EPA
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Managing Stormwater with Low Impact Development Practices: Addressing Barriers to LID

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Executive Summary

Low Impact Development or *LID* practices manage stormwater by minimizing impervious cover and by using natural or man-made systems to filter and recharge stormwater into the ground. Roads, parking lots, and other types of impervious cover are the most significant contributors to stormwater runoff. **There is a direct relationship between the amount of impervious cover and the biological and physical condition of downstream receiving waters.**

The goal of LID is to reduce runoff and to mimic a site's predevelopment hydrology by minimizing disturbed areas and impervious cover and then infiltrating, filtering, storing, evaporating, and detaining stormwater runoff close to its source. LID practices include measures such as preserving undeveloped open space, rain gardens, green roofs, porous pavement, and biofiltration.

LID has a number of advantages over conventional stormwater management practices. LID can reduce or eliminate the need for larger detention ponds and flood controls. It also reduces pollutant loading to receiving waters as well as stream bank erosion associated with peak flows. LID also can provide a visual amenity in developments and allow more flexible site layouts. Finally, LID can cost less than conventional techniques.

Stormwater and TMDLs

In New England, many streams are impaired by stormwater and as a result, a total maximum daily load (TMDL) water quality study is required. Research has shown that there is a strong correlation between pollutant loads, stormwater flows, and runoff from impervious cover. Therefore, TMDLs have been developed using Impervious Cover (IC) as a surrogate parameter for a mix of pollutants conveyed by stormwater. Because they reduce or have the same effect as reducing IC, LID techniques and best management practices (BMPs) will help with the implementation of these TMDLs and result in restored water quality. Additional information on incorporating green infrastructure and/or LID concepts into TMDLs and implementing stormwater TMDLs can be found at the following websites.

http://www.epa.gov/owow/tmdl/stormwater/pdf/tmdl_lid_final.pdf

http://www.epa.gov/region1/eco/tmdl/assets/pdfs/Stormwater-TMDL-Implementation-Support-Manual.pdf

For more information about LID and its many benefits over conventional stormwater management, see *Incorporating Low Impact Development into Municipal Stormwater Programs,* on EPA Region 1's Web site under Stormwater.

This fact sheet seeks to address potential concerns and barriers regarding LID techniques, compared to conventional stormwater management practices.

Cost Concerns

Q. I have heard that LID practices cost more than conventional methods of stormwater management.

A. LID can actually cost less than conventional stormwater management and be environmentally beneficial. EPA recently commissioned a detailed study that examined 17 development projects that used LID techniques. The study compared the actual cost of the LID developments to the estimated cost of the project using conventional stormwater management. The study found that LID can achieve significant cost savings through reduced grading, landscaping, paving, and infrastructure costs (curbing, pipes and catch basins, for example). (LID techniques can also eliminate or reduce the size of stormwater structures, which can provide more open space or buildable lots.) With a few exceptions, total LID capital costs were lower than conventional methods, with savings ranging from 15 to 80 percent. The EPA report is titled *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices,* December 2007, EPA 841-F-07-006. For a copy of the report go to **http://www.epa.gov/owow/nps/lid/costs07/documents/reducingstormwatercosts.pdf**

The EPA LID study did not compare maintenance costs, but another EPA study found that LID has similar maintenance costs compared to conventional methods. See Page 6-14 of EPA's 1999 report, *Preliminary Data Summary of Urban Stormwater Best Management Practices*, EPA-821-R-99-012 at **http://www.epa.gov/OST/stormwater**.

The following is a table from the EPA LID study comparing the cost of conventional and LID approaches for a number of the developments in the case study. Note that negative values denote increased cost for LID design over conventional developments costs.

Project	Conventional development cost (estimated)	Actual LID cost	Cost difference	Percentage difference
2nd Avenue SEA Street, Seattle, WA	$868,803	$651,548	$217,255	25%
Auburn Hills, WI	$2,360,385	$1,598,989	$761,396	32%
Bellingham City Hall, WA	$27,600	$5,600	$22,000	80%
Bellingham Donovan Park, WA	$52,800	$12,800	$40,000	76%
Gap Greek, AR	$4,620,360	$3,942,100	$678,500	15%
Garden Valley, WA	$324,400	$260,700	$63,700	20%
Kensington Estates, WA	$765,700	$1,502,900	($737,200)	-96%
Laurel Springs, WI	$1,654,021	$1,149,552	$504,469	30%
Mill Creek (per lot), IL	$12,510	$9,100	$3,411	27%
Prairie Glen, WI	$1,004,848	$599,536	$405,312	40%
Somerset, MD	$2,456,843	$1,671,461	$785,382	32%
Tellabs Corporate Campus, IL	$3,162,160	$2,700,650	$461,510	15%

