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Low Impact Development: An Alternative Approach to Site Design

by Asa Foss

Low impact development (LID) is a cost-effective and visually appealing approach to site design that involves innovative land planning practices and technologies for managing stormwater and wastewater. LID techniques are designed to reduce stormwater runoff, protect watersheds, lower installation and infrastructure maintenance costs, and add aesthetic value. The primary goal of this approach is to protect a community's natural, pre-development water flow in order to minimize the ecological impacts of urbanization.

The Partnership for Advancing Technology in Housing (PATH), a public-private initiative dedicated to improving America's housing, outlines LID principles and techniques in *The Practice of Low Impact Development,* developed by the National Association of Home Builders (NAHB) Research Center. This *PAS Memo* provides background on the development of LID; an overview of the four areas of emphasis: stormwater management, wastewater management, circulation design, and site design; examples of communities that have adopted LID principles; and some of the issues to address when incorporating LID into practice.

Background

Integrating stormwater controls into site design at the lot level is not a new concept. Ian McHarg promoted this concept 40 years ago in his book *Design With Nature* and incorporated these principles into many projects, perhaps most famously in The Woodlands in Houston. J. Toby Tourbier and Richard Westmacott, authors of *Water Resources Protection Technologies,* have also used lot-level stormwater controls extensively in their practices.

In the early 1990s planners and ecologists in Prince George's County, Maryland, developed LID formally with support from the U.S. Environmental Protection Agency and the U.S. Department of Defense. LID was originally developed as an alternative to conventional stormwater management approaches, which usually convey untreated stormwater through piping systems into large ponds that are often difficult to maintain. Stormwater runoff is a contentious issue in the Chesapeake Bay watershed, where excess nutrients from lawns and factories flow into creeks and rivers, then drain into the Maryland estuary.

In Prince George's County, this approach caused heavily polluted stormwater to contaminate the Chesapeake Bay. Flipping this strategy on its head, county planners sought to control stormwater at the source — on the homeowner or land owner's property — with rain gardens, grassed swales, and other LID techniques. "The philosophy behind LID is that water is not our enemy, it's our friend," says Larry Coffman, former associate director of the programs and planning division in the Prince George's County Department of Environmental Resources.

While working for the county, Coffman led the effort to make LID part of the Chesapeake Bay initiative. He and Neil Weinstein, executive director of the Low Impact Development Center, are largely responsible for the county's status as a leading voice in LID. After initial experiments with point-source control of stormwater proved successful, the county expanded its concept of LID to include all aspects of development that affect water: stormwater management, wastewater treatment, circulation design, and site design.

Stormwater Management

Four types of environmentally friendly systems are used to control stormwater at its source: infiltration, filtering, conveyance, and collection. Although most of these techniques are less expensive than conventional stormwater management practices, the real value is that they produce a higher quality effluent to recharge groundwater levels. Because each project is unique, planners must undertake a careful site analysis to determine which system is most suitable and how it should be designed.

It is important to incorporate LID techniques into a site plan during the design phase of the project. Planners have had notable success in introducing LID concepts at pre-development meetings, which offer owners, developers, and design professionals an opportunity to obtain information from planners about regulations, as well as

alternative means of stormwater management that apply to a site-specific development proposal.

Infiltration Systems

Infiltration systems allow for water absorption into the underlying soil and reduce the amount of runoff and pollutant loads from impervious surfaces. These systems include trenches, drainfields, dry wells, and rain gardens (see figures 1 and 2). Compared with traditional conveyance systems, such as sewers, curbs, and gutters, infiltration systems can be quite cost effective. According to a PATH study, conventional conveyance and collection systems typically cost about $45 per linear foot, while rain gardens cost between $3 and $4 per square foot, plus the cost of plants, which cost approximately $6.40 per cubic foot of stormwater treated.

