

Conservation Subdivision: Construction Phase—Low Impact Development (LID) and Stormwater Treatment¹

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Introduction

As urban communities grow, design and management strategies for residential developments become critical factors in determining impacts on natural resources. How can we accommodate growth and yet conserve natural resources, such as biodiversity, water, and energy? Recently, a popular concept called conservation subdivision design or its product, a conservation subdivision, has been advanced by the landscape architecture community and has gained traction in the design fields. Conservation design is intended to plan for growth while conserving biodiversity and natural resources. Conservation subdivisions typically are developments of small lots clustered to use a smaller area of land than conventional subdivisions, while allowing open space to be conserved.

The goals for conservation subdivisions are twofold: 1) to improve biodiversity and natural resource conservation within a designated subdivision; and 2) to minimize development-related impacts on surrounding habitats. Often, though, most of the effort is on the design of the entire site. To conserve and improve biodiversity within urban environments effectively, one must consider the following three phases of development: design, construction, and post-construction.

The design phase typically involves, among other aspects, lot size and open space, as well as road distribution

throughout the site. Goals for the development project are discussed and prioritized. In this phase, homes and lots are placed across the site and the remaining area designated as (natural) open space. Basically, everything is laid out on paper and vertical structures (buildings) and horizontal structures (roads, lots, conserved areas, and shared spaces) are given specific spaces within the development.

Next, during the construction phase, a whole host of built environment professionals including architects, contractors, and subcontractors take whatever is on paper and implement this on the ground, constructing homes, streets, waste treatment systems, and landscaped areas (i.e., yards and parks). In the absence of fully trained or engaged contractors or landscapers, many things can happen during this phase that could impact the viability of onsite and nearby natural habitat. For example, even if the most important large trees are preserved across the subdivision and built areas are designed around them, the placement of topsoil and routes used by heavy construction vehicles could impair the survival of these trees. If heavy vehicles continually run over the root zone of a tree or if topsoil is placed against the tree trunk, the roots may not be able to acquire nutrients, water, and oxygen, and the tree may die.

In the final phase, post-construction, buyers purchase the homes, move into the community, and manage their own homes and yards, neighborhoods, and common areas. It is now the responsibility of residents to manage their homes,

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yards, and neighborhoods in ways that do not compromise the original intent of the community. Additional problems can arise if residents are not fully engaged—imagine residents moving in and planting invasive exotic plants in their yards. Residents could also improperly apply fertilizers and pesticides. The spread of invasive plants and stormwater runoff could then destroy or at least severely reduce the diversity of animals and plants found in the conserved areas.

Overall, these three phases must be addressed in order to create and maintain biodiversity and to conserve natural resources within residential subdivisions. The EDIS documents in the series titled “Conservation Subdivision” discuss biodiversity conservation pertaining to all three phases of development: design, construction, and post-construction. This fact sheet focuses on decisions made in the construction phase concerning stormwater treatment. Because so much area in subdivisions is covered by impervious surfaces such as roads, buildings, and driveways, stormwater runoff must be accounted for and treated to prevent flooding and to remove contaminants. Often, stormwater runoff impacts surrounding landscapes and water bodies due to nutrient loading (Clark and Acomb, 2008). Below, we discuss the importance of using a more distributed stormwater treatment system that treats runoff closer to the source. Often called Low Impact Development (LID), this stormwater management approach is being used to more effectively remove pollutants from runoff.

Issues concerning stormwater treatment

The major transition of land to urban uses over the recent decades has created a range of stormwater runoff issues (Clark and Acomb 2008, Rushton 2001, Williams and Wise 2009). The management of stormwater with a focus on water quality is a fairly recent practice. In the not-so-distant past, urban stormwater runoff was largely considered a quantity problem (flooding). The solution to flooding has been to collect runoff by draining roadway gutters into pipes and to direct the water either to large centralized retention ponds or directly into natural bodies (lakes, oceans, rivers, etc.) (Clark and Acomb 2008, Hostetler et al. 2008, Rushton n.d). These pipe-and-pond design practices have been the “conventional” manner of dealing with stormwater due to the effectiveness of removing stormwater from the site (Clark and Acomb 2008). Unfortunately, these conventional practices of treating stormwater have now been associated with increased stormwater runoff volume, and they leave pollutants in the water (USEPA 2003).

