Chapter 5

Low-Impact Development

A. Introduction

"Low-impact development" (LID) is a set of site planning and design methods that preserve a landscape's hydrologic functions and both minimize and mitigate stormwater runoff close to its sources. LID is an alternative to traditional site design and traditional stormwater management.

As discussed in Chapter 2 of this handbook, traditional site design and development practices remove trees and vegetation, compact soils, and add significant amounts of impervious cover to lands, all of which alter the way that water moves through the environment. The result is degraded water quality from pollution and from high quantities and velocities of runoff that alter watershed structure and functioning.

Moreover, traditional stormwater management has had trouble providing adequate abatement and treatment of stormwater at current rates of development. Traditional stormwater management practices focus on two main elements: drainage of the site, and off-site flood control. They are implemented using control-and-treatment strategies. This form of management focuses on removing stormwater runoff from a site as quickly as possible and conveying that runoff to a central location, which is typically located at the end of a pipe system. Although this type of system results in efficient stormwater conveyance, it amplifies the loss of natural storage, increases the amount of impervious surfaces, decreases the time of concentration, and decreases runoff travel times. Natural features that decrease stormwater travel times and detain or infiltrate runoff are lost, which harms ecosystems.

LID, on the other hand, does not rely on traditional end-of-pipe or in-the-pipe structural methods. Instead, it integrates stormwater controls throughout the landscape. LID practices manage stormwater runoff as close to its source as possible, and in ways that mimic the natural hydrology of the particular site. This enables more storage, infiltration, and evaporation of stormwater, thus mitigating the negative effects on a community's water resources.

LID is a comprehensive approach to managing stormwater. Small landscape features located on each lot link together to manage the stormwater. LID can be utilized to reduce runoff and pollutants by managing stormwater runoff close to its source. LID helps to protect surface and ground water quality, maintain the integrity of aquatic ecosystems, and preserve the physical integrity of receiving streams. LID allows for natural functions such as infiltration, frequency and volume of discharges, and groundwater recharge to be maintained.

Figures 5-1 to 5-3: High-impact development includes sprawling subdivisions with extensive road connectors, and sites with substantial impervious cover.

Sources: Center for Watershed Protection; Keith Mountain

LID controls stormwater by creating a hydrologically functional site design that mimics the predevelopment site hydrology by using site design techniques that allow for natural functions such as infiltration, frequency and volume of discharges, and groundwater recharge to be maintained. It accomplishes this by:

- minimizing stormwater impacts;

- providing runoff storage measures that are dispersed throughout a site's landscape;
- maintaining predevelopment time of concentration by routing flows to control the discharge;
- utilizing pollution prevention measures; and
- designing with aesthetically-pleasing landscaping (Prince George's County 1999, p. ix).

LID can be utilized for new development, as well as redevelopment projects. For new development, LID is used to maintain or closely mimic the site's predevelopment hydrology. For sites located in developed areas, LID can be used to retrofit sites to reduce runoff volumes, pollutants, and the overall impacts of existing development on the affected receiving water resources. In fact, LID practices are particularly useful in urban areas because most of its techniques use small amounts of land on a given site, and many are easily integrated into existing infrastructure, such as roads and parking areas.

The main goals of LID are as follows:

- to manage stormwater as close to its source as possible;
- incorporate natural site features and processes as design elements;
- protect natural systems and processes, such as sensitive areas, drainage ways, vegetation, and soils;
- customize site design to each site;
- mimic or replicate hydrologic functions;
- focus on prevention rather than mitigation; and
- emphasize simple, nonstructural, low-tech, and low cost methods.

B. Benefits of Low-Impact Development

LID can have tremendous environmental, economic, and social benefits. The environmental benefits are great, especially related to water resources. With the implementation of LID techniques, receiving waters experience less negative impacts in the volume, frequency, and quality of runoff. This helps water resources maintain base flows, and it more closely resembles predevelopment runoff conditions. Additional environmental benefits include a decrease in the amount of pollutants in stormwater runoff, recharge of ground water, improved water quality, a reduction in the amount of CSO's, a reduction in ambient air temperatures and thus reduced energy demand, improved air quality, and improved habitats. LID also reduces downstream flooding that is often exacerbated by traditional stormwater management techniques.