Figure 1: Rain Garden in the Somerset Community, Bowie, Maryland

Bioretention areas, or rain gardens, are shallow depressions filled with soil, sand, and plants that naturally retain, filter, and treat stormwater. Often installed adjacent to parking lots and in residential settings, rain gardens require regular maintenance, although less time is needed once the garden is established.

Source: Asa Foss

Figure 2: Typical Rain Garden Vegetation

Vegetation used in rain gardens can be used as plant material elsewhere on a property as a landscape design element.

Source: Asa Foss

Filtering Systems

While infiltration systems can remove pollutants from stormwater, filtering systems — including filter strips, dry swales, and wetlands — are specifically designed for this task. Filter strips and dry swales, or exfiltration trenches, are low-maintenance systems often used for pre-treatment before water enters an infiltration system. Constructed wetlands remove pollutants from stormwater, provide a habitat for wildlife, and often offer recreational and educational opportunities.

Conveyance Systems

Conveyance systems, which include vegetated channels and grassed swales, carry water to ponds or infiltration systems for treatment. They also slow the erosive velocity of stormwater while filtering pollutants. These systems must have a minimum slope of one degree to avoid standing water. At about 50 cents per square foot, they are less expensive than conventional systems such as curbs or concrete channels.

Figure 3: Example of a Swale

Vegetated swales along a roadway transport stormwater and its pollutants and slow its erosive velocity, while also beautifying the corridor.

Source: Seattle Public Utilities

Collection Systems

Collection systems, typically rain barrels and cisterns, are low-cost water retention devices. Although prices vary by size, rain barrels cost around $100, while cisterns range from $200 to thousands of dollars, depending on size and system complexity. They collect water during storms, which can then be used for irrigation during dry periods. Rain barrels are stored above ground and capture water from roof downspouts; cisterns, usually much larger, are buried underground. Both storage devices are sealed for mosquito control.

Circulation Design

New designs for streets, sidewalks, and driveways can maintain traffic circulation while reducing the amount of impervious surfaces. Minimizing the amount of asphalt and other impervious road surfaces decreases the amount of runoff and pollutants, while reducing both infrastructure and maintenance costs.

Street and intersection widths, cul-de-sacs, parking, driveways, traffic calming measures, and even street layouts can all be modified to reduce the amount of impervious surfaces. Compared with conventional street layouts, LID roadways have lower maintenance costs, can increase safety through traffic calming measures, and improve a community's appearance through roadway greening. New street designs can also affect the layout of lots, which could increase the volume of open space, connect greenways, and protect sensitive natural features.

Street Design

Depending on the density, location, and type of development, alternative street networks can often minimize the amount of impervious surfaces, conserve open space, and protect natural features and water quality. A hybrid street network that combines a conventional grid with a curvilinear system combines green space for forests, wetlands, and trees with street elements. This approach reduces the amount of total roadways while still allowing for smooth traffic circulation (see figures 4 to 6).

Figure 4: Typical Grid Layout
The typical grid layout, which often includes alleys as shown, supports traffic circulation.

Source: *Low Impact Development: Technical Guidance Manual for Puget Sound*, 2005.

Figure 5: Typical Curvilinear Layout
The typical curvilinear layout, with cul-de-sacs, often results in less paved area.

Source: Low Impact Development: Technical Guidance Manual for Puget Sound, 2005.

Figure 6: Hybrid Street Layout
The hybrid street combines the circulation advantages of a grid with the open space aspects of a curvilinear system.

Source: *Low Impact Development: Technical Guidance Manual for Puget Sound*, 2005.

The Puget Sound Action Team, a government partnership charged with developing conservation programs to protect Washington State's Puget Sound, recommends several ways to reduce the length and amount of roadways:

- Lengthen street blocks to reduce the number of cross streets for grid or modified grid layouts.
- Provide pedestrian paths to connect the end of a cul-de-sac with other pathways, roads, or open spaces.
- Create pedestrian routes to neighborhood destinations that are direct, safe, and aesthetically pleasing.
- Narrow lot frontages and cluster homes to reduce the need for more roads.

