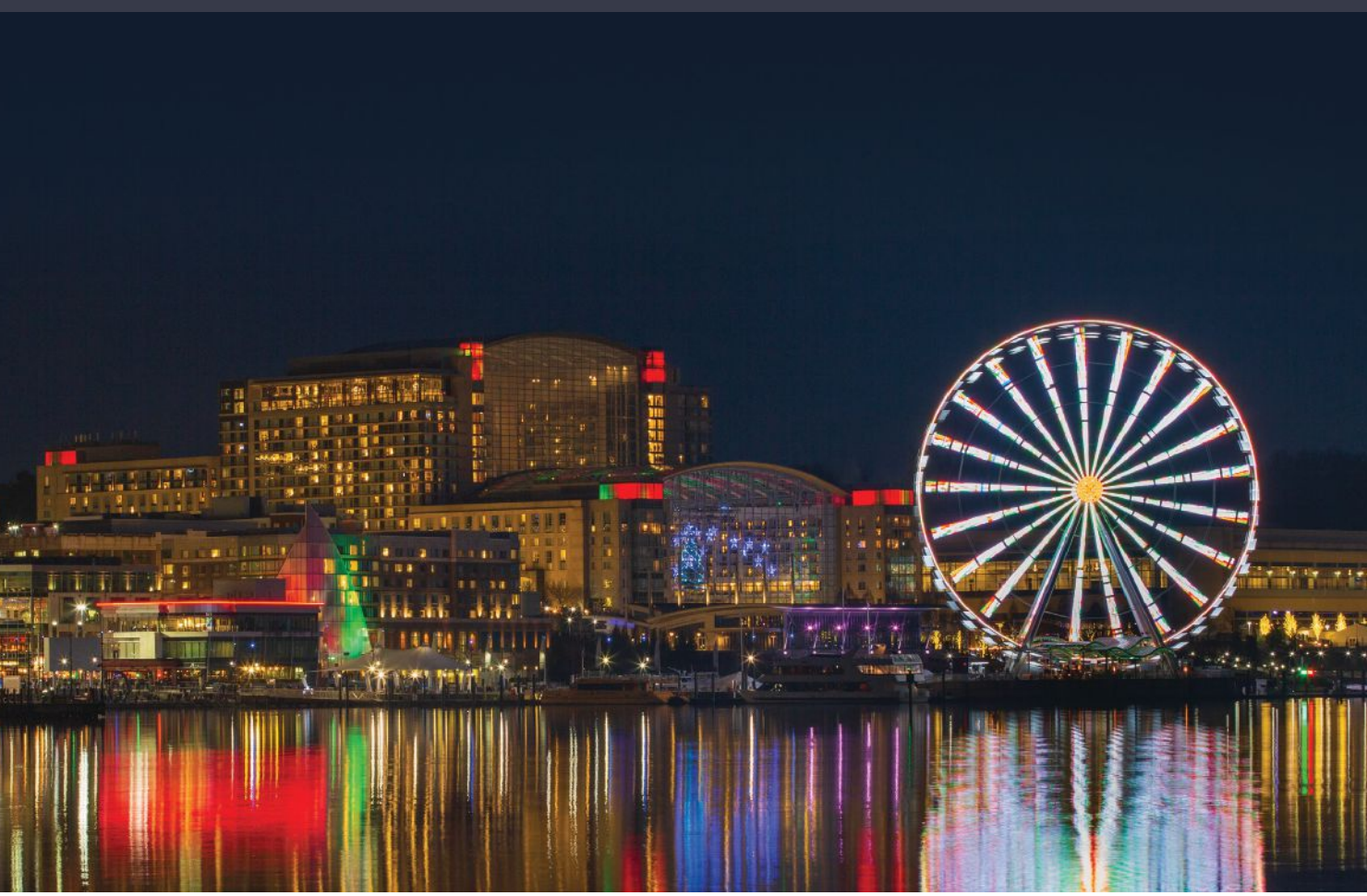

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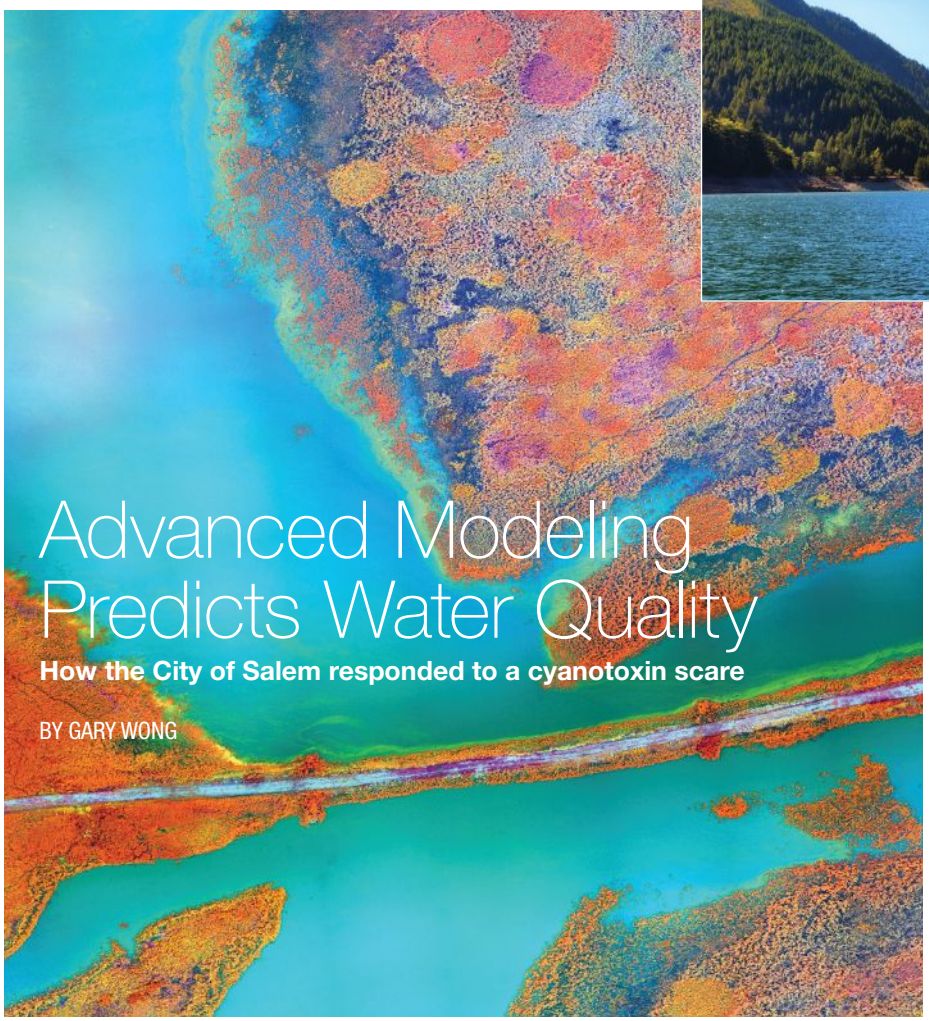

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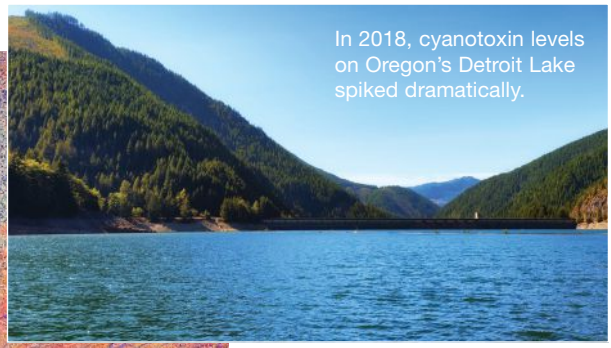

In 2018, cyanotoxin levels on Oregon's Detroit Lake spiked dramatically.

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Advanced Modeling Predicts Water Quality

How the City of Salem responded to a cyanotoxin scare

BY GARY WONG

Algal blooms can be harmful to fragile wetland ecosystems. Predictive modeling can help to alleviate the threats HABs can cause to neighboring communities.

As Earth's weather patterns shift, new challenges have arisen for those tasked with keeping basic utilities running reliably. Although they may not be large spectacles on the evening news, some of climate change's subtler effects have the same potential for real catastrophe.

These challenges often go unnoticed by the general public but, to those who work on the front lines, the need to harden infrastructure remains constant and urgent. One such potentially catastrophic event occurs in lakes and reservoirs around the world: harmful algal blooms (HABs).