LID practices can be economically beneficial, as well. LID techniques can cost less to install, cost less to operate and maintain, and provide more cost-effective stormwater management than traditional stormwater controls. Development costs can be significantly reduced by reducing the amount of materials needed for impervious surfaces, such as roads and driveways, as well as for curbs and gutters. Additional costs can be saved by decreasing the use of storm drain piping, inlet structures, stormwater ponds, and other flood control structures. LID also reduces the amount of land required for stormwater management techniques. Traditional stormwater management practices require land in addition to individual lots and community areas, but LID can be incorporated into yards, rights-of-way, and parking lots. Land that would have been used for the traditional management practices can then be used for additional lots, thus yielding greater profits. Not only are costs decreased for developers, but LID techniques can also reduce public expenditures spent on stormwater infrastructure.

ECONorthwest (2007) provides an excellent overview of studies that have been conducted on the costs and benefits of LID, the costs of managing combined sewer overflows by LID techniques, and the economic benefits of LID. The article also includes tables that summarize the results of studies that compared the construction costs of using LID with those of traditional stormwater controls for both residential and commercial developments.

Not only do LID practices decrease construction costs, regulatory costs can also be reduced. Many communities offer streamlined or simpler permit processes and other incentives for the implementation of LID techniques. LID projects can also require smaller impact fees because they have less of an environmental impact than traditional developments. Many communities charge fees when stormwater mitigation requirements cannot be met. In certain redevelopment projects where land is not available for large stormwater management practices, developers can employ site-dispersed LID techniques in sidewalk areas, on rooftops, in parking lots, and in other small outdoor spaces, thus avoiding these fees. Additionally, many stormwater utilities provide credits for the incorporation of stormwater runoff management practices such as LID techniques into the site design.

LID can have additional benefits. It can be aesthetically pleasing, thus improving property values of surrounding property. The quality of life of community residents is also improved with such development, as it can beautify the area, create habitats, and sometimes be available for public open space.

Even when the implementation of LID practices cost more in the initial stages of development, they may be more economical in the long term. In such instances, the LID techniques may control a larger volume of stormwater compared to traditional management options and improve water quality. This means less stormwater in pipes and treatment facilities, thus reducing operation and maintenance costs. It can also result in the extension of useful life of the infrastructure, reducing future construction costs. Although developers may focus only on construction costs, communities would be well served to consider future costs because they will be responsible for the infrastructure’s maintenance and operation. Furthermore, many LID technologies are relatively new, and have just recently become commonplace. Thus, as with any new technology, costs will continue to decrease as LID practices are utilized more often.

C. Concepts of Low-Impact Development Site Planning and Design

LID site planning should allow for the development of the property while maintaining site hydrologic functions. Site designs should be focused on minimizing the impacts on the site's hydrology that are caused by development of the site, as well as mitigating or restoring any disturbances to the hydrology that cannot be avoided. Consideration of the site's hydrology should be incorporated into the site planning process as early as possible.

Communities should keep in mind the key concepts of LID site planning when creating plans. There are five fundamental concepts of LID site planning, as described below (Prince George's County 1999, ch. 2):

1. Use hydrology as the integrating framework.

Hydrology should be integrated into the site planning process, and consideration of hydrology principles in every phase of site development is necessary to optimize the effectiveness of LID sites. A hydrologically integrated site plan maintains the predevelopment hydrology. Sensitive areas that affect the hydrology should be identified and preserved. These areas include streams and their buffers, floodplains, wetlands, steep slopes, and high-permeability soils. After identifying the sensitive areas, evaluation of the potential site development and layout is performed. The goal is to minimize and disconnect the total impervious area at the site. The impervious areas that cannot be avoided are then analyzed so that directly connected impervious surfaces are reduced.

2. Think micromanagement.

To make LID work, the developer must think small. A distributed control of stormwater using throughout the entire site using different techniques provides the opportunity to maintain the site's key hydrologic functions. These functions include infiltration, depression storage, and interception, as well as a reduction in the time of concentration. By utilizing micromanagement techniques, a community can choose from a wider variety of control practices that can be used, and can adapt the appropriate techniques to specific site conditions. Micromanagement techniques also allow for on-lot control practices to be integrated into the natural features of the site, and provide stormwater runoff volume control. They also help to maintain groundwater recharge functions.

3. Control stormwater at the source.

Minimizing and then mitigating the impacts of development on the hydrology of the site closer to the source of generation is vital to restoring the predevelopment hydrologic functions of the site. Interception, depression storage, and infiltration are all natural functions that are evenly distributed throughout a site that has not been developed. Restoration of these hydrologic functions should be incorporated as close as possible to source. This can be accomplished using micromanagement techniques throughout the site.