In addition, by reducing paved residential streets to 22 feet wide rather than the conventional 36 feet, ample room can remain for parking on one side of the street and the passage of large vehicles, such as buses and emergency vehicles on the other. This measure can drastically reduce the amount of stormwater runoff and result in substantial cost savings — more than $12,000 per 100 feet of street, according to PATH estimates.

Other street design techniques include replacing conventional intersections with traffic circles around rain gardens. This technique safely slows traffic, reduces runoff, and provides aesthetic benefits. A rain garden can also be added to a cul-de-sac to achieve similar results.

Parking

Reducing the amount of space for parking — especially in suburban areas where garages and driveways typically offer more parking than needed — can have a significant impact on reducing the amount of stormwater runoff. The land saved provides space for larger yards or increased open space. Where parking is necessary, permeable surfaces such as porous asphalt and concrete, gravel, or grass allow stormwater to be absorbed.

Site Design

As mentioned, modifying a project's lot layout can reduce the length and number of streets needed. LID projects use clustering and other strategies to minimize site disturbance, reduce the amount of impervious surfaces, and permanently set aside open space. A variety of lot layouts can be used to achieve these objectives, including flag lot, zero-lot-line lot, z-lot or z-angled lot, and zipper lot designs (see figure 7). Please note the following caveats when considering these approaches, and check with local regulations to determine whether such lot configurations are allowed:

- A flag lot does not meet minimum road frontage requirements. However in some cases houses can be built behind another house with a shared driveway to the street.
- Zero-lot-line lots have homes built on the edge of a property. These lots allow for a maximum amount of usable space and are often used in communities that incorporate passive solar into house designs.
- Z- or angled z-lots are also placed on lot lines, but they are angled at 30 or 40 degrees, allowing for the use of shared driveways.
- A zipper lot concentrates the usable space on the side of the lot by varying the rear yard depth while setting the minimum rear setback to zero.

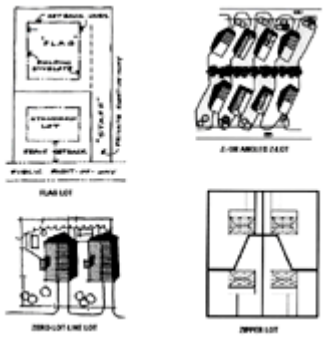

Figure 7
Examples of Alternative Lot Layouts

Source: *The Practice of Low Impact Development*, 2003.

Wastewater Treatment

According to the U.S. Census Bureau, 25 percent of all residential septic systems fail, allowing pathogens, nitrogen, and phosphorous to enter into groundwater. LID techniques can serve as a backup for septic systems to minimize the pollution of groundwater. These techniques include sand filters, mounds, trickling filters, and aerobic systems.

- Sand filters allow the effluent to undergo natural chemical and microbial treatments that purify the water as it percolates through the filter.
- Mounds containing a sand filter are typically one to four feet high, and are used in areas with a high water table.
- Trickling filters trickle water over a fixed medium, such as rocks, which allows a bed of microorganisms to remove the nitrogen from the wastewater
- Aerobic systems are similar to septic systems but allow oxygen to enter, which causes the effluent to deteriorate more rapidly.

Urban and Suburban Applications

Although LID techniques can be used in many projects, some areas will see greater benefits than others. In suburban developments, opportunities abound to preserve undeveloped spaces and connect them to existing greenways. Because suburbs often require a greater number of roads, stormwater drains, and sewers per capita than cities, reducing or eliminating this infrastructure can result in financial benefits for both installation and maintenance, such as by changing the width and layout of roads or eliminating curb and gutter systems. Because of their size, large suburban developments offer economies of scale, says Neil Weinstein of LIDC.

LID is also compelling in urban areas, but usually on a smaller scale. Because stormwater infrastructure is already in place, LID is often used in combination with conventional practices. LID techniques can beautify a city, reduce heat island effects, and reduce the amount of stomwater runoff, lessening the strain on urban infrastructure. Among the techniques that can be used include green roofs and rain gardens.

