Chapter 2

Stormwater Management in Michigan: Why LID?

Clean water resources are essential to the economic vitality of Michigan. Proper stormwater management is an essential component of water quality protection. Low impact development is a cornerstone of stormwater management and thus is the pathway to protecting water resources and enabling economic growth.

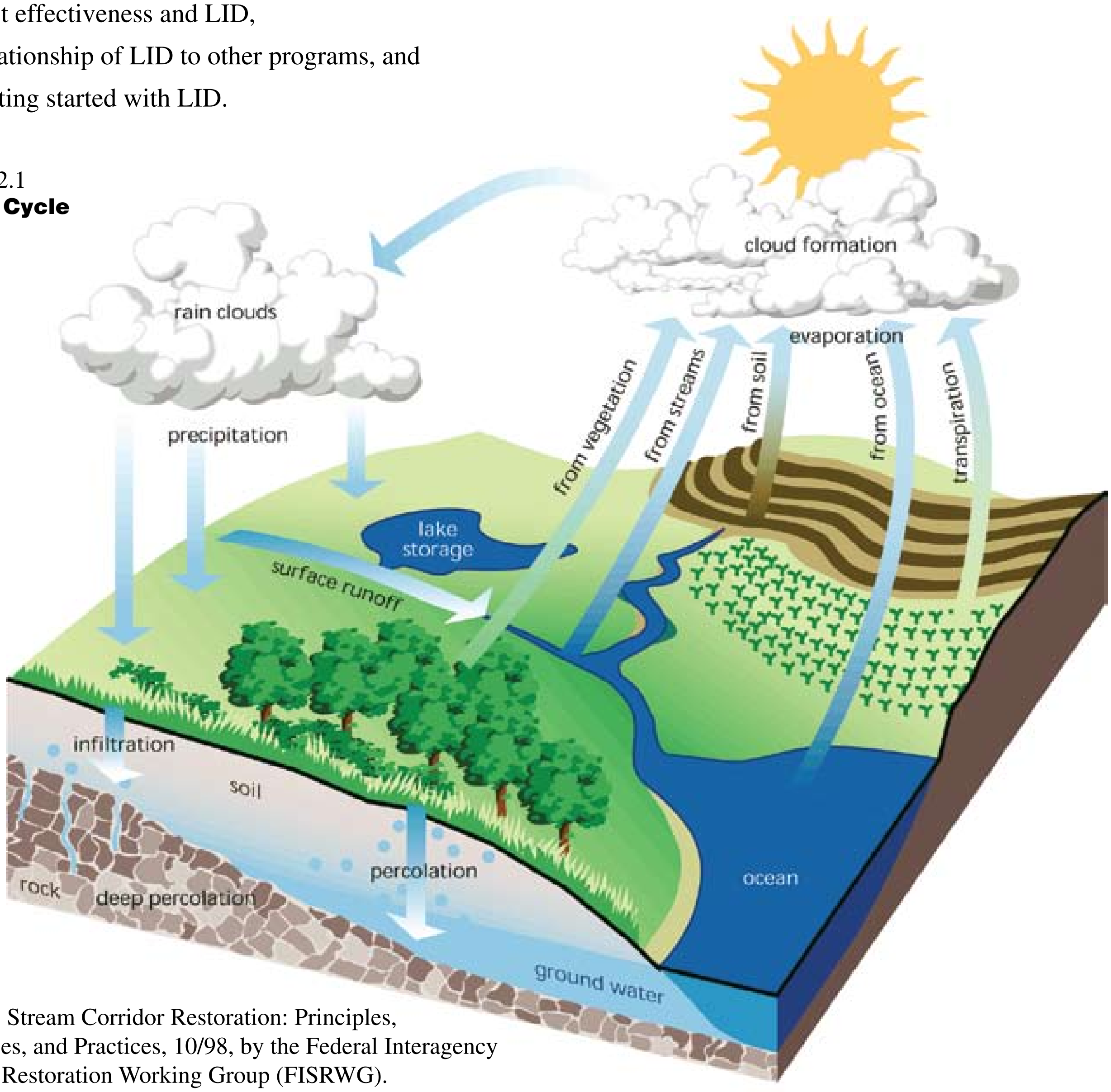
This chapter discusses:

- The importance of the water cycle,
- The impacts of stormwater runoff,
- An overview of what LID is and how it works,
- Benefits of implementing LID,
- Cost effectiveness and LID,
- Relationship of LID to other programs, and
- Getting started with LID.