In 2018, this was precisely the scenario at Detroit Lake, which serves as the main source of drinking water for the City of Salem, Ore. With little warning, the levels of cyanotoxins spiked.

Officials raced to ascertain the scope of the problem. While some HABs are just a nuisance, tainting drinking water with a musty taste or smell, those that produce cyanotoxins pose serious health risks to humans and animals. Local news media ran a story on the cyanotoxin levels, which officials worried might drive public panic.

When the dust settled, officials identified a need for better predictive modeling, which would allow them to adjust processes quickly in response to real water conditions.

While the City of Salem's Public Works Department (PWD) had already adopted machine learning and other digital technologies to make its operations more efficient, at the time of the 2018 HAB event, it had yet to use its data management platform to predict cyanotoxin spikes.

New Models for the Future

In 2016, the City of Salem installed an operations data management platform to help make its water and wastewater operations more efficient. The AVEVA Process Information (PI) System delivered real-time data to team members via the cloud, helping users visualize their processes and act proactively.

As the City of Salem further digitized its assets, it partnered with Casne Engineering to build out an asset framework for its PI system, hoping that the predictive asset maintenance could lead to significant reductions in overall energy consumption. Salem achieved many gains in operational efficiency as a result — but, to combat harmful algal blooms, the city needed the ability to predict and react quickly to new threats.

The city needed to know when an HAB event might happen again. With advanced warning, the PWD could make operational changes to address the presence of harmful cyanotoxins before they become a public health concern.

"We ultimately wanted to predict when harmful algal blooms were going to be present in our reservoir," said Devin Doring, technical services supervisor for the Salem Public Works Department. "If we could predict that, we'd have time to adjust our processes."

Doring and his teammates set a clear goal that utilized the PI system's central data hub to make real-time data accessible from any location.

The Predictive Analytics Solution

Predictive modeling is one of the best tools available in the field of climate science. It has been used for years to follow ocean currents and temperatures, extreme weather events, and the enduring drought in the Western United States. Scientists have only recently applied predictive models to monitor water quality in freshwater supplies.

As Doring and his team strategized ways to use technology to predict the next HAB in Detroit Lake, they contacted researchers at Oregon State University who specialized in advanced predictive models.

The City of Salem decided to invest in a wider set of data resources to reach its goal, integrating advanced modeling algorithms into its existing PI System. Doring and his team incorporated weather data from the National Oceanic and Atmospheric Administration and the US Geological Survey, as well as satellite imagery and data from water quality monitoring equipment attached to pontoon floats. In its current iteration, the updated system also integrates data from laboratory analysis and the SCADA control system.

Building Trust and Ensuring Quality

Aided by its operations data platform, the City of Salem created a highly integrated system that — given the multiplicity of data points from both the natural and built environment — offers optimal monitoring of water quality at the Detroit Lake site.

To raise awareness and foster public trust after the 2018 cyanotoxin scare, the City of Salem now regularly publishes modeling data for public use with a predictive lead time of one week. Salem's PWD plans to continue honing its modeling algorithms, with the hope of increasing the predictive lead time to a month or more.

As climate change creates uncertainty and new challenges in the water and wastewater industries, it's more imperative than ever that enterprises improve their resilience, agility, and operational efficiency, so that they're best prepared to meet the challenges and opportunities of the future.

Gary Wong *is the Global Industry Principal of Infrastructure and Water at AVEVA. He leads their global data centers, facilities, smart cities and water businesses. Wong is also the Chairman of the Smart Water Networks Forum (SWAN) Americas Alliance.*