LID in Practice

With a foothold in the Northwest and Mid-Atlantic states, support from multiple government agencies, and promotion from the home building industry through the NAHB Research Center, LID has gained acceptance nationwide in both suburbs and cities over the last decade. "Currently, there are hundreds of local governments that promote or allow LID techniques," says Weinstein. Three communities that use LID are described below. A short list of other communities that have adopted LID principles are included in a sidebar at the end of this article.

Somerset, Maryland

Somerset, an 80-acre, 199-home community developed in 1995 in Prince George's County, Maryland, was the first community to integrate stormwater controls into lot-level site design under the tenets of LID. "We

disconnected impervious surfaces and explored the technical and practical aspects of using rain gardens on site. We also reduced the amount of [conventional] conveyance systems and got rid of the ecologically destructive stormwater infrastructure," recalls Larry Coffman. These and other LID techniques saved developers more than $900,000.

Rain gardens in Somerset range in size from 300 to 400 square feet, with one or two rain gardens per lot. By combining the gardens with shallow grassed swales next to the streets, the community eliminated the use of curbs, gutters, and even a stormwater pond. Along with decreasing the large "first flush" pollutant carried by stormwater, these techniques saved $4,000 per lot and allowed six additional lots to be developed.

Somerset was successfully marketed as an environmentally sensitive development, attracting buyers who were excited to live in a "green" community. The community also has more plants, trees, and green spaces than conventional communities, which has shown to have a beneficial effect on property values. "Experience has shown in every case we know of that has used LID techniques, property values have increased compared to other types of development," notes Coffman.

A key to the success of Somerset was educating homeowners about the importance of their cooperation and the impact of garden maintenance on the Chesapeake Bay's water quality. Such outreach was especially important because the community, rather than the municipality, is responsible for the maintenance. To determine what to preserve, the residents "define the ecological underpinnings of the community," says Jeff Schoenbauer, Executive Vice President of the planning firm Brauer & Associates, Ltd., in Hopkins, Minnesota. In the long run, taking action like this at the outset ensures much greater success. "The outreach allows [us] to determine which LID improvements the community will support and potentially maintain," says Weinstein. From these priorities, planners can take a conservation-based approach to site design, identifying the green spaces and then the areas for the built environment.

Stafford County, Virginia

It took four years for an advocacy group to convince Stafford County to accept LID techniques for stormwater management. The result of this long-term effort is one of the most progressive stormwater management programs in the country, in which every new development must prioritize LID measures. "The process started in 1999 with demonstration projects, then a variety of consensus building efforts, and then education with government staff and elected officials," recalls John Tippett, executive director of Friends of the Rappahannock, a nonprofit organization that seeks to protect water quality through environmentally responsible planning. "Then it advanced to the engineers, who wrestled with some of the more difficult challenges that tend to be roadblocks to LID," such as which techniques and materials to use in which locations.

LID supporters educated subcommittees of the planning commission, then moved up to the planning commission, and finally the Board of Supervisors. Eventually, the county adopted the national *Low Impact Development Design Strategies* manual, a document created by Prince George's County. Tippett regards this manual as the "bible" of LID; many other counties use either this manual or other guides produced by the Low Impact Development Center.

"In 2003, a four-year advocacy process culminated in some code changes to facilitate LID in Stafford County," says Tippett. "A year later, those code enhancements took LID from an incentivized option to a requirement that developers do everything practicable. Since the judgment of what is practicable is left up to county staff, the county is working on coming up with some tighter guidelines."

"The Stafford County case is a great example of the public and private sectors working together toward a common goal," says Rich Dooley, AICP, of the NAHB Research Center. "Developers nationwide are often interested in using LID techniques in their projects, but they quickly become turned off by the increased time delays, e.g., additional public hearings [and] increased permit review time imposed on them for trying to do something good for the environment. Planners have the chance to play a key role in creating the flexibility needed in the land development regulations to facilitate the use of LID."