The importance of the water cycle

A key component of protecting water resources is keeping the water cycle in balance. The movement of rainfall from the atmosphere to the land and then back to the atmosphere — the water (hydrologic) cycle — is a naturally continuous process essential to human and virtually all other forms of life (Figure 2.1). This balanced water cycle of precipitation, evapotranspiration, infiltration, groundwater recharge, and stream base flow sustains Michigan's vast but fragile water resources.

Figure 2.1
Water Cycle



Source: Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG).

In a natural woodland or meadow in Michigan, most of the annual rainfall soaks into (infiltrates) the soil mantle. Over half of the annual rainfall returns to the atmosphere through evapotranspiration. Surface vegetation, especially trees, transpire water to the atmosphere with seasonal variations.

Water that continues to percolate downward through the soil reaches the water table and moves slowly down-gradient under the influence of gravity, ultimately providing baseflow for streams and rivers, lakes, and wetlands. On an annual basis, under natural conditions, only a small portion of annual rainfall results in immediate stormwater runoff (Figure 2.2). Although the total amount of rainfall varies in different regions of the state (see Chapter 3), the basic relationships of the water cycle are relatively constant.

Conventional land development changes the land surface and impacts the water cycle (Figure 2.3). Altering one component of the water cycle invariably causes changes in other elements of the cycle. Impervious surfaces, such as roads, buildings, and parking areas, prevent rainfall from soaking into the soil and significantly increase the amount of rainfall that runs off. Additionally, research shows that soil compaction resulting from land development produces far more runoff than the presettlement soil conditions. As natural vegetation systems are removed, the amount of evapotranspiration decreases. As impervious areas increase, runoff increases, and the amount of groundwater recharge decreases.

These changes in the water cycle have a dramatic effect on our water resources. As impervious and disturbed or compacted pervious surfaces increase and runoff volumes increase, stream channels erode, substrate in the river bottom is impacted, habitat is lost or reduced, and populations of fish and other aquatic species decline. Reduced infiltration and groundwater recharge results in lowered water tables and reduced stream baseflow, generally worsening low flow conditions in streams during dry periods.

The Impacts of stormwater runoff

Stormwater runoff is rainfall or snowmelt that runs off the land and is released into rivers and lakes. Problems related to stormwater runoff are most evident in areas where urbanization has occurred. As mentioned above, the change in the water cycle has a dramatic effect on our water resources. This impact is based on both the quantity and quality of stormwater runoff reaching our rivers and lakes.

The impacts of stormwater runoff are well documented in Michigan and throughout the country. They include:

- **Increased flooding and property damage.** Increased impervious surfaces decrease the amount of rainwater that can naturally infiltrate into the soil and increase the volume and rate of stormwater runoff. These changes lead to more frequent and severe flooding and potential damage to public and private property.