4. Use simplistic, nonstructural methods.

Simple solutions can prove to be very effective in preserving a landscape's hydrologic functions. Natural materials like native plants can be easily integrated into the site. The more natural appearance is also more aesthetically pleasing. An additional advantage of small, distributed systems is that one or more of the systems can fail without causing the overall integrity of the stormwater management strategy to fail, as well. Using these landscape features can result in significant maintenance and upkeep savings.

5. Create a multifunctional landscape.

LID allows the incorporation of detention, retention, filtration, or runoff use into any rural or urban landscape. Incorporating LID practices into a site only requires the development of various ways to creatively prevent, retain, detain, use, and treat runoff within multifunctional landscape features unique to that site.

D. Processes of Low-Impact Development.

Once communities have become acquainted with the key concepts in LID site planning, they can proceed to the site planning process. Steps in the LID site planning process are:

1. identify applicable zoning, land use, subdivision, and other local regulations;
2. define the site areas that affect the hydrology and any protected areas;
3. use drainage/hydrology as a design element;
4. reduce/minimize total site impervious areas;
5. develop integrated preliminary site plan;
6. minimize directly connected impervious areas;
7. modify/increase drainage flow paths;
8. compare pre-development and post-development hydrology; and
9. complete LID site plan (Prince George's County 1999, p. 2-6).

E. Low-Impact Development Principles and Techniques

During site planning process, particular LID management practices must be chosen to integrate into the site design so that the intended post-development hydrologic conditions can be achieved. The selection of specific LID development features depends on how stormwater needs to be controlled on the site.

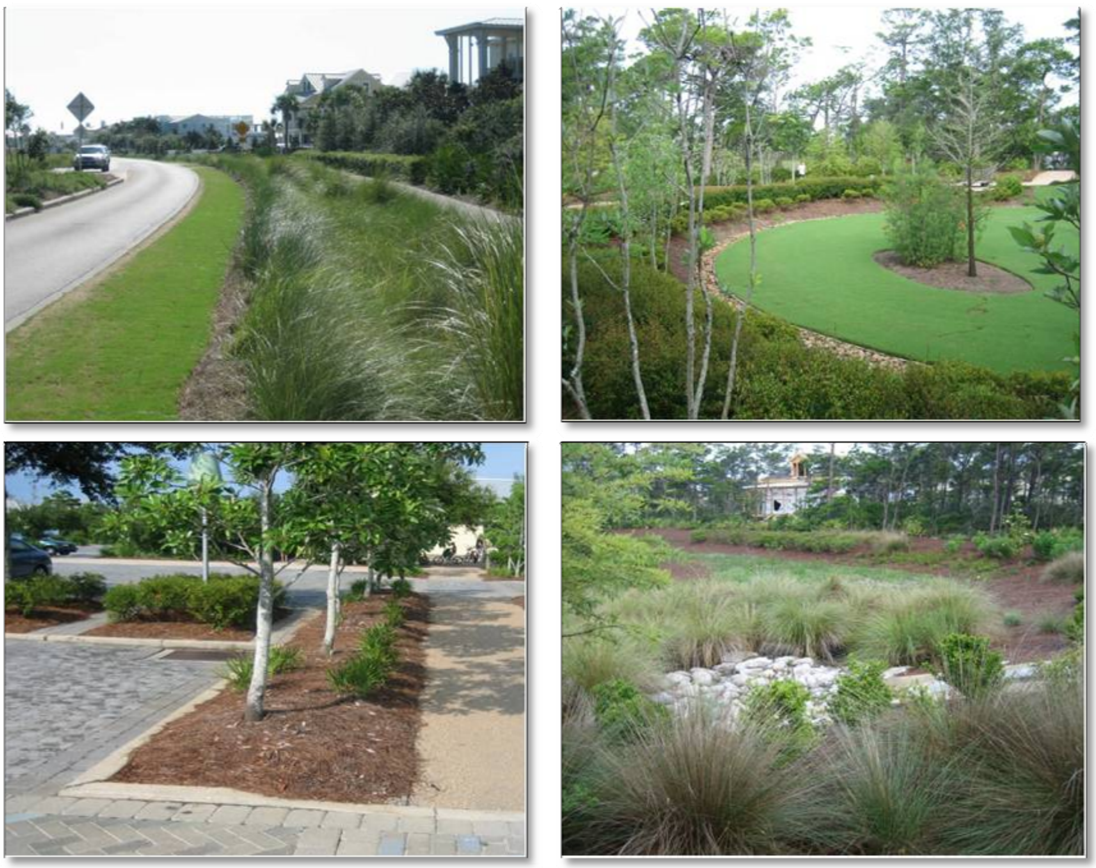
Communities will want to first define the control that is needed, and then will want to evaluate any constraints on the site that would hinder the implementation of a particular management practice. Evaluation should include space requirements, proximity to foundations, soils, slopes, water table, maximum depth, and maintenance burden (Prince George's County 1999, p. 4-5). Once this is done, certain management practices will emerge as viable. After each is evaluated, the optimal practice should be chosen, as well as the configuration and design of that particular practice at the site. Once all management practices are chosen for a site, traditional controls can then be added to supplement them if additional control of the stormwater is needed.