Further, these conventional practices result in soil compaction and, therefore, increased impervious surfaces, which is the primary reason these methods increase runoff volume and velocity (flow rate) (Heaney and Lee 2006, USEPA 2003). Also, large stormwater retention facilities hold massive volumes of runoff accumulated from watersheds, which in turn produce high levels of head pressure, which is essentially lots of water on top of a given area, causing the water to permeate and move through the soil at unnatural rates.

Conventional stormwater management systems divert runoff from its natural hydrologic path to impervious surfaces, collecting pollutants. They do not provide necessary soil-to-water contact time, which is crucial for the removal of impurities. Increased urbanization has been strongly correlated with “downstream” degradation such as nutrient enrichment, sedimentation, and habitat/species loss (USEPA 2000, Rushton 2001). Stormwater runoff often carries contaminants such as automobile oils, fertilizers, heavy metals, and pet wastes, which are at the greatest concentration in the first few centimeters (Hostetler et al. 2008, Clark and Acomb 2008, MacMullen and Reich 2007). This type of pollutant load is known as non-point source (Clark and Acomb 2008). Research has shown that since the 1970s more than half of the pollutant loads inundating waterways comes from non-point, stormwater sources (Rushton, Clark and Acomb 2008). Low Impact Development (LID) is an alternative design approach (ADA) that has been researched, tested, and used to help improve stormwater runoff quantity and quality issues.

What is LID?

LID is a design strategy of maintaining the pre-development hydrologic function of the area by encouraging runoff infiltration, shallow surface storage, filtering, evaporation, and detention through a variety of design “tools” (USEPA 2005, USEPA 2000, Powell et al. 2005, Hubbart 2011, Clark and Acomb 2008). It was introduced in Prince George’s County, Maryland, in the early 1990s as an alternative or complement to the conventional style of stormwater management practices (Clark and Acomb 2008, Bowman and Thompson 2009). Multiple, small-scale LID “tools” are often used together in a “treatment train” along the flow of water through a site (Figure 1). This method allows water to percolate into the soil closer to where it falls, reducing the amount of water running off site and allowing for smaller retention ponds (Hostetler et al. 2008, Rushton 2001).



Figure 1. Centralized (left) stormwater management scheme vs. decentralized (right), “LID” scheme.
Credits: Prince George’s County, n.d.

How does LID work?

LID tools are used together in a systematic way to retain, detain, recharge, filter, and reuse stormwater. They aid in maintaining natural soil properties (biological, perviousness, etc.) and pollutant treatment by maximizing the contact time/area between stormwater and soil (Clark and Acomb 2008). These methods also use vegetation to increase rainfall interception capacity and to cleanse contaminated runoff through biological processes (Clark and Acomb 2008). LID can be used both in small areas and in much larger areas — “lot scale” to “community-scale” — and it is effective when used in association with conventional practices, offering a greater flexibility in stormwater infrastructure design (USEPA 2000, Clark and Acomb 2008). In contrast to conventional stormwater management, which focuses on collecting, concentrating, conveying, centralizing, and controlling runoff, LID is not a standardized, “one size fits all” method. It requires increased planning to meet the requirements of the specific site or sites (Hostetler et al. 2009, Bowman and Thompson 2009). Some of the major tools that can be used in LID design are:

- **Permeable Surfaces:** These include numerous types of porous pavement, concrete, and pavers, often positioned to overlay aggregate water storage areas. Such structures provide direct stormwater infiltration while serving as a structural surface: they are among the most frequently used and most effective LID tools for reducing stormwater runoff (Hostetler et al. 2008, Clark and Acomb 2008). The physical limits of building materials, of course, must also figure into the equation: different permeable surfaces allow different amounts of water to percolate into the ground.
- **Bioretention Basins/Rain Gardens:** These are shallow, planted depressions designed to retain or detain

stormwater before it filters into the groundwater or discharges downstream. Bioretention areas, typically larger in size, are designed to decrease pollutant export through plant uptake, filtering and sorption (Figure 2).