Figure 2.2
Approximate annual water cycle for an undeveloped acre in Michigan

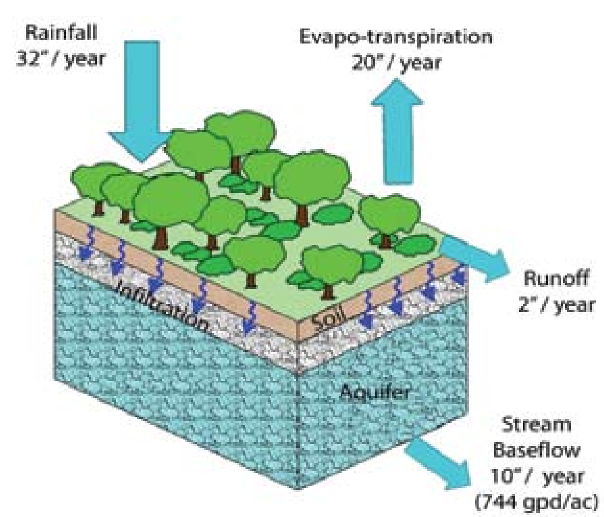
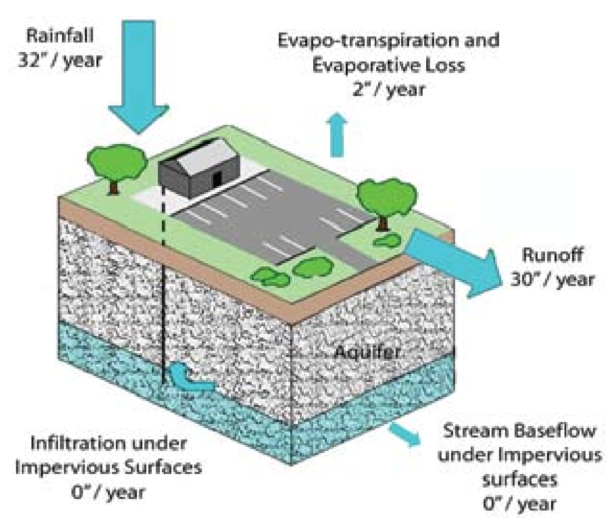


Figure 2.3
Representative altered water cycle under the impervious parking lot



- **Degradation of the stream channel**. One result of runoff can be more water moving at higher velocities through stream channels. This condition is called “flashy flows” and happens at increased frequency as an area is developed. As a result, both the streambank and stream bed are eroded more frequently. This can result in widening and deepening the channel, as well as a decline in stream substrate quality, and degradation of habitat.

Streambank erosion and degraded habitat
Source: Wayne County Department of Environment

- **Less groundwater recharge and dry weather flow**. As impervious surfaces increase, the infiltration of stormwater to replenish groundwater decreases. Groundwater is important because many people rely on groundwater for their drinking water supply. In addition, the groundwater “feeds” rivers and lakes especially during the dry season to ensure a steady flow. When the groundwater recharge decreases, the amount of dry weather flow decreases, negatively impacting aquatic life and recreational opportunities.
- **Impaired water quality**. Impervious surfaces accumulate pollutants that are absorbed by stormwater runoff and carried to lakes and streams. Examples of these pollutants include:
  - Hydrocarbons and trace metals from vehicles,
  - Suspended solids from erosive stream banks and construction sites,
  - Chlorides from road salt,
  - Nutrients from fertilizer and grass clippings and leaves left on streets and sidewalks, and
  - Bacteria from pet waste, goose droppings, and other wildlife.
- **Increased water temperature**. Impervious surfaces are warmed by the sun. Runoff from these warmed surfaces increase the temperature of water entering our rivers and lakes. This can adversely impact aquatic life that requires cold water conditions (e.g., trout).
- **Loss of habitat**. The decline in habitat due primarily to the erosive flows and the increased water temperature will negatively impact the diversity and amount of fish and aquatic insects.
- **Decreased recreational opportunities**. Stormwater runoff can negatively impact water resources in many different ways (e.g., decreased water quality, increased temperature, and decreased habitat). The result is diminished recreational and economic opportunities for communities throughout the state.

Stormwater solutions — Low Impact Development

What is LID?

From a stormwater management perspective, low impact development (LID) is the application of techniques that emulate the natural water cycle described in the previous section LID uses a basic principle modeled after nature: manage rainfall by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source.

Techniques are based on the premise that stormwater is a resource, not a waste to be quickly transported and disposed. Instead of conveying and managing/treating stormwater in large, costly, end-of-pipe facilities located often at the bottom of drainage areas, LID addresses stormwater through small, cost-effective landscape features often located at the lot level.

Native plantings at East Grand Rapids, MI Community Center

Almost all components of the urban environment have the potential to serve as elements of an integrated stormwater management system. This includes open space, as well as rooftops, streetscapes, parking lots, sidewalks, and medians. LID is a versatile approach that can be applied equally well to new development, urban redevelopment, and in limited space applications such as along transportation corridors.

How does LID work?

