Large Volume Storms and Low Impact Development

Using LID Practices in Areas with Intense Rainfall Events

LID Barrier Busters Fact Sheet Series

People often think low impact development (LID) practices, which are designed to capture and treat the so-called first flush of polluted runoff, are not suited for areas subject to large volume storms because the practices could become overwhelmed with excess stormwater flow and fail. This is not the case. Properly sited and designed practices offer cost-effective treatment in a wide range of conditions and locations, and usually serve as an important first line of defense against high volume storm events.

Properly designed LID practices will allow excess water to bypass or flow through the system to avoid damage. Even in areas subject to high volume storms, LID practices successfully trap and filter a portion of the stormwater runoff—which helps alleviate pressure on existing stormwater conveyance systems and reduces downstream erosion, pollutant loadings, and damage to habitat in streams and riparian areas.

Frequently Asked Question

Is it true that LID practices don't work in areas that receive large volume storms?

Barrier Busted!

LID practices can be effective in areas subject to large volume storms if properly sited and designed to manage anticipated runoff volumes.

EPA's LID Barrier Busters fact sheet series... helping to overcome misperceptions that can block adoption of LID in your community

Equipping LID Practices with High Volume Flow Controls

The process of siting and selecting LID practices is influenced by soil type, land use, terrain, average rainfall and many other factors. Designers must consider a practice's hydraulic performance under both low-flow and high-flow conditions, and incorporate elements that can manage excess flow as needed.

An infiltration system such as a rain garden or permeable pavement is designed to treat a particular volume of water (also known as a water quality volume) over a prescribed period of time. Because these practices have a limited capacity to retain or treat excess volume, they are often built with features intended to protect the long-term function of the practices.

If the stormwater enters the practice at a low velocity and is not erosive, the excess runoff that ponds on the surface can be spilled into drainage systems built on the perimeter of the practice or discharged through overflow devices (Figure 1).

Other design features can be used to direct or convey high volume flows away from the practice and to alternative drainage systems. For example, in Figure 2, road runoff flows through curb cuts into a series of stormwater bioretention planters in Portland, Oregon. When all stormwater planters reach their maximum water capacity, water is forced to continue along the curb without entering the practice, bypassing it completely and flowing into an existing storm drain inlet.

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Figure 1. A parking lot bioretention area near Frederick, Maryland, is equipped with an overflow drain.

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Figure 2. Stormwater planters treat runoff and can bypass flows that exceed their treatment capacity.

Figure 3. Street runoff enters the upper end of this bioretention area and fills the practice. The overflow volume exits through an opening on the lower end and drops into a storm drain.

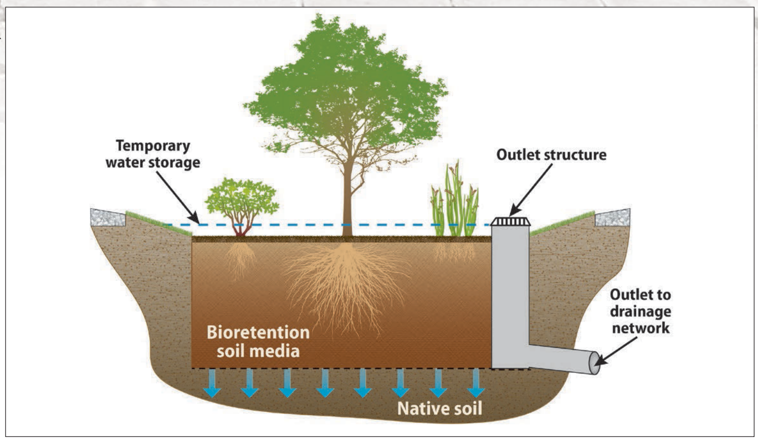

Figure 4. Overflow drain. Stormwater fills the practice and begins soaking through the bioretention soil media and into native soil. Excess water can spill through an outlet structure to an alternative drainage network.

Specific design elements incorporated in LID practices to convey excess flow through or around the practice include overflow and bypass devices, backup infiltration, and underdrains:

Overflow Devices

Overflow devices are typically used in online LID practices (i.e., practices that are placed within the normal stormwater runoff flow path). Online practices treat the water quality volume from smaller storm events and are designed to convey or partially detain flows from larger storm events. When the level of water rises to the height of the overflow structure within the practice, any excess runoff is discharged by gravity flow out of the practice and into another treatment practice or into a storm drain.