There are several different lists of specific LID techniques that should be considered, many of which have substantial overlap. Three commonly used sets of LID methods are identified here.

First, the U.S. EPA (2007) has identified a number of specific techniques and methods to be used, many of which are listed below:

- cluster development;
- natural land preservation;
- reduced pavement widths and lengths;
- avoidance of overbuilt parking lots;
- infiltration basins and trenches;
- porous pavement;
- disconnected downspouts;
- rain gardens and bioretention landscaping;
- rain barrels and cisterns;
- rainwater recycling;
- runoff storage beneath or integrated into parking lots, streets, and sidewalks;
- depressional storage in landscape islands and in tree, shrub, or turf depressions;
- green roofs;
- development without curbs and gutters, or elimination of curbs and gutters;
- vegetated swales;
- vegetated filter strips and buffers;
- grass-lined channels;
- roughened surfaces;
- long-flow paths for runoff over landscaped areas;
- smaller culverts, pipes, and inlets;
- terraces and check dams;
- native and drought-tolerant landscaping;
- preservation of existing trees and vegetation, especially mature and large trees;

- use of trees and shrubs instead of turf, or replacement of turf with trees and shrubs;
- wildflower meadows;
- vegetation of medians with trees, shrubs, and/or wildflowers (to the extent compatible with traffic safety);
- reforestation;
- maintaining grasses at longer lengths;
- soil modification to increase infiltration capacity; and
- methods to control or prevent soil and erosion from construction sites and other soil disturbance activities (U.S. EPA 2007, pp. 2-5).



Source: Southeast Watershed Forum

Figures 5-4 to 5-7: LID techniques of vegetated swales, rain gardens, pervious pavements, and bioretention.

The U.S. EPA organizes these LID practices according to six broad categories:

1) conservation designs;
2) infiltration practices;
3) runoff storage practices;
4) runoff conveyance practices;
5) filtration practices; and
6) low impact landscaping.

Many specific practices appear in more than one category (U.S. EPA 2007, pp. 3-5). See http://www.epa.gov/owow/nps/lid/costs07/documents/reducingstormwatercosts.pdf.

Second, in order to focus communities on several LID practices that can be used frequently in land development and site design, the Natural Resources Defense Council (1999) has developed its list of "Ten Common LID Practices":

- rain gardens and bioretention;
- rooftop gardens;
- sidewalk storage;
- vegetated swales, buffers, and strips, and tree preservation;
- roof leader disconnection;
- rain barrels and cisterns;
- permeable pavers;
- soil amendments;
- impervious surface reduction and disconnection; and
- pollution prevention and good housekeeping (NRDC 1999, ch. 12).

Third, the Site Planning Roundtable, convened by the Center for Watershed Protection, has developed a *Consensus Agreement on Model Development Principles to Protect Our Streams, Lakes, and Wetlands* (Site Planning Roundtable 1999), which has the following 22 model development principles for site design and development:

Streets and Parking Lots (Principles 1-10):

- Model Principle 1. Street Width
  "Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume."

- Model Principle 2. Street Length
  "Reduce the total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length."

- Model Principle 3. Right-of-Way Width
  "Wherever possible, residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible."

- Model Principle 4. Cul-de-sacs
  "Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered."

- Model Principle 5. Vegetated Open Channels
  "Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff."

- Model Principle 6. Parking Ratios
  "The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to see if lower ratios are warranted and feasible."