An example of permeable paving. (Source: Silver Lake Project: Massachusetts Executive Office of Energy and Environmental Affairs)

Cold Weather Issues

Q. Does LID work in New England's cold weather?

A. Yes. LID practices work in cold and freezing weather. The University of New Hampshire's (UNH's) Stormwater Center has looked at this issue closely. It carefully monitored the performance of a number of LID practices in both summer and winter at its controlled field site in New Hampshire. In its 2007 Annual Report, the UNH Stormwater Center reached the following conclusion:

> All of the LID stormwater approaches we have monitored—bioretention systems, tree filter, porous asphalt parking lot, sand filter and gravel wetland—demonstrated excellent water quality treatment and peak flow reduction year round.

The only system that had reduced efficiency in winter was a vegetated swale. Winter conditions significantly lowered the swales' ability to treat water quality and manage water quantity, likely as a result of icing of the ground surface. This swale was not a more complex engineered water quality swale or *bioswale*. Such swales might have better cold weather performance than a conventional vegetated swale.

The UNH Stormwater Center's report is at **http://www.unh.edu/erg/cstev/2007_stormwater_annual_report.pdf**

> "Our research data tell us that it's possible to design and install systems that do an excellent job of treating pollutants in stormwater, dampening the peak flows of runoff, and reducing the volume of stormwater through infiltration, even in cold climates with poor soils."
>
> – UNH Stormwater Center 2007 Annual Report.

The findings regarding porous asphalt are especially encouraging. The UNH Stormwater Center found that some of the highest infiltration rates were in the winter, as opposed to the summer, because of the larger pore space of the asphalt in the winter compared to the summer. The center also found that the porous asphalt required significantly less salt for deicing than a similar lot paved with conventional asphalt. The center concluded that porous pavement is a high-performance stormwater management practice that with proper design and oversight can be affordable and effective.

For more information on cold weather performance of porous pavement, see Pervious Pavements: New Findings About Their Functionality and Performance in Cold Climates, *Stormwater*, September 2008. Also, for more information on permeable pavement, see **http://www.mapc.org/regional_planning/LID/permeable_paving.html**

Hydrodynamic separators, which have been installed in many New England locations, are small, flow-through devices that remove sediments and floating oils primarily by creating a swirling action in the stormwater and by particle settling. The UNH Stormwater Center data demonstrated that the performance of hydrodynamic separators was significantly reduced during cold winter months because of the increased viscosity of winter stormwater runoff and high chloride concentrations, which combine to reduce particle settling velocity. A number of LID practices had better performance than the separators tested. The center concluded that hydrodynamic separators are most effective when used as a pretreatment device for a system that also includes filtration or infiltration. See pages 22 and 23 of the UNH Stormwater Center 2007 Report **http://www.unh.edu/erg/cstev/2007_stormwater_annual_report.pdf**

Ground Water Issues

Q. Will LID practices that infiltrate stormwater into the ground pollute drinking water sources?

A. If properly sited and designed, infiltration practices should not adversely affect ground water. Data from the UNH Stormwater Center indicate that infiltration practices remove pollutants found in urban stormwater below levels of concern for ground water protection. Furthermore, the benefits of replenishing ground water supplies for future use and stream base flow maintenance are substantial.

Depending on local site conditions, infiltration practices without pretreatment might not be appropriate in areas where ground water is a drinking water source (such as a zone of influence of a drinking water well) or in other sensitive ground water areas identified by a federal, state, or local government (such as aquifers overlain with thin, porous soils). Also, infiltrating stormwater runoff from certain land uses or activities with likely or known exposed contamination should be avoided, especially in drinking water wellhead protection areas, unless special precautions are taken. Examples of such *hot spot* or *high load* areas include gasoline service stations, manufacturing facilities that store or handle hazardous materials, salt storage piles, and brownfield properties. Contact your local and state regulators, such as the state drinking water program, to obtain further information regarding where infiltration may and may not be used.

As for sites with contaminated soils, there are a number of practices that can successfully manage stormwater and prevent the mobilization of subsurface contamination. For example, LID filtration systems can be lined with an impermeable liner and outfitted with subdrains that discharge to the surface or away from subsurface plumes. Green roofs can be installed on the top of buildings to reduce the amount of stormwater runoff, and stormwater can be captured and reused for toilet flushing or irrigation.

Further Information on Contaminated Sites

EPA has prepared two fact sheets that contain more information and links to design guidelines for contaminated sites.