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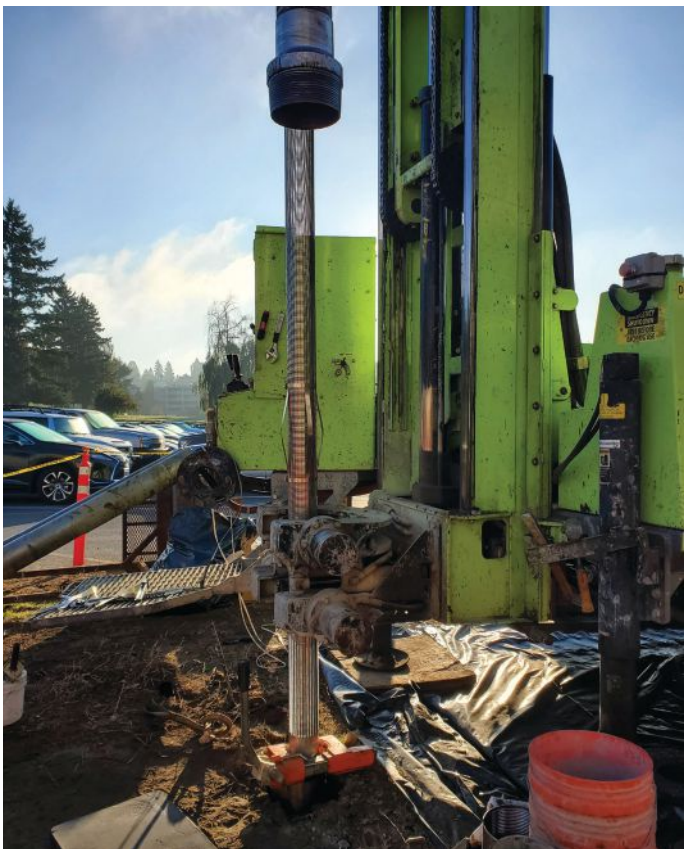
tuning of infiltration BMP flowrates and spacing can further avoid mounding problems.

Deep Infiltration

The use of deep infiltration to meet Low Impact Development and flow control requirements on projects has been increasing, particularly where surface soils have low permeability but overlie an unsaturated, higher-permeability soil. It's sometimes feasible to bore through the surface soil and install an infiltration well in a more permeable receptor soil. Stormwater runoff is then routed into the well and infiltrated into the receptor soil.

The concept of deep infiltration is straightforward, but a system that reliably functions for decades requires some careful thought.

Although preferred methods vary, for deep infiltration testing and analysis in general accordance with Borehole Injection Testing and the Well Permeameter Method (USBR Test Method 7300-89) is recommended. After analysis of test data, the well permeameter equation can be used to estimate infiltration flow rates for other well diameters and screen lengths.



Working with the Port of Seattle's Seattle-Tacoma International Airport (STIA), Aspect Consulting developed Standard Operating Procedures (SOPs) for shallow and deep infiltration systems.

To prevent plugging, it's critical to keep sediment out of deep infiltration wells. However, normally some runoff is allowed to bypass treatment BMPs during large storms. Directing untreated flow into infiltration wells will reduce their service life.

Another consideration is whether advance BMPs can be a source of initial sediment loading. For instance: Is that drain rock really clean? Should I specify on-site washing of drain rock? Will my bioretention mix initially leach sediment? Should I flush the system before connecting to infiltration BMPs?

Deep infiltration wells are designed to:

- Include treatment to remove sediment for all flows to the well,
- Control the rate of flow into the well to the design rate,
- Reserve head to allow water levels to rise to counteract plugging,
- Prevent baseflows from entering infiltration wells, and
- Ensure the system drains down in a reasonable time.

Using the 'Infiltration Cookbook'

Consistently achieving successful stormwater infiltration requires clear and comprehensive guidance for planning through construction. As part of the team preparing an updated LID Manual for the Port of Seattle's Seattle-Tacoma International Airport (STIA), Aspect Consulting developed Standard Operating Procedures (SOPs) for shallow and deep infiltration systems.

The SOPs provide consolidated guidance for planning, testing, analysis, design, and construction of infiltration facilities.

The scope of work included soil borings, to characterize surface and receptor soils; design and installation of a groundwater monitoring well; design and installation of infiltration test wells; deep infiltration testing and groundwater monitoring; soil treatability tests; infiltration test data analysis; estimations of saturated hydraulic conductivity; development of alternative infiltration well options; hydrologic modeling for planned development; and final estimates for the number of wells for the development site.

In order to protect your infiltration BMP, project managers should work to prevent compaction of the infiltration soil, protect the system from construction runoff, remove construction sediment from the upstream drainage system, and specify and verify that the proper geotextiles are being used.