- **Overflow Channels.** If the runoff volume entering an online LID practice exceeds the water treatment design capacity, a downgradient opening such as a gravel channel or curb cut will allow excess flow to exit the system and proceed along the normal stormwater runoff flow path (Figure 3).
- **Overflow Drains.** A common design to control excess flow entering online LID practices is a vertical standpipe or box drain connected to an underground drainage system and topped by a grate or screen to prevent objects from entering the storm drain. The inlet of the overflow drain is set at the maximum allowable ponding elevation. The overflow control should be set at the downstream side, far away from the incoming flow (Figures 4 and 5).

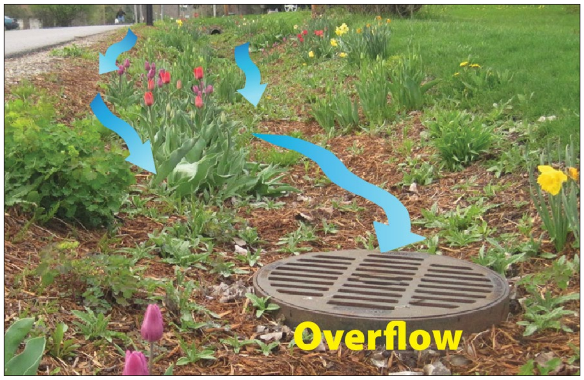

Figure 5. Overflow drain. Runoff water flows into this roadside bioretention channel, which is equipped with an overflow drain to prevent street flooding during high volume storm events.

Figure 6. Bypass system. A curb cut allows street runoff to enter this sidewalk planter. If the planter fills completely, additional runoff water volume will be forced to bypass the practice and continue flowing down the road.

Bypass Devices

Bypass devices (i.e., diverters, splitters) are typically incorporated into offline LID practices that are sited outside of the normal runoff flow path (Figures 6 and 7). Offline practices are designed to receive and treat a specified water quality volume (e.g., the runoff generated from a 1-inch, 24-hour storm). In the case of roadside facilities (e.g., planter, bioretention cell), the size of the inlet opening and the depth of the LID practice controls the amount of runoff allowed to enter the practice. As a result, flow can be bypassed in two ways. First, because the offline practices are designed with an entrance that restricts the amount of water able to enter the practice (e.g., curb cuts, weirs), high volume flows are split so only a controlled amount of runoff enters the practice while the rest continues on its normal flow path. Second, the system accommodates a controlled amount of runoff until the LID practice has reached its water quality treatment design volume.

At that time, the system will redirect all excess stormwater back into the normal runoff flow path, which is often a conventional curb-and-gutter stormwater conveyance system.

Backup Infiltration

Backup infiltration approaches can be used when adjacent surface areas are available to provide additional infiltration capacity. For example, overflows from permeable pavements can be managed by placing a strip of exposed gravel downslope of the pavement (Figure 8). Excess runoff will flow into this gravel strip, which will discharge a non-erosive flow stream to nearby vegetated areas.

Underdrains

Underdrains are needed where soils don't percolate/drain well or where there's a high groundwater table or frequent inundation of the practice. An underdrain is installed near the bottom of the LID feature. Some practices are designed with underdrains in tandem with overflow and bypass systems to ensure acceptable dewatering times and to protect the long-term functioning of the practice. Avoiding long-term ponding within the system prevents mosquitos from breeding and helps protect the health of plants that treat the runoff. Where infiltration could deteriorate over time and drainage become compromised due to sediment deposition, underdrains can be designed with removable caps to allow access for cleaning.

If water retention is a performance requirement, underdrains can be installed above the bottom extent of the practice or designed with a 90-degree upturned pipe so that the system begins to drain only after the required water volume is retained (Figure 9). The water percolates down through the soil into the internal water storage (IWS) layer and is slowly released into the soil underneath the practice.