Design Principles for Stormwater Management on Compacted, Contaminated Soils in Dense Urban Areas, April, 2008: **http://www.epa.gov/brownfields/publications/swdp0408.pdf**

Case Studies for Stormwater Management on Compacted, Contaminated Soils in Dense Urban Areas, April, 2008: **http://www.epa.gov/brownfields/publications/swcs0408.pdf**

Q. I have heard that LID infiltration practices are regulated under the Underground Injection Control (UIC) program of the federal Safe Drinking Water Act. Is this true?

A. EPA has clarified that most LID practices are not regulated under the UIC program. In a memorandum dated June 13, 2008, EPA described the situations where the UIC program applies to various stormwater infiltration best management practices (BMPs). Generally, practices such as rain gardens, bioretention areas, vegetated swales, stormwater wetlands, and permeable pavement are typically not regulated under the UIC program. Systems that are deeper than they are wide or that include a subsurface distribution system are subject to the UIC program. These could include infiltration galleries and trenches, drywells, and some manufactured infiltration systems. Even for infiltration systems that require UIC permitting, most states have general permits or expedited permitting for typical road and parking lot stormwater infiltration systems.

UIC Program Links

For EPA's June 13, 2008, guidance memorandum, see **http://www.ecy.wa.gov/programs/wq/stormwater/municipal/resources/EPAmemoinfiltrationclassvwells.pdf**

For EPA New England's UIC program, see **http://www.epa.gov/region1/eco/drinkwater/pc_groundwater_discharges.html**

For New England state UIC program contacts, see **http://www.epa.gov/region1/eco/drinkwater/state.html**

An example of a tree filter. (Source: University of New Hampshire Stormwater Center)

Public Safety Issues

Q. I am aware that, in some instances, LID calls for reducing street widths and reduced use of sidewalks to decrease impervious surfaces. Isn't this a threat to public safety?

A. National road design associations and the American Association of State Highway and Transportation Officials have changed their standards to allow reduced roadway widths. Studies have shown that reduced street widths still provide all the functions of access, parking, and circulation for residents and emergency vehicles alike. In fact, some studies have shown that narrower street widths are associated with reduced traffic speeds and fewer accidents. Depending on density, minimizing the use of sidewalks might help to reduce development costs, increase housing affordability, and reduce impervious surfaces. Sidewalks can be limited to one side of a street and incorporate pervious surfaces such as pervious concrete pavers.

A number of municipalities have addressed the concern that narrow roads cannot accommodate large fire trucks by eliminating curbing or by reinforcing the street right-of-way so that emergency vehicles can travel on road shoulders, if necessary. Permeable pavement can also be used for street shoulders.

Low impact cluster design subdivision. (Source: Massachusetts Executive Office of Energy and Environmental Affairs)

More Information on Narrower Streets

American Association of State Highway and Transportation Officials. *Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT≤ 400)* **http://www.transportation.org**

EPA's Web site on LID Street Design **http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=87**

ITE Journal. June 1996. *A Toolbox Approach to Residential Traffic Management*

ITE Journal. February 2000. *Child Pedestrian Injuries on Residential Streets: Implication for Traffic Engineering.*

Walter M. Kulash. *Residential Streets*. 3rd ed. Urban Land Institute

Q. Don't LID stormwater management practices increase the likelihood of flooding?

A. No. All stormwater systems, whether conventional or low impact in design, are typically designed to safely convey large storm flows by including appropriate overflow controls that bypass the stormwater system to prevent flooding of the stormwater system. Many LID practices offer the advantage of reducing the volume and intensity of stormwater runoff, thereby reducing the scope and capacity of required overflow controls. LID infiltration and filtration practices also reduce the likelihood of flooding downstream of the stormwater controls, thereby reducing the burden on drainage infrastructure and reducing the potential for sewer overflows.

Q. What about mosquitoes?

A. LID practices mostly process stormwater in the ground or are designed to completely drain any standing water within 48 to 72 hours. This drainage time prevents mosquitoes from breeding because mosquitoes need more than three days of standing water to breed and reproduce.

Concerns Related to Novelty of LID

Q. Aren't LID techniques untested and innovative? Will I get in trouble if I use something new?

A. LID practices have been used successfully across the country and in New England. Hard data has been developed that measures the efficiency of LID and compares LID to conventional practices. For example, the UNH Stormwater Center has carefully monitored the water quality treatment and water quantity control of a number of structural LID techniques. See its Annual Report for more details. The University of Connecticut has also analytically compared the performance of a conventional and LID subdivision. See **http://www.jordancove.uconn.edu/jordan_cove/publications/final_report.pdf.**

Also, many LID techniques are *nonstructural*, such as practices that reduce the amount of developed area in a subdivision. These techniques are tested in that they control stormwater by mimicking the natural systems.

More Information on LID Practices

The UNH Stormwater Center has an inventory of real-world examples of successful and innovative BMP installations throughout New England. The inventory can be searched by state or practice. See **http://www.erg.unh.edu/stormwater/index.asp**.