Seattle Street Edge Alternative (SEA) Streets

Seattle's public utilities and transportation departments are experimenting with LID design elements in their Street Edge Alternatives (SEA) projects. By modifying circulation design, SEA Streets significantly improved stormwater management: the initial project to retrofit a 660-foot long residential street has resulted in a 98 percent reduction in stormwater runoff over the past three years.

The project was initiated to control heavily polluted stormwater that ran off impervious road surfaces, adversely affecting the area's creeks and wildlife. To minimize these impacts, more than 100 evergreen trees and 1,100 shrubs were planted, the road width was reduced from more than 20 feet (plus space for angled parking) to 14 feet, and grassed swales and two feet of grass shoulder were added next to the curb-free roads. The amount of parking was determined by each owner, and parallel and angle parking was grouped between swales and driveways. Sidewalks were installed on only one side of the road, which was considered adequate for residential communities (see figures 8 to 10).

Figure 8
SEA Street Before Redesign

Source: Seattle Public Utilities

Figure 9
SEA Street After Redesign

Source: Seattle Public Utilities

Figure 10
Aerial View of SEA Street

Source: Seattle Public Utilities

The pilot project cost $850,000, which included an extensive budget for design and consulting with residents. However, SEA Streets planners anticipate future projects will cost substantially less — and even less than traditional street improvements. "You could take $200,000 off the price just from what we didn't know," says Denise Andrews, manager of Seattle's surface water program. "The pilot phases that we are currently in are more expensive, but as the project becomes institutionalized, all the costs will come down. Even still, these projects are less expensive than standard projects."

In addition to the stormwater benefits, the SEA Street had some unanticipated quality-of-life benefits as well. "When you make a street as user- and pedestrian-friendly as we have done, especially in residential areas, people notice," says Andrews. "More and more people get to know their neighbors because they walk more. Now people from other communities are walking down these streets too."

Challenges

Although there are numerous benefits to LID, it is not without its challenges. Maintenance, site plan modifications, and existing regulations can all be implementation barriers.

Maintenance

Shifting responsibility for maintaining LID technologies from the municipality to the property owner is one of LID's greatest strengths. It is also a point of contention for LID critics, who often argue that LID imposes a maintenance burden on property owners, and owners may fail to maintain the systems.

"The misperception is that LID techniques are difficult to maintain and will fail if they aren't. But most of these techniques really require minimal to no maintenance, and still function very well if they aren't maintained," Weinstein notes.

Many LID practices, particularly those relating to circulation and design, require no further effort once they are installed. Other techniques like rain gardens require some maintenance but with proper landscaping such maintenance should be minimal.

Site Plan Modifications

Incorporating LID into a site plan for the first time can be somewhat complex, because numerous LID techniques are available, and site planners must pick the right ones for each project. Tailoring solutions to the site can be time consuming for the uninitiated. However, as LID techniques are used in similar sites throughout a community, they can usually be replicated for a particular area.

The site plan review process also adds a step. Many municipalities, such as Stafford County, require a stormwater concept plan that shows how the project is going to address LID on the site at the earliest stages of the project. Local officials must ensure that this step does not significantly slow the review process, which could erode support for LID.

"In Stafford County, the plan doesn't address specifics, but it does provide a broad concept as to how developers are going to use LID techniques." If LID is not considered to be appropriate for a site, there is flexibility in the code to use other techniques.

Existing Regulations

Restrictive local ordinances have also inhibited the widespread use of LID. For example, many jurisdictions have road design requirements that mandate excessive amounts of impervious surfaces. This includes unnecessarily wide roads, as well as larger than necessary road turnarounds and intersections. Many also require the use of conventional drainage systems. By mandating curbs, gutters, and storm drains, they leave no room for LID.