Figure 2. A bioretention area at SW Recreation Center, University of Florida
Credits: Program for Resource Efficient Communities, University of Florida 2004

- **Bioswales/Vegetated Swales:** Shallow depressions used to collect, partially treat, and convey stormwater from critical structures towards infiltration or detention areas using a gentle slope.
- **Enhanced Stormwater Basins:** Also known as stormwater wetlands, they are used to capture and treat stormwater runoff in order to reduce flooding and to improve water quality. They are designed to support increased vegetative diversity, wildlife species, and more complex biogeochemical processes (Figure 3), which result in their being an amenity rather than merely a stormwater facility.



Figure 3. An enhanced stormwater basin used to treat runoff.
Credits: Program for Resource Efficient Communities, University of Florida 2004

- *Low Impact Site Design Practices:* These can help maintain a site's pre-development hydrologic scheme and biological characteristics. Some of the most notable of these practices include minimizing impervious cover (paving and roof area), limiting compaction of soils, reducing the footprint of material storage, minimizing the removal of trees and native vegetation, preventing damage to existing vegetation root systems, designing to limit alteration of existing topography and limiting the stripping of topsoil (Clark and Acomb 2008).
- *Green Roofs/Eco-roofs:* Vegetated roofs that are partially or completely covered by growing media and plants to achieve the following: retain or detain rainwater intercepted by the roof (thereby reducing runoff); conserve energy; extend the roof life; reduce "urban heat island effect;" and contribute to biodiversity (Clark and Acomb 2008).
- *Cisterns/Rain Barrels:* Large-scale or small-scale storage tanks that collect runoff from large areas such as rooftops. Cisterns help to reduce and slow stormwater runoff, which aids in flood control and downstream management. The rainwater can be reused for irrigation or flushing toilets (Clark and Acomb 2008).
- *Subsurface Detention/Retention:* Engineered tanks or trenches filled with gravel, rocks, or other aggregate material to provide large storage areas, are used in combination with permeable surfaces to control, store, and filtrate significant runoff volume before it is slowly released into the surrounding groundwater (Clark and Acomb 2008, Figure 4).



Figure 4. A subsurface exfiltration system installed at the Madera subdivision in Gainesville, FL.
Credits: Program for Resource Efficient Communities, University of Florida 2004

- *Cluster Design:* A site planning technique also known as "conservation design," which uses smaller lot sizes that are "clustered" to achieve a smaller impact area. Sometimes this practice is considered a separate element from LID tools or is included in the low impact site preparation category. The smaller footprint of a cluster design reduces impervious surfaces, protects natural drainage paths and high infiltration soils, and maintains open space/natural areas (USEPA 2007, Williams and Wise 2009).

What are the benefits of LID?

LID provides improvements in biodiversity and water quality (Hostetler et al. 2008, USEPA 2000). Some of the notable environmental benefits include:

- Better provision of groundwater recharge and baseflow in streams
- Decreased local and downstream water quality degradation
- Increased soil fertility
- Increased soil fauna diversity
- Improved soil moisture mosaic
- Increased open-space/ habitat conservation

Because LID uses plants and open space to help capture stormwater throughout a site, there are many opportunities to enhance site functions through the use of native plants and conserve wildlife habitat (see Conservation

Subdivision: Construction Phase – Native Landscaping Palmette, <http://edis.ifas.ufl.edu/uw329>; Conservation Subdivision: Construction Phase – Protecting Trees and Conserved Natural Areas, <http://edis.ifas.ufl.edu/uw323>). For example, swales and enhanced stormwater basins can be planted with native plants and be designed to provide wildlife with habitat. Stormwater basins that contain water all year round can attract wading birds foraging for fish and other aquatic wildlife found in the water. To attract birds, the shoreline edges of retention ponds should include open areas and areas with native tall and shrubby vegetation. The area within the first few meters of a pond, i.e., the littoral zone, should contain a mixture of open water, floating vegetation, and both short and tall emergent vegetation. A mixture of floating and emergent native vegetation will attract a wide variety of wading birds. In order to have a food-rich littoral zone, the edges of a stormwater basin must not be dug too deep. Instead, a gently graded shoreline will provide shallows for dabbling and foraging birds. A diversity of species will favor ponds with just a small amount of the shoreline dominated by lawn; the rest could be a mixture of native trees, shrubs, and other vegetation occurring around the shore. Detention ponds will be of little use to wildlife if they are cut deep (with no littoral shelf at the edge of the pond), if they are completely surrounded with cement or grass, or if they have no native vegetation around or in the water. For an example of an enhanced stormwater pond, please see University of Florida's SEEP project (<http://natl.ifas.ufl.edu/seepgall.html>).