***John Knutson** is a principal engineer with Aspect Consulting. He has 29 years of experience leading stormwater, flood management, and habitat restoration projects for clients throughout the Pacific Northwest. He can be contacted at jknutson@aspectconsulting.com.*

Showcase

Modular bioretention

TerraMod™ offers a top tier bioretention solution designed to maximize simplicity and flexibility for urban stormwater management systems. Focused on providing a green, localized and simple solution, the modular design allows for you to meet local bioretention specifications. Due to the flexibility and variety of usage, TerraMod expedites design and installation through prefabrication and minimal onsite assembly. Leveraging biological processes, infiltration and pervious surfaces, TerraMod is a green, modular stormwater bioretention solution engineered to meet site specific low-impact development requirements.

Oldcastle Infrastructure
www.oldcastleinfrastructure.com

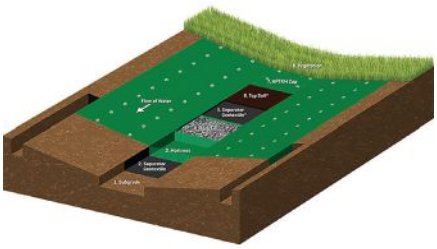
Rainfall sensor

The Precip Sensor utilizes tipping rain bucket technology to measure on-site precipitation, communicating real-time data across networked controllers and performance components. With the Precip Sensor, the BaseStation 3200 will pause, stop, and start individual irrigation programs based on rainfall rate, accumulation, and effective rainfall in the landscape. When combined with the EPA WaterSense labeled soil moisture sensor, it provides a closed loop measurement of rainfall events. With Baseline's Analytics application, users can generate reports with detailed information about historical rain accumulation, rainfall rate and duration at a site. Up to eight Precip Sensors can be connected to a single controller.

HydroPoint
www.hydropoint.com

Erosion control turf

The PYRAMATTRESS® Engineered Mattress System is an erosion control solution designed to resist potential scour and erosion caused by the constant flow of water or high hydraulic stresses. The system utilizes the durability and erosion resistance of PYRAMAT® 75 High-Performance Turf Reinforcement Mat (HPTRM) to construct a geosynthetic/soil/rock composite for protection of channels, slopes, and spillways. The design allows for smaller rock-fill size, which improves water flow. Smaller void space also allows for reduced erosion and higher performance overall. PYRAMATTRESS components are also corrosion resistant and promote vegetation, allowing for an increased design life that is environmentally friendly.



Propex
www.propexglobal.com

Water phosphate sensor

The LG Sonic PO4 Sensor monitors phosphate in real time at different water depths. Through the implementation of colorimetric phosphate detection, the sensor provides highly accurate readings over a large measurement range. The LG Sonic PO4 Sensor is stable at high temperature ranges, features lab-on-chip technology, and can operate completely autonomously. The sensor has a robust design and high durability of reagents. It automatically calibrates and cleans for ease of use and minimal maintenance.

LG Sonic
www.lgsonic.com

Ultrasonic algae treatment

The Sentinel AIQ from WaterIQ Technologies is designed to combat harmful algae and biofilm without the use of chemicals. Sentinel AIQ is built for larger bodies of water that require an autonomous system independent of land-based power. Sentinel is a watercraft equipped with solar energy to provide electricity to all onboard systems. Every component is designed for performance and reliability over many years of use. Every Sentinel AIQ is also equipped with a Pulsar 4000 ultrasonic algae remediation appliance. In addition, the company uses IoT technology to report the operational status of units and water health data for remote monitoring.

WaterIQ Technologies
www.wateriqtech.com

Urban stormwater management

Advanced Drainage Systems Inc. (ADS) recently released the EcoPure BioFilter — an NJCAT-NJDEP approved urban stormwater management solution. EcoPure BioFilter is engineered for low-impact developments (LID) and green infrastructure projects requiring design flexibility, application of diverse plant life and hassle-free installation and maintenance. The device, which is available is multiple sizes ranging from 4' by 8' to 10' by 20', is appropriate for new construction and retrofit commercial jobs. It can be easily configured to fit curb inlet, direct-pipe connection and roof drains, and the device arrives on site ready to be installed.