LID strives to replicate virtually all components of the natural water cycle by:

- Minimizing total runoff volume,
- Controlling peak rate of runoff,
- Maximizing infiltration and groundwater recharge,
- Maintaining stream baseflow,
- Maximizing evapotranspiration, and
- Protecting water quality.

Stormwater management historically focused on managing the flood effects from larger storms. Exclusive reliance on peak rate control prevents flooding, but doesn't protect streams and water quality. Thorough stormwater management should target infrequent large storms, as well as the much more frequent, smaller storms.

With the change in land surface generated by land development, not only does the peak rate of runoff increase, but the *total volume* of runoff also often dramatically increases. LID focuses on both peak rates and total volumes of runoff. LID application techniques are designed to hold constant peak rates of runoff for larger storms and prevent runoff volume increases for the much more frequent, smaller storms. Thus, the natural flow pattern is kept in better balance, avoiding many of the adverse impacts associated with stormwater runoff.

LID focuses on the following stormwater outcomes, described in more detail in Chapter 9:

- Preventing flooding,
- Protecting the stream channel,
- Improving and protecting water quality, and
- Recharging groundwater.

Chapter 9 describes recommended criteria that communities and/or developers may use at the site level to implement LID designs. This may also be used at the community level to develop standards to ensure that development meets the outcomes listed above.

Infiltration practices often associated with LID provide enhanced water quality benefit compared to many other BMPs. Percent of pollutant removal for various LID practices is shown in the table below.

Table 2.1
Pollutant Removal Table (in percentages)

Pollutant	Infiltration Practices	Stormwater Wetlands	Stormwater Ponds Wet	Filtering Practices	Water Quality Swales	Stormwater Dry Ponds
Total Phosphorus	70	49	51	59	34	19
Soluble Phosphorus	85	35	66	3	38	-6
Total Nitrogen	51	30	33	38	84	25
Nitrate	82	67	43	-14	31	4
Copper	N/A	40	57	49	51	26
Zinc	99	44	66	88	71	26
TSS	95	76	80	86	81	47

Source: "National Pollutant Removal Performance Database for Stormwater Treatment practices" Center for Watershed Protection, June 2000.

Principles of LID

Successful application of LID is maximized when it is viewed in the context of the larger design process. This process is reflected in a set of principles used to guide development of this manual.

- Plan first,
- Prevent. Then mitigate,
- Minimize disturbance,
- Manage stormwater as a resource — not a waste,
- Mimic the natural water cycle,
- Disconnect. Decentralize. Distribute,
- Integrate natural systems,
- Maximize the multiple benefits of LID,
- Use LID everywhere, and
- Make maintenance a priority.

Plan first. To minimize stormwater impacts and optimize the benefits of LID, stormwater management and LID should be integrated into the community planning and zoning process.

Prevent. Then mitigate. A primary goal of LID is preventing stormwater runoff by incorporating nonstructural practices into the site development process. This can include preserving natural features, clustering development, and minimizing impervious surfaces. Once prevention as a design strategy is maximized, then the site design — using structural BMPs — can be prepared.

Minimize disturbance. Limiting the disturbance of a site reduces the amount of stormwater runoff control needed to maintain the natural hydrology.

Manage stormwater as a resource — not a waste. Approaching LID as part of a larger design process enables us to move away from the conventional concept of runoff as a disposal problem (and disposed of as rapidly as possible) to understanding that stormwater is a resource for groundwater recharge, stream base flow, lake and wetland health, water supply, and recreation.

Mimic the natural water cycle. Stormwater management using LID includes mimicking the water cycle through careful control of peak rates as well as the volume of runoff and groundwater recharge, while protecting water quality. LID reflects an appreciation for management of both the largest storms, as well as the much more frequent, smaller storms.

Disconnect. Decentralize. Distribute. An important element of LID is directing runoff to BMPs as close to the generation point as possible in patterns that are decentralized and broadly distributed across the site.

Integrate natural systems. LID includes careful inventorying and protecting of a site's natural resources that can be integrated into the stormwater management design. The result is a natural or "green infrastructure" that not only provides water quality benefits, but greatly improves appearance by minimizing infrastructure.

Maximize the multiple benefits of LID. LID provides numerous stormwater management benefits, but also contributes to other environmental, social, and economic benefits. In considering the extent of the application of LID, communities need to consider these other benefits.