For several LID case studies in Massachusetts, see **http://www.mass.gov/envir/smart_growth_toolkit/pages/SG-CS.html**

The University of Massachusetts maintains a database of verified technical information on innovative stormwater practices. See **http://www.mastep.net**

Q. What about the monitoring and maintenance of LID techniques?

A. Both conventional and LID stormwater treatment facilities typically require maintenance to ensure that the facility operates as designed and to prolong the effectiveness of the systems to treat stormwater. Municipalities should require maintenance for conventional and LID stormwater facilities. Each type of facility should have a maintenance plan specific to that facility and location to account for sites where sediment and pollutant loading might be especially high.

An example of a rain garden.

Maintenance includes items such as sediment removal, erosion repair, and vegetation pruning. LID techniques do not typically require specialized maintenance equipment and may be able to be maintained as part of typical landscaping activities.

Regulatory Barriers

Q. I've heard that local ordinances actually discourage or can prohibit certain LID practices and that such ordinances do not allow LID.

A. In some instances, local ordinances and bylaws can prohibit or restrict certain LID practices, but LID in general is not prohibited. For example, subdivision regulations might require curb and gutter conveyance designs. Conflicts may also exist regarding road widths and parking requirements. There are, however, a number of tools to help alleviate this problem. LID practitioners have developed checklists of municipal regulations that can be barriers to LID so that such regulations can be modified or repealed. Municipalities can also provide guidance that LID techniques will be allowed under waiver, variance, or site plan or special permit review provisions.

There are a number of model ordinances that expressly require LID and other practices that reduce stormwater runoff both during construction and post-construction. A good number of municipalities have enacted regulations that reduce stormwater pollution. Municipal stormwater regulation is also a requirement for some municipalities under EPA's Phase II Stormwater regulations.

Websites Relevant to Regulatory Barriers

For checklists of potential LID barriers in existing regulations, see the following websites:

Center for Watershed Protection
http://www.cwp.org/Resource_Library/Center_Docs/SW/pcguidance/Tool4.pdf

Massachusetts Metropolitan Area Planning Council
http://mapc.org/regional_planning/LID/LID_codes.html

For model ordinances that promote LID and runoff reduction, see the following websites:

Massachusetts Model LID By-Law
http://www.mass.gov/envir/smart_growth_toolkit/pages/SG-bylaws-lid.html

New Hampshire Model LID By-Law
http://des.nh.gov/organization/divisions/water/wmb/repp/innovative_land_use.htm

An example of a biofilter in Portland, Maine. (Source: University of Southern Maine, Portland)

Q. What about individual house lots?

A. In many areas, individual house lots are the predominant land use, and their stormwater contributions cannot be ignored. Luckily, LID can be used to infiltrate roof and driveway runoff with drip line trenches, rain barrels, and rain gardens. The University of Maine Cooperative Extension has an excellent guide for installing rain gardens that can be found at **http://www.uri.edu/ce/healthylandscapes/2702.pdf**

Additional Resources

This fact sheet is one of a series of four prepared by EPA Region 1. The others are listed below and are available on the EPA Region 1 website. **http://www.epa.gov/region1/npdes/stormwater**

- *Funding Stormwater Programs*
- *Incorporating Low Impact Development into Municipal Stormwater Programs*
- *Restoring Impaired Waters: Total Maximum Daily Loads (TMDL) and Municipal Stormwater Programs*

For other EPA and non-EPA Web sites, see the following:

EPA's National LID website
http://www.epa.gov/owow/nps/lid
A compilation of a number of resources, with links, a literature review, fact sheets and technical guidance. This site includes a national menu of BMPs.

EPA's New England Stormwater page
http://www.epa.gov/region1/topics/water/stormwater.html
Includes information, resources, links and contacts.

The Massachusetts LID Toolkit, Metropolitan Area Planning Council
http://www.mapc.org/lid.html
Includes fact sheets on Low Impact Site Design, roadways and parking areas, permeable paving, bioretention, vegetated swales, filter strips, infiltration trenches and dry wells, cisterns and rain barrels, and green roofs.

Center for Watershed Protection website
http://www.cwp.org
A nonprofit organization that provides technical tools for protecting water resources.

Low Impact Development Center website
http://www.lowimpactdevelopment.org
This is a nonprofit organization that promotes proper site design that replicates preexisting hydrologic site conditions. The Web site contains a variety of technical resources and case studies regarding LID.

The University of New Hampshire Stormwater Center
http://www.unh.edu/erg/cstev/index.htm
The center serves as a technical resource for stormwater practitioners by studying the design, water quality and quantity, cost, maintenance, and operations of stormwater management systems.

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