Advanced Drainage Systems
www.adspipe.com

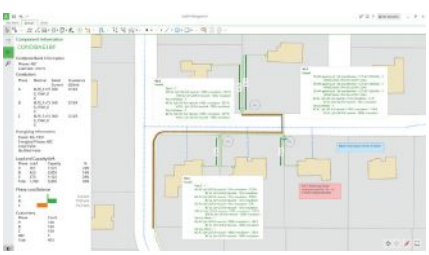
Phosphate removal

Clean TeQ Water's new PHOSPHIX™ technology uses a combination of Continuous Ionic Filtration (CIF®) technology and chemical precipitation to selectively remove phosphate from water and recover a solid phosphorus product that is suitable for reuse. PHOSPHIX™ can achieve very low effluent concentrations (<0.1 ppm) with over 99% water recovery, and provides phosphate recycling into hydroxyapatite, which can be used for fertilizer production. The solution provides reduced footprints and low chemical consumption, leading to significant reductions in operating costs. The cost reduction could make phosphate recycling a more viable solution for treating water across industries.

Clean TeQ Water Ltd.
www.cleanteqwater.com

Engineering platform

Schneider Electric has released version 11.3.3 of its ArcFM Designer. Purpose-built for designers and engineers, the new features of ArcFM Designer XI include the ability to leverage CAD files during the design process. Now, designers and engineers no longer have to rely on extended processes to access the CAD data in their design environment, greatly enhancing efficiency and productivity. ArcFM Designer XI now includes functionality for comparing design options; a reimagined and faster-loading work page; and the ability to support design creation from scratch, as well as moving a design to a different work request for more flexibility.



Schneider Electric
www.se.com

Hydrologic modelling

Smart City Water has launched a new approach to drainage system modeling. The approach models how overland flow and sewer systems interact and predicts how the sewers could become overloaded due to excess surface water. The approach adds powerful tools to the company's Visual OTTHYMO (VO) hydraulic and hydrologic modelling platform. With the increasing urban growth across major cities and regulatory requirements for sustainable drainage infrastructure VO-SWMM aims to assist cities, consulting engineers, and scientists in analyzing the impact of severe storms and increasing efficiencies to allow safe and resilient development in growing cities and towns.

Smart City Water Inc.
www.smartcitywater.ca

Concrete volute pump

Kirloskar Brothers Limited (KBL) has recently patented its Concrete Volute Pumping Assembly. Concrete Volute Pumps derive their name as the casting and suction draft tube is concrete, while the rotating parts are metallic. As the casing is constructed in concrete at the site, CVP is a suitable pumping option for handling large volumes of water. Concrete Volute Pumps provide strength and rigidity with very low rates of corrosion and erosion. It also ensures consistent pump efficiencies over a sustained period of operation. Concrete Volute Pumps by Kirloskar are widely used for lift irrigation, water supply, and drainage and flood control.

Kirloskar Brothers Ltd.
www.kirloskarpumps.com

Slope stabilization

The new Remote Operated Launcher System from GeoStabilization International® provides flexible and customizable carrier configurations for virtually any slope angle and slope length. The Remote Operated Launcher System uses high-pressure compressed air technology to rapidly install soil nails at a speed of nearly 250 miles per hour without producing drill cuttings or spoils. The air compressor can decouple from the excavator, allowing it to be attached to smaller, more maneuverable equipment. Doing so reduces the equipment footprint and impact on traffic flow, while providing crews more mobility to safely traverse steep slopes.

GeoStabilization International
www.geostabilization.com

Advanced AC Pump

Yaskawa's U1000 iQpump Low-Harmonic Intelligent Pump Drive converts input AC voltage to output AC voltage. Designed for water pumping applications, this drive provides extremely low harmonic distortion, energy savings, and serviceability in a space-saving design. The U1000 iQpump meets all IEEE 519 standards out of the box. Built with pump operators and service technicians in mind, the pump drive also features intuitive, integrated pump-specific software and setup parameters. This allows operators to easily program control values for a wide range of applications including constant pressure, accurate flows, controlled acceleration/deceleration, multiple pump booster systems, and more.

Yaskawa
www.yaskawa.com

Market Place Spotlight

Advertiser's Index

TOUGH on Debris.
EASY on the Environment.

Introducing Hybrid Broom Bear®

UNCOMPROMISED
PERFORMANCE

The plug-in hybrid electric Broom Bear is another example of Elgin Sweeper's ongoing commitment to help our customers reduce their carbon footprint, improve air quality, and mitigate climate change.

Designed to tackle everything from heavy-duty construction debris, such as millings or gravel, to light street maintenance, the hybrid sweeper's performance, speeds, capacity, and its availability to work all day remains unchanged from the standard Broom Bear sweeper.