Use LID everywhere. LID can work on redevelopment, as well as new development sites. In fact, LID can be used on sites that might not traditionally consider LID techniques, such as in combined sewer systems, along transportation corridors, and on brownfield sites. Broad application of LID techniques improves the likelihood that the desired outcome of water resource protection and restoration will be achieved.

Make maintenance a priority. The best LID designs lose value without commitment to maintenance. An important component of selecting a LID technique is understanding the maintenance needs and institutionalizing a maintenance program. Selection of optimal LID BMPs should be coordinated with both the nature of the proposed land use/building program and the owners/operators of the proposed use for implementation of future maintenance activities.

Benefits of implementing LID

Implementing LID offers numerous benefits to communities, developers, and the public that extend well beyond water quality protection. Here are some examples:

Communities, agencies, and the public

- Reduces municipal infrastructure and utility maintenance costs (e.g., streets, curbs, gutters, storm sewers).
- Increases energy and cost savings for heating, cooling, and irrigation.
- Reduces flooding and streambank erosion.
- Replenishes groundwater drinking supply.
- Assists in meeting regulatory obligations.
- Serves multiple purposes (e.g., traffic calming, greenways).
- Brings neighborhoods together in maintaining LID.
- Increases recreational opportunities.
- Provides environmental education opportunities.
- Improves quality of life for residents.
- Protects community character/aesthetics.
- Protects and enhances sensitive habitat.
- Restores/protects fisheries and other aquatic life.
- Reduces salt usage and snow removal on paved surfaces.

Developers

- Reduces land clearing and grading costs.
- Potentially reduces infrastructure costs (e.g., streets, curb, gutters).
- Reduces stormwater management construction costs.
- Increases marketability leading to faster sales.
- Potentially increases lot yields/amount of developable land.
- Assists in meeting LEED (Leadership in Energy and Environmental Design) Certification requirements.
- Appealing development consistent with the public's desire for environmental responsibility.

Environmental

- Protects/restores the water quality of rivers and lakes.
- Protects stream channels.
- Reduces energy consumption.
- Improves air quality.
- Preserves ecological and biological systems.
- Reduces impacts to terrestrial and aquatic plants and animals.
- Preserves trees and natural vegetation.
- Maintains consistent dry weather flow (baseflow) through groundwater recharge.
- Enhances carbon sequestration through preservation and planting of vegetation.

Recreation in Glen Haven, MI

Michigan inland lakeshore on Horseshoe Lake, Northfield Township, MI

Cost effectiveness and LID

A variety of sources are now available documenting the cost effectiveness — even cost reductions — which can be achieved through the application of LID practices. The U.S. Environmental Protection Agency (EPA) released *Reducing Stormwater Costs Through Low Impact Development (LID) Strategies and Practices*, reporting on cost comparisons for 17 different case studies across the country. EPA results demonstrate the positive cost advantages of LID practices, when compared with traditional development patterns using conventional stormwater management techniques.

Based on this recent work, EPA concludes that, in the majority of cases, significant cost savings resulted from reduced site grading and preparation, less stormwater infrastructure, reduced site paving, and modified landscaping. Total capital cost savings ranged from 15 to 80 percent when using LID methods. Furthermore, these results are likely to conservatively undercount LID benefits. In all cases, there were benefits that this EPA study did not monetize or factor into each project's bottom line. These benefits include:

- Improved aesthetics,
- Expanded recreational opportunities,
- Increased property values due to the desirability of the lots and their proximity to open space,
- Increased total number of units developed,
- Increased marketing potential, and
- Faster sales.

Traverse City, MI, Marina

Using LID to meet regulatory requirements

LID practices can be used to meet a variety of state and federal permit programs. These range from the National Pollutant Discharge Elimination System (NPDES) Phase I and Phase II stormwater requirements, to combined sewer overflow (CSO) and sanitary sewer overflow (SSO) requirements. For example, many Michigan municipalities are plagued with CSO problems as well as SSOs caused by excessive inflow of stormwater and groundwater into the sanitary sewer system. Communities can integrate LID practices, such as a residential rain barrel program and downspout disconnection to their overflow control programs to help reduce stormwater inflow into the system, thereby reducing overflows.