- Model Principle 7. Parking Codes
  "Parking codes should be revised to lower parking requirements where mass transit is available or enforceable shared parking arrangements are made."

- Model Principle 8. Parking Lot Design
  "Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in the spillover parking areas."

- Model Principle 9. Structured Parking
  "Provide meaningful incentives to encourage structured and shared parking to make it more economically viable."

- Model Principle 10. Parking Lot Runoff
  "Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands."

Lot Development (Principles 11-16):

- Model Principle 11. Open Space Developments
  "Advocate open space design development incorporating smaller

lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection."

- Model Principle 12. Setbacks and Frontages
  "Relax side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness."

- Model Principle 13. Sidewalks
  "Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas."

- Model Principle 14. Driveways
  "Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together."

- Model Principle 15. Open Space Management
  "Clearly specify how community open space will be managed and designate a sustainable legal entity responsible for managing both natural and recreational open space."

- Model Principle 16. Rooftop Runoff
  "Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas and avoid routing rooftop runoff to the roadway and the storm water conveyance system."

Conservation of Natural Areas (Principles 17-22):

- Model Principle 17. Aquatic Buffers
  "Create a variable width, naturally vegetated buffer system along all perennial streams that also encompasses critical environmental features such as the 100-year floodplain, steep slopes and freshwater wetlands."

- Model Principle 18. Buffer Maintenance
  "The riparian stream buffer should be preserved or restored with native vegetation that can be maintained throughout the plan review, delineation, construction, and occupancy stages of development."

Source: Center for Watershed Protection

Figures 5-8 to 5-9: LID projects combine many different methods to minimize impact on water resources.

- Model Principle 19. Clearing and Grading
  "Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. Manage fixed portion of any community open space as protected green space in a consolidated manner."

- Model Principle 20. Tree Conservation
  "Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants. Wherever practical, manage community open

space, street rights-of-way, parking lot islands, and other landscaped areas to promote natural vegetation."

- Model Principle 21. Conservation Incentives
  "Incentives and flexibility in the form of density compensation, buffer averaging, property tax reduction, storm water credits, and by-right open space development should be encouraged to promote conservation of stream buffers, forests, meadows, and other areas of environmental value. In addition, off-site mitigation consistent with locally adopted watershed plans should be encouraged."

- Model Principle 22. Stormwater Outfalls
  "New stormwater outfalls should not discharge unmanaged stormwater into jurisdictional wetlands, sole-source aquifers, or other water bodies." (Site Planning Roundtable 1999, pp. 3-6)

F. Maintenance of Low-Impact Development

Once LID techniques have been implemented, they must be maintained. The maintenance of LID facilities is imperative for the designed stormwater management performance and other benefits to continue over the full life cycle of the development. One way communities can ensure the continued maintenance of LID techniques by landowners is to have the property owner sign a maintenance covenant. A sample maintenance covenant is provided in the Prince George's County, Maryland, document *Low-Impact Development Design Strategies: An Integrated Design Approach* (Prince George's County 1999, App. B).

Pierce County, Washington offers an excellent document about the maintenance of LID techniques. It discusses goals and objectives of LID maintenance, strategies to ensure quality maintenance, and maintenance responsibilities. The document also provides maintenance schedules for several LID techniques. It is available at http://www.co.pierce.wa.us/xml/services/home/environ/water/cip/LID/A.-MaintSpecs.pdf.

G. Low-Impact Development Policies and Ordinances

Not only can communities integrate LID into public development projects, but they can also promote the adoption of LID for private developments and can work to reduce the regulatory uncertainty and risk that developers face when they include LID in private developments. Updating zoning codes and building codes to specifically address LID stormwater controls can reduce regulatory uncertainty. Communities can also provide incentives for developers to incorporate LID techniques. Eliminating the need for developers to file variances to implement LID techniques is also helpful because it can save developers time and money. Additionally, communities can grant density bonuses to those developments that install LID stormwater controls. Finally, communities can require developers to use LID development standards – either particular methods or the developer's selection from a list or menu of methods – as ways of avoiding harms to the public and to water resources that would be causes by high-impact development projects.

In particular, Kentucky communities may wish to use the Center for Watershed Protection's Codes and Ordinances Worksheet (COW) to evaluate their existing codes and ordinances for compatibility with LID principles. The COW is produced in Appendix A. Furthermore, Chapter 12 of this handbook describes a variety of ordinances and land-development code provisions that Kentucky communities could adopt to allow, facilitate, and/or require LID. The Appendices of this handbook contain some sample ordinances.

