

STORM WATER

Test Results Permit Side-by-Side Comparisons of BMPs

Initial results from what is perhaps the first comprehensive attempt to compare a variety of so-called storm-water best management practices (BMPs) under identical conditions indicate that low-impact development (LID) approaches generally remove the highest levels of key contaminants. LID techniques attempt to maintain a site's predevelopment hydrology by minimizing runoff and treating and retaining storm water on-site to the fullest extent possible. Released in January, the findings of the UNH Stormwater Center—a component of the Environmental Research Group at the University of New Hampshire (UNH)—also affirm that LID practices are effective even in cold climates.

Because treatment performance depends to a marked extent on site conditions and storm characteristics, comparisons of BMPs implemented at different locations must account for a host of variables that can complicate the evaluation process. "There's a tremendous amount of inherent variability in storm water," says Robert Roseen, the director of the UNH Stormwater Center. For example, some watersheds are more contaminated than others, and storms, depending on their intensity and duration, can produce varying levels of polluted runoff. By testing BMPs at the same site and under the same storm conditions, the researchers ensure that the treatment approaches are evaluated on an equal basis.

The researchers took pains to ensure that all the areas being tested received equal amounts of runoff with identical water quality characteristics. Located next to a 9 acre (3.6 ha) commuter parking lot on the university campus, the test site was designed to convey runoff from the parking lot through a 36 in. (914 mm) diameter pipeline to a distribution box. From there a series of 12 in. (300 mm) pipes conveyed the runoff to areas on which particular

BMPs were implemented. The distribution box and the pipes had to be specially designed to ensure that they do not allow sediment and other pollutants to settle out of the storm water. "We don't want the distribution system itself to affect water quality," Roseen says.

To ensure that water does not collect anywhere within the distribution box, its floor was leveled within 0.01 ft (3 mm) by using a self-leveling epoxy that has a smooth surface after drying. Moreover, the outlet pipes conveying runoff from the box to the areas on which the particular BMPs are implemented are situated slightly below the box. "There's no sedimentation occurring within the distribution chamber," Roseen notes. The pipes were installed at a sufficient slope to ensure that "all the sediment is pushed through the pipes and there are no losses due to sedimentation," he says.

Effluent from the tested areas was conveyed to a central gallery, where sampling and flow measurements were conducted. To assess performance, the researchers determined each BMP's "event mean concentration," that is, the total storm-water flow and the mass of a pollutant in a system's influent and effluent. From this, the method's pollutant removal efficiency could then be determined.

The BMPs were evaluated with respect to their ability to remove total suspended solids (TSS), total zinc, total petroleum hydrocarbons-diesel (TPH-D), and nitrate-nitrogen. TSS was selected because it is the "primary target in storm water these days," Roseen says. Zinc, a common contaminant in storm water, is easy to measure, Roseen notes. TPH-D was chosen because storm-water runoff is largely influenced by such by-products of transportation. Nitrate-nitrogen was selected because it is "probably the number one contaminant of concern" in regions near water bodies that expe-

rience low levels of dissolved oxygen, Roseen says. He notes that his center is also assessing the ability of the devices to remove total phosphorus, the nutrient most likely to degrade water quality in rivers and lakes. However, these data are not yet available.

BMPs with the capacity to detain storm water were also evaluated with respect to how much they reduced peak flows and the amount of time that flows exiting the device lagged behind the first flows to enter it.

Thus far, performance evaluations of the BMPs are based on results from 11 storm events between September 2004 and August 2005. Of the 11 BMPs for which performance data are available, 5 are nonproprietary: a surface sand filter, a retention pond, a bioretention unit, a gravel wetland, and a stone-lined swale. Of these, the sand filter, the bioretention unit, and the gravel wetland are considered LID approaches, while the retention pond and the swale are generally thought of as more conventional treatment techniques. The six proprietary devices include a water quality unit comprising a series of weirs and baffles to retain solids, oils, and trash; the same water quality unit employed in advance of a subsurface infiltration unit; a hydrodynamic separator together with a filtration chamber that contains media to screen fine particles; and three hydrodynamic separators made by different manufacturers.

Results from the first year of testing (see table) indicate that filtration systems, particularly vegetated LID systems, are "the top performers hands down," Roseen says. One of the more innovative LID approaches, a gravel wetland designed by researchers with the center, is "probably the best performer all around," he says. In one of the "biggest surprises," Roseen says, one of the proprietary methods used in series—the

water quality device with the subsurface infiltration unit—performed on a par with the LID approaches in terms of removing TSS, zinc, and TPH-D. "That's very good news," he notes, because the systems are increasingly being installed under the parking lots of so-called big-box stores.

However, Roseen hastens to point out that the results must not be interpreted as indicating that one class of BMPs is better than another. "You really have to compare them within the class of systems," he says. For example, comparing the performance of a hydrodynamic separator with a bioretention system is "not fair," he says, because they employ different approaches to treat storm water in different locations. Although a bioretention system may appear to perform better, it requires

significantly more space, making it impractical in many urban applications that might be well served by a hydrodynamic separator.

One of the "big contributions" that the research is making to the storm-water field, Roseen says, involves offering evidence that LID systems work well even in cold climates. Storm-water practitioners in the northeastern part of the country have been reluctant to employ LID approaches for fear that they will not perform properly during cold weather. However, "these systems work fine," Roseen says, "even in the middle of winter." He notes that even if the filter media used in some devices freeze, they quickly thaw in the presence of runoff. Furthermore, such systems as bioretention units maintain sufficient biological activity to prevent

filter media from freezing in the first place, Roseen says.

Funding for the research has been provided by a grant from the Cooperative Institute for Coastal and Estuarine Environmental Technology, a partnership between the U.S. National Oceanic and Atmospheric Administration and the University of New Hampshire. Results from the center's first year of testing were presented in Washington, D.C., in January at the annual meeting of the Transportation Research Board. A paper summarizing the results by Roseen, Thomas Ballesterio, P.E., the principal investigator at the UNH Stormwater Center, and James Houle, the center's facility manager, is to be published as part of the conference proceedings.

—Jay Landers

Performance Data

Treatment unit	Total suspended solids removal (percent)	Nitrate-nitrogen removal (percent)	Total zinc removal (percent)	Total petroleum hydrocarbons-diesel removal (percent)	Average peak flow reduction (percent)	Average lag time (minutes)
Water quality unit ^a	66	0	74	47	—	—
Water quality unit and subsurface infiltration unit ^a	100	0	100	100	83	364
Surface sand filter	49	6	81	100	60	220
Retention pond	81	64	92	61	85	554
Bioretention unit	97	44	100	100	85	615
Hydrodynamic separator and filtration chamber ^a	66	10	61	42	—	—
Hydrodynamic separators ^a	29–41	0–37	26–42	26–53	—	—
Gravel wetland	100	99	100	100	85	336
Stone swale	52	0	66	33	0	0

Source: UNH Stormwater Center.

Note: All removal efficiencies are median values.

^aManufactured device.