Additionally, cost estimates do not include any sort of monetizing of the environmental impacts which are avoided through LID, as well as reductions in long-term operation and maintenance costs, and/or reductions in the life cycle costs of replacing or rehabilitating infrastructure.

Confirming EPA results, a recent report by the Conservation Research Institute for the Illinois Conservation Foundation, *Changing Cost Perceptions: An Analysis of Conservation Development*, 2005, undertook three different types of analyses on this cost issue — a literature review, an analysis of built-site case studies, and a cost analysis of hypothetical conventional versus conservation design templates. In terms of literature review, this study concludes:

- Public infrastructure costs are lower when a development is built within the context of smart growth patterns that conserve land.
- At the site level, significant cost savings can be achieved from clustering, including costs for clearing and grading, stormwater and transportation infrastructure, and utilities.
- Installation costs can be between \$4,400 and \$8,850 cheaper per acre for natural landscaping than for turf grass approaches.

Table 2.2
Summary of Cost Comparisons Between Conventional and LID Approaches

Project	Conventional Development Cost	LID Cost	Cost Difference	Percent Difference
2nd Avenue SEA Street	$868,803	$651,548	$217,255	25%
Auburn Hills	$2,360,385	$1,598,989	$761,396	32%
Bellingham City Hall	$27,600	$5,600	$22,000	80%
Bellingham Bloedel Donovan Park	$52,800	$12,800	$40,000	76%
Gap Creek	$4,620,600	$3,942,100	$678,500	15%
Garden Valley	$324,400	$260,700	$63,700	20%
Laurel Springs	$1,654,021	$1,149,552	$504,469	30%
Mill Creek[a]	$12,510	$9,099	$3,411	27%
Pairie Glen	$1,004,848	$599,536	$405,312	40%
Somerset	$2,456,843	$1,671,461	$785,382	32%
Tellabs Corporate Campus	$3,162,160	$2,700,650	$461,510	15%

[a] Mill Creek costs are reported on a per-lot basis.

Source: *Low Impact Development (LID) Strategies and Practices*, USEPA, 2007

- Maintenance cost savings range between $3,950 and $4,583 per acre, per year over 10 years for native landscaping approaches over turf grass approaches.
- While conventional paving materials are less expensive than conservation alternatives, porous materials can help total development costs go down, sometimes as much as 30 percent by reducing conveyance and detention needs.
- Swale conveyance is cheaper than pipe systems.
- Costs of retention or detention cannot be examined in isolation, but must instead be analyzed in combination with conveyance costs, at which point conservation methods generally have a cost advantage.
- Green roofs are currently more expensive to install than standard roofs, yet costs are highly variable and decreasing. Green roofs also have significant cost advantages when looking at life cycle costs (e.g., building, heating, and cooling costs).

Principles of Smart Growth

- Create a range of housing opportunities and choices.
- Create walkable neighborhoods.
- Encourage community and stakeholder collaboration.
- Foster distinctive, attractive communities with a strong sense of place.
- Make development decisions predictable, fair, and cost effective.
- Mix land uses.
- Preserve open space, farmland, natural beauty, and critical environmental areas.
- Provide a variety of transportation choices.
- Strengthen and direct development towards existing communities.
- Take advantage of compact building design.

Source: Smart Growth Network

Relationship of LID to other programs

LID is compatible with the principles of smart growth and the requirements of the U.S. Green Building Council's LEED program because LID offers prevention and mitigation benefits that make land development much more sustainable.

LID and Smart Growth

LID is often seen as a site specific stormwater management practice, while smart growth is often a broader vision held at a community, county, or regional level. However, as noted in Chapter 4, an important first step in LID is incorporating LID at the community level.

There are direct connections between LID and smart growth. For example, principles relating to compact building design and preserving natural features directly relate to nonstructural LID BMPs listed in Chapter 6. Upon further evaluation, LID is also consistent with the larger concepts of stakeholder collaboration; fostering communities with a strong sense of place; and implementing fair, predictable, and cost effective development decisions.