H. Case Studies

Several case studies illustrate how LID has been used in communities throughout the United States.

1. Olympia, Washington
(City of Olympia 2002)

The city of Olympia, Washington, adopted mandatory LID regulations within its Green Cove watershed as part of a comprehensive policy revision. The regulations were adopted to prevent further damage to this area from urban development, as the city wanted to accommodate its rapidly growing population while also maintaining environmental quality. Realizing that the city's policy goals for habitat protection may not be able to be achieved in all basins due to development that had already occurred, it was decided that they would focus on those watersheds that were sensitive and could still be protected. The Green Cove Creek Watershed was chosen as the first focus. These regulations were somewhat unique as to what was being done in similar communities because they were mandatory, as opposed to voluntary "low-impact standards" or "standards affecting only one aspect of development."

As part of the process, city planners analyzed actual development proposals for two sites in the Green Cove basin and then enlisted the help of consultants to design development proposals for the same sites that incorporated LID strategies that could help to ensure protection of the habitat. The original two development proposals were for standard subdivisions with relatively small lot single-family housing. When comparing the traditional site plans to the ones that incorporated LID practices, several findings were made. Development density in the LID plans was reduced by about 40%, forest retention increased to 55%, street related impervious surface decreased by about 25% and overall impervious surface coverage decreased by about 50%.

Changes were made concurrently in the city's Comprehensive Plan, zoning and tree protection ordinances, street, sidewalk, and parking standards, and drainage design and erosion control standards. The city supplemented its Comprehensive Plan's chapters on Land Use and Urban Design, Environment, Utilities and Public Facilities, and Transportation with goals and policies that establish the Green Cove basin as a unique area subject to enhanced environmental regulations. The primary goals and policy changes added to the Comprehensive Plan include:

- designate Green Cove Creek as a sensitive drainage basin;
- avoid high-density development where new development would have a significant adverse impact upon the habitat within designated sensitive drainage basins;
- administer development regulations that protect critical areas and designated sensitive drainage basins;
- adopt LID regulations within the designated sensitive basins. These could include stormwater standards, critical area regulations, zoning designations, and other development standards; and
- establish street designs, particularly within sensitive areas, that minimize impacts to the natural environment.

The Olympia Municipal Code was also supplemented with an ordinance that created a new zoning district (Residential Low Impact) and increased tree protection and replacement requirements for designated sensitive basins, particularly the Green Cove basin. The new Residential Low Impact zoning district required increased residential densities, reduced lot widths and rear setbacks, increased maximum building heights, and limited maximum impervious surface coverage per lot. It also permitted several land uses such as duplexes and parking lots that are not typically permitted in single-family residential developments.

Another ordinance created a new chapter in the Development Guidelines and Public Works Standards. The chapter contained specific standards for engineered features of new developments in the Green Cove basin. These standards focus on street designs and stormwater conveyance. For instance, driveways and sidewalks can be constructed of porous surfaces, sidewalk planter widths can be increased, additional parking within LIDs can be provided by the construction of porous surface lots, street widths are narrower for some streets, and a rocked infiltration gallery/conveyance system is to be constructed for certain street slopes. Changes to the City's stormwater management manual included increased stormwater storage requirements and seasonal grading limitations in the Green Cove basin. Thurston County, in which the unincorporated portions of the Green Cove basin are located, also made changes to its Comprehensive Plan and zoning code to be consistent with Olympia.

2. 2^{nd} Avenue SEA Street, Seattle, Washington
(U.S. EPA 2007, pp. 12-13)

Seattle Public Utilities undertook the 2^{nd} Avenue Street Edge Alternative (SEA) Street project as a pilot project to redesign an entire 660-foot block with a number of LID techniques. The goals of the project were to reduce stormwater runoff and to provide a more "livable" community. Street residents were involved throughout the design and construction process. The project design reduced imperviousness, included retrofits of bioswales to treat and manage stormwater, and added 100 evergreen trees and over one thousand shrubs. The street width was reduced and conventional curbs and gutters were replaced with bioswales in the rights-of-way on both sides of the street. After construction was completed, imperviousness had been reduced by more than 18%. The LID retrofit resulted in a stormwater management cost savings of 29%, and the reduction in street width and sidewalks reduced paving costs by 49%. The environmental benefits of the project were even greater, as it has resulted in a 99% reduction in total potential surface runoff. Models show that a traditional curb-and-gutter system for the street would result in 98 times more stormwater being discharged from the site.