"In Southern California, builders have run against some well-meaning public officials that are trying to incorporate LID in ways that are redundant with what's already there" says Dooley. "For example, developers have noted they are required to install a natural swale alongside a curb and gutter." To optimize the benefits of LID, planning departments should consider promoting zoning options that allow for new development techniques.

Integrating LID into a Community

Using LID may require a change of local ordinances; however, many codes allow LID but may not promote it explicitly. To determine whether ordinances need to be changed, the Low Impact Development Center encourages planners to start by analyzing which LID techniques are currently allowed by code. For example, requirements for water quality control devices and easements may encourage or discourage the use of LID.

Once it has been determined how LID fits into the local ordinances, examine whether the techniques can be applied seamlessly. If LID techniques are not prohibited but not commonly used, suggest that developers submit an alternative proposal that uses LID techniques. This proposal c ould be included with the site plan application and considered in conjunction with the site plan review.

To determine whether a community's regulations are ready for LID, Dooley recommends asking two questions: Will a developer with a proposal that incorporates LID techniques require more review meetings or public hearings? Is there a need to educate code enforcement officials or planning board members on the LID approach? If the answer to either question is yes, "identify the potential hurdles for integrating LID into the existing regulations — for example, a mandate for curb and gutter," says Dooley. "Then determine the most efficient way that LID can be integrated into the codes." Several counties, such as Stafford County, have successfully taken such steps.

If local codes already allow for LID techniques, start educating elected planning board officials. Dooley recommends explaining the principles behind LID and how it helps the community. "Tying the community's mission statement elements back to LID techniques on a one-to-one basis can be really effective," he says.

"Since LID uses hundreds of techniques (conservation, minimization, strategic timing, integrated management practices, and pollution prevention), there really isn't any limit to where and how to use LID technology," says Neil Coffman. "You simply pick the suite of LID techniques that best meets your goals given the unique characteristics of the watershed you are working in. The only limitations to LID are one's knowledge, experience, and imagination on integrating ecological functions into the built environment."

During 2005, PATH is gathering and publishing more information on LID techniques. One effort will be a major expansion of LID-related information on ToolBase Services, which provides technical information on innovative home building technologies. PATH is interested in hearing from planners who have experimented with LID techniques. To share your story, please contact PATH at info@pathnet.org.

Author

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Resources

- *The Practice of Low Impact Development*
- *Low Impact Development: Technical Guidance Manual for Puget Sound*
- *Low-Impact Development Design Strategies: An Integrated Design Approach*
- *Onsite Wastewater Treatment Systems Manual*
- *Better Site Design: A Handbook for Changing Development Rules in Your Community*
- The Storm Water Manager's Resource Center
- Non-Residential Low Impact Development Tools
- Low Impact Development Center
- National On-Site Demonstration Program
- Green Roofs for Healthy Cities

National Center for Residential Land Development Technologies

The NAHB Research Center has recently formed the *National Center for Residential Land Development Technologies*. The center's overarching mission is to focus attention on land development technologies and strategies that consider all aspects of environmental performance and sustainability, and promote the affordability and quality of American housing.

LID in Practice

Following is a sampling of communities or initiatives that have incorporated LID techniques:

Arkansas
Gap Creek Subdivision, Sherwood

California
California Department of Transportation Storm Water Management Program

Illinois
Prairie Crossing, Grayslake

Maryland
Somerset Community, Prince George's County
Northridge Community, Bowie

Minnesota
Fox Den, Lino Lakes
Bassett Creek Watershed, Minneapolis

Oregon
Buckman Heights, Portland

Utah
Little Bear River Watershed, Blacksmith

Virginia

Tinner Hill Cultural Center, Falls Church
Duke Street Square, Alexandria
Chancery on the Lake, Alexandria

Washington, D.C.
Capitol Hill Police Station Retrofit
Naval Yards

Washington
Kensington Estates, Pierce County
Salishan Neighborhood Revitalization, Tacoma
SEA Streets, Seattle