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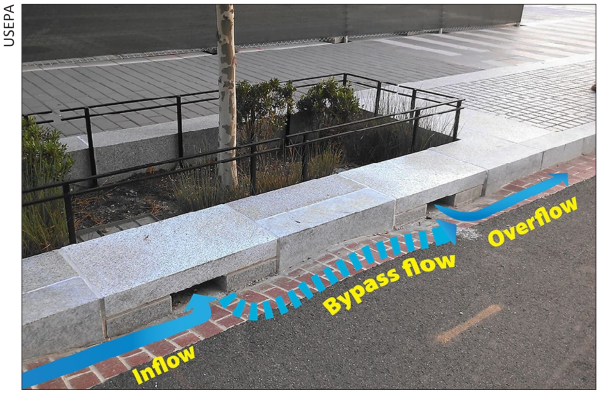

Figure 7. Bypass and overflow system. Runoff enters a planter box through a curb cut and collects until the practice's storage capacity is reached; additional water will either overflow through the second curb cut or will bypass the practice.

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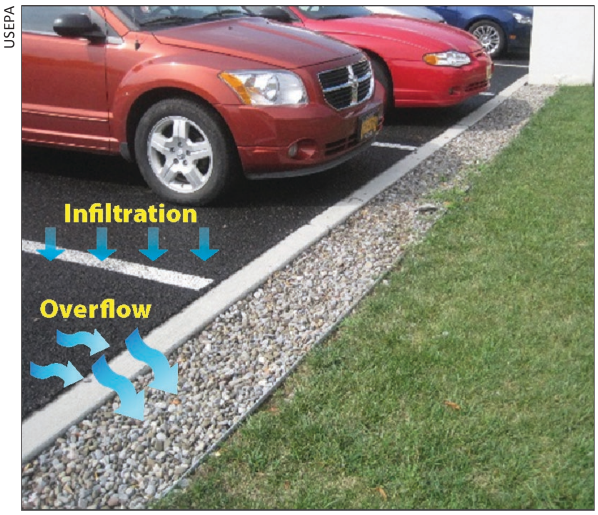

Figure 8. Back up infiltration system. A gravel aggregate strip adjacent to a permeable pavement parking lot collects overflow and directs it into a storm drain or alternative drainage practice.

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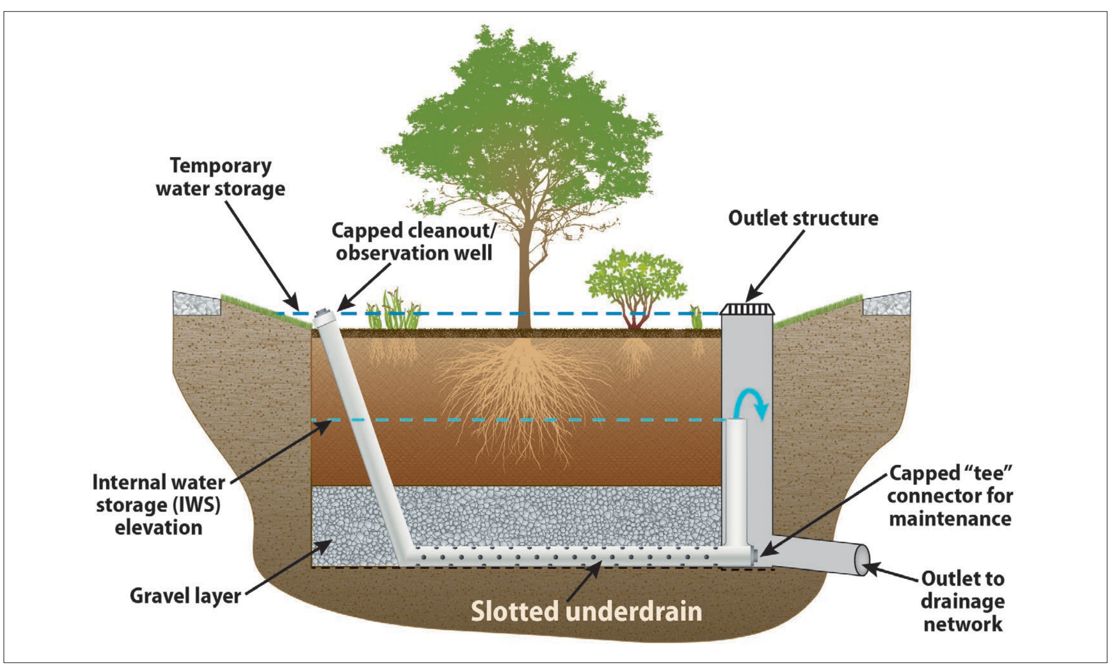

Figure 9. In this underdrain cross-section image, an upturned pipe design allows excess water to drain to an alternative drainage network while also ensuring a permanent internal water storage layer within the practice. An outlet structure can be included in the design to provide added protection against high volume flows.