3. Poplar Street Apartments, Aberdeen, North Carolina
(U.S. EPA 2007, p. 21)

The design of the 270-unit Poplar Street Apartment complex utilized bioretention, topographical depressions, grass channels, swales, and stormwater basins. The result was improved stormwater treatment and reduced construction costs. The design created longer flow paths, reduced runoff volume, filtered pollutants from runoff, and allowed almost all conventional underground storm drains to be eliminated. The United States Department of Housing and Urban Development has reported that the use of LID techniques resulted in a 72% savings.

4. Tellabs Corporate Campus, Naperville, Illinois
(U.S. EPA 2007, p. 25)

The Tellabs corporate campus is located on a 55-acres site, and includes more than 330,000 square feet of office space. The company chose to develop the site with conservation design techniques after comparing it with the costs of traditional design. The use of LID techniques resulted in a 14% total cost savings for the project. Savings were realized in site prep, stormwater management, and landscape development. The site design included the preservation of trees and much of the site's natural features and topography. The site uses bioswales and other infiltration techniques in parking lots and other locations for stormwater management. Bioswales complemented the naturalized areas and allowed the site to function as a whole, with the engineered stormwater management techniques supplementing the benefits of the native areas.

5. Central Park Commercial Redesigns, Fredericksburg, Virginia
(U.S. EPA 2007, p. 14)

A group of developers conducted a cost analysis involving the redesign of site plans for several stores in a large commercial development in the Fredericksburg area. They compared the cost additions and reductions for each site for scenarios where LID techniques such as bioswales were incorporated into the existing, traditional design. The costs for the LID redesigns were higher than those for the original designs in five of six examples, but they never exceeded $10,000. One example yielded a savings of over $5,000. Because the costs were very similar for the LID designs when compared to the traditional designs, the developer began to incorporate LID techniques into future projects.

6. Somerset Subdivision, Prince George's County, Maryland
(ECONorthwest 2007, p . 24)

Somerset is an 80-acre development, with almost 200 homes on 10,000-square-foot-lots. The developer of the subdivision used LID techniques to reduce stormwater management, including rain gardens and grass swales along streets. By using bioretention techniques, stormwater ponds could be eliminated. Additionally, the LID techniques enabled the developer to gain six additional lots. The developer saved approximately $900,000 on the project.

I. Resources on LID

- The Center for Watershed Protection, Better Site Design Resources, http://www.cwp.org/Resource_Library/Better_Site_Design/ (containing download links for the following handbooks, Center for Watershed Protection, *Better Site Design: A Handbook for Changing Development Rules in Your Community* (1999); Site Planning Roundtable, *Consensus Agreement on Model Development Principles to Protect Our Streams, Lakes, and Wetlands* (1998); Center for Watershed Protection, *Redevelopment Roundtable Consensus Agreement: Smart Site Practices for Redevelopment and Infill Projects* (2001); Tom Schueler, *Site Planning for Urban Stream Protection* (1995).
- Prince George's County, Maryland's *Low- Impact Development Design Strategies: An Integrated Design Approach*, http://www.co.pg.md.us/Government/AgencyIndex/DER/.
- Low Impact Development Center, www.lowimpactdevelopment.org.
- NAHB Research Center Toolbase Services, www.toolbase.org.
- U.S. Environmental Protection Agency, Low-Impact Development website, http://www.epa.gov/owow/nps/lid/.
- U.S Environmental Protection Agency, Reducing Stormwater Costs Through Low Impact Development (LID) Strategies and Practices,

http://www.epa.gov/owow/nps/lid/costs07/documents/reducingstormwatercosts.pdf.

- U.S. Department of Housing and Urban Development, *The Practice of Low Impact Development*, http://www.huduser.org/Publications/PDF/practLowImpctDevel.pdf.
- U.S. Department of Defense, *Design: Low Impact Development Manual*, http://www.wbdg.org/ccb/DOD/UFC/ufc_3_210_10.pdf.
- *Urban Small Sites Best Management Practice Manual*, http://www.metrocouncil.org/environment/Watershed/bmp/manual.htm.
- International Stormwater BMP Database, http://www.bmpdatabase.org.

Sources:

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