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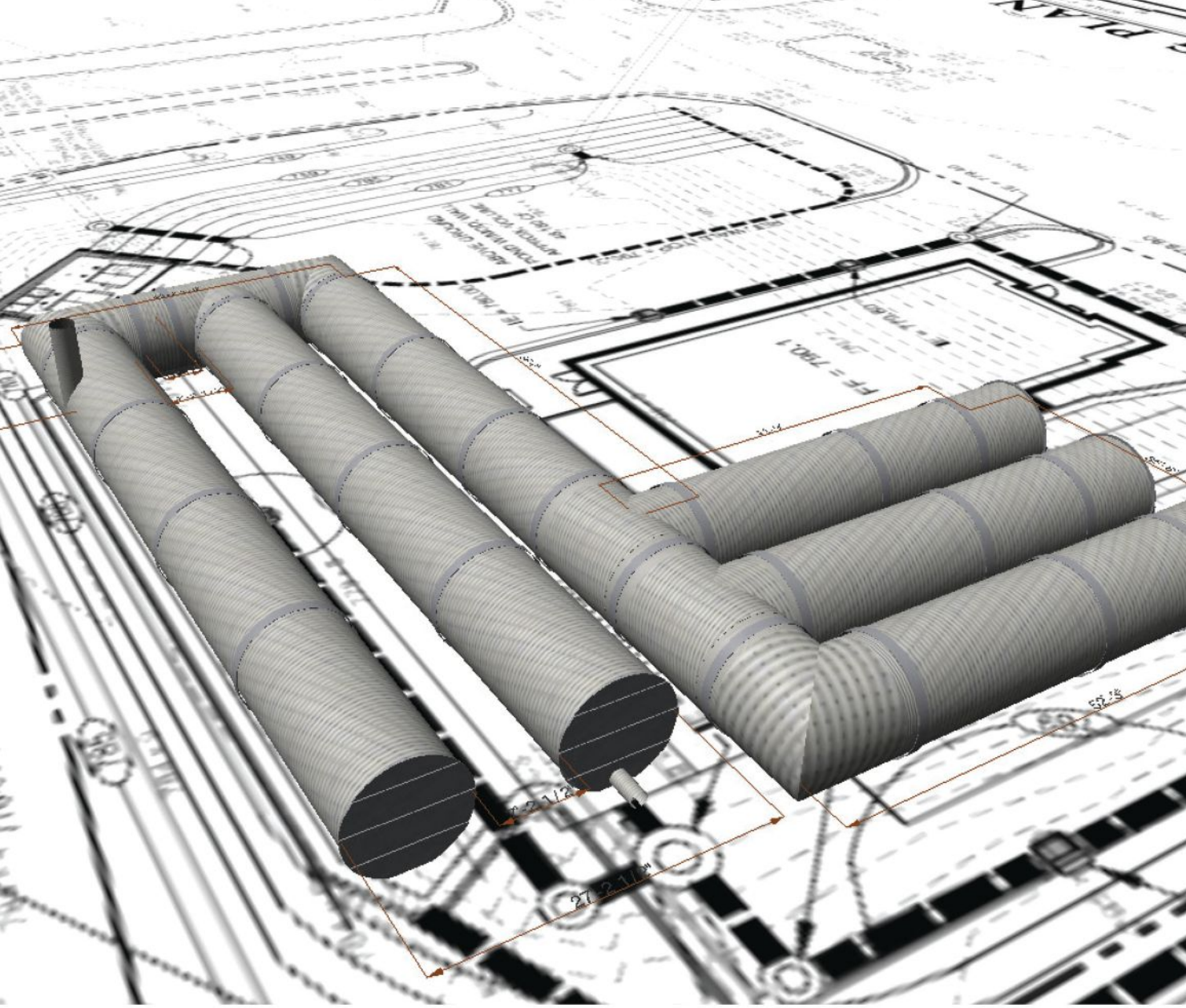
- ***350 Gallon Water Capacity***
- ***Seamless Transition Between Systems***
- ***Available In Diesel Or CNG***
- ***Pause-sweep Functionality***

REQUEST A DEMO

ELGIN
Subsidiary of Federal Signal Corporation

HYBRID
Broom Bear®



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