LID and LEED

The Leadership in Energy and Environmental Design (LEED) certification encourages and accelerates global adoption of sustainable green building and development practices by creating and implementing widely understood and accepted tools and performance criteria. LEED has developed rating systems for a myriad of development scenarios, including new construction, existing buildings, commercial interiors, core and shell, schools, retail, healthcare, homes, and neighborhood development.

As with Smart Growth, there are significant connections between LID and LEED certification. In fact, LID practices are integrated into each of the LEED rating systems.

The United States Green Building Council (USGBC), the Congress for New Urbanism and the National Resources Defense Council are currently working on a new rating system called LEED for Neighborhood Development (LEED-ND). The strongest connection between the LEED system and LID will be through LEED-ND certification. LEED-ND is part of the natural evolution of the green building movement, expanding sustainability standards to the scale of the neighborhood. While current green building standards focus on buildings in isolation, LEED-ND will bring emphasis to the elements that determine a development's relationship with its neighborhood, region, and landscape. LEED-ND sets standards in four categories that pinpoint essential neighborhood characteristics:

- Complete, compact, and connected neighborhoods,
- Location efficiency,
- Resource efficiency, and
- Environmental preservation.

Currently, the LEED-ND system is being piloted by the USGBC. The post-pilot version of the rating system, which will be available to the public, is expected to launch in 2009 (See LEED-ND criteria pullout).

Fairmount Square LEED Certification

Fairmount Square is a 4-acre infill site that uses rainwater capture, porous pavement, and rain gardens to manage its stormwater. The project is also seeking various LEED credits for new construction.

The building was designed with a focus of structural longevity and durability, energy efficiency, and a high quality indoor environment. Key site features include: better insulated concrete framing and roofing material and the use of low off-gassing interior materials such as carpet, paints, caulks, and adhesives. The project also takes advantage of existing infrastructure by being close to transit lines and other community features within walking distance to the site.

Fairmount Square, Grand Rapids, MI

Source: Fishbeck, Thompson, Carr & Huber, Inc.

Getting started with LID

LID can be implemented by many different groups, including communities, counties, developers, agencies, or individuals. Implementing LID can take many forms. For some, implementation might be encouraged on a voluntary basis during the site plan review process. For others, LID might become an expected application at each site and be institutionalized in an ordinance or through multiple ordinances.

A key first step is for different institutions within a local government to discuss the pros and cons of various approaches to LID. These stakeholders might include mayors/supervisors, councils/trustees, planning commissions, public works department, etc. The outcome of these discussions will be action steps toward instituting LID at the desired scale on a community basis.

City of Wixom, MI Habitat Park
Source: Hubbell, Roth & Clark, Inc.

LEED-ND Criteria

Smart Location and Linkage (SLL)

SLL Prerequisite 3: Imperiled species and ecological communities

SLL Prerequisite 4: Wetland and water body conservation

SLL Prerequisite 6: Floodplain avoidance

SLL Credit 8: Steep slope protection

SLL Credit 9: Site design for habitat or wetland conservation

SLL Credit 10: Restoration of habitat or wetlands

SLL Credit 11: Conservation management of habitat or wetlands

Neighborhood pattern and design (NPD)

NPD Prerequisite 1: Open community

NPD Prerequisite 2: Compact development

NPD Credit 1: Compact development

Green construction and technology (GCT)

GCT Prerequisite 1: Construction activity pollution prevention

GCT Credit 3: Reduced water use

GCT Credit 6: Minimize site disturbance through site design

GCT Credit 7: Minimize site disturbance during construction

GCT Credit 9: Stormwater management

GCT Credit 10: Heat island reduction

References

Center for Watershed Protection. www.cwp.org

Conservation Research Institute. *Changing Cost Perceptions: An Analysis of Conservation Development*, 2005. www.nipc.org/environment/sustainable/conservationdesign/cost_analysis/

Smart Growth Network. www.smartgrowth.org

U.S. Environmental Protection Agency. *Reducing Stormwater Costs Through Low Impact Development (LID) Strategies and Practices*, December 2007. www.epa.gov/owow/nps/lid/costs07/

U.S. Green Building Council. LEED Rating System. www.usgbc.org