Case Studies: Successfully Treating and Controlling Flow from Large and Small Storms with Diverse LID Practices

LID practices typically are designed to manage small- and medium-sized runoff events. Large storms will generally be diverted using bypass or overflow design features. The following case studies show how communities are balancing the need to convey and control peak stormwater flows with the need to treat and retain stormwater runoff.

Michigan Avenue Bioretention Planter Boxes, Lansing, Michigan

In 2006 bioretention planter boxes were installed along four blocks of Michigan Avenue, a busy five-lane street in Lansing, Michigan (Figure 10). The planters can treat the runoff from 1 to 4 inches of rain falling on the adjacent street and sidewalk. Water held in the soil is used by the plants, infiltrates to groundwater, or is released slowly through an underdrain. If the planter reaches its maximum volumetric capacity, the extra stormwater flows to the conventional curb-and-gutter street drainage system and into a storm drain.

Results

- Flow meters were used to monitor the system; model results show that about 90 percent of the total annual stormwater volume was treated by the planter box.
- The planters absorb/retain 16 percent and ultimately discharge 84 percent of the total volume of stormwater received. By collecting and filtering the stormwater, the planters delay discharge of the excess water into the local water body. The peak flow rate of the water released through the underdrain is lowered by 87 percent, thereby reducing the overall impact of the stormwater runoff.

Christian, D. and Novaes, V. 2011. Michigan Avenue Bioretention: Monitoring the Results Three Years Later. *In Proceedings of the Michigan Water Environment Association's 86th Annual Conference*, Bellaire, Michigan, June 26-29, 2011.

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Figure 10. Bioretention planter boxes in Lansing capture and treat much of the stormwater from roads and sidewalks.

Sterncrest Drive Bioswale and Rain Gardens, Cuyahoga County, Ohio

In 2007 the Chagrin River Watershed Partners received a U.S. Environmental Protection Agency grant to install nine rain gardens and replace 1,400 feet of roadside ditch with grassed bioswale (Figure 11). The U.S. Geological Survey monitored the site from 2008 to 2010 to assess the effect of green infrastructure on stormwater runoff. The rain gardens and bioswales were designed to handle a 0.75-inch rain falling on the adjacent roadway. Rainfall and runoff data were collected, along with overflow data, to determine how well the system performed. A 2-foot-square elevated grate (6 inches above the land surface) in the center of each rain garden allows excess stormwater runoff to overflow into to the storm sewer (an example of an overflow system installed in an online LID practice). A perforated underdrain prevents long-term saturation of the LID system.

Results

- Numerous rainfall events greater than 0.75-inch were absorbed by the bioswales and rain gardens.
- The bioswales and rain gardens performed better than expected. During three years of monitoring, the system overflowed only 19 times during 47 rain events when more than 0.75 inches of rain fell within a 96-hour span.

USGS

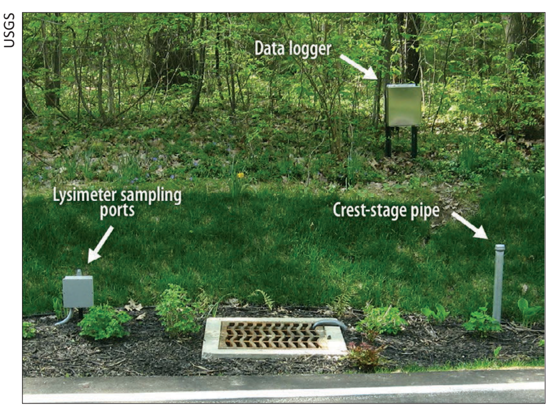

Figure 11. Roadside rain garden in Cuyahoga County is monitored for its effectiveness in absorbing stormwater.

Source: Darner, R.A., and Dumouchelle, D. H. 2011. Hydraulic characteristics of low-impact development practices in northeastern Ohio, 2008–2010. U.S. Geological Survey Scientific Investigations Report 2011-5165, 19 p.

United States Environmental Protection Agency • Office of Wetlands, Oceans, and Watersheds
1200 Pennsylvania Avenue, NW, Washington, DC 20460
EPA 841-F-16-009 • October 2017