A limited but growing body of research reveals that LID can be a cost-effective stormwater management approach (MacMullen and Reich 2007, USEPA 2007, USEPA 2000, USEPA 2005). A U.S. EPA (2007) paper examined 17 case studies of development projects that utilized LID and concluded that capital cost savings ranged from 15–80% when LID was used in these project designs. Only one of the projects resulted in a higher cost associated with LID (USEPA 2007). LID offers the potential for various land value and quality-of-life benefits. Some of these include:

- Reduced downstream flooding and property damage
- Increased real estate value/property tax revenue
- Increased lot yields
- Improved aesthetic value

If one evaluates the 4 bullets above, there could be cost savings to LID, especially when one considers increased lot value, tax value, and protection of downstream flooding. Due to the nature of the development industry, the

quantitative value of water resource protection is often grossly overlooked when sustainable alternatives are considered.

What are the challenges/limitations to LID?

There are numerous issues, both site-specific and regulatory, that can limit the implementation of LID designs. We discuss these in turn below.

Site-Specific

- *Space:* Although LID can help reduce the additional space needed for large centralized retention on the community level, distributed micro-scale tools at the lot level do tend to use more space within the lot itself (USEPA 2000, Clark and Acomb 2008).
- *Soil Conditions:* Soil permeability and water table depth are two very important factors when considering LID tools. An area with well-drained soils will allow the selection of infiltration-based LID tools such as bioretention basins, permeable surfaces, or enhanced stormwater basins. However, an area with a high water table will preclude such choices in favor of decentralized soil-water storage space (USEPA 2000). Sites with well-drained soils may convey runoff to sinkholes and springs before remediation can occur. In these cases, additional study and mapping are required.
- *Topography:* Slope and natural hydrologic features of each site must be suitable for LID tools (USEPA 2000, Clark and Acomb 2008). Features such as bioswales have limitations to the slope that can be accommodated without risk for soil and bank erosion, but other topographical features might not be as suitable for LID methods.
- *Climate:* Areas prone to extreme tropical events or large-scale flooding may need additional storage beyond what LID can provide (USEPA 2000, Clark and Acomb 2008).

Regulatory

- *Codes and Regulations:* Many municipal subdivision codes, zoning regulations, parking and street standards, and land development ordinances have not embraced LID and may contain standards that require conventional designs (USEPA 2000, Bowman and Thompson 2009).
- *Permitting Process:* Many municipalities either lack standards for permitting LID practices or simply have not embraced LID tools. This often leads to increased

approval time and associated increases in risk and/or cost (USEPA 2000, Bowman and Thompson 2009). Some research is showing this to be the strongest barrier to LID use in Florida. Much of the reluctance to embrace LID from the regulatory permitting side in Florida comes from lack of knowledge and performance data on these biological systems.

- *Operations and Maintenance (O&M) Issues:* Uncertainties about O&M have been a major issue for regulatory acceptance of LID. Data is becoming more widely available concerning O&M specifications and costs for various LID tools. Maintenance of conventional stormwater systems is often under-provided or neglected, which greatly decreases desired performance. This fact should be noted with any comparison to LID O&M costs and/or effort level.
- *Reluctance to Adopt:* Uncertainty concerning the maintenance regime and long-term performance of the biological systems associated with LID has led to the majority of reluctance from the engineering and regulatory community. Although some of the concern is valid, the benefits of LID are becoming a compelling argument for further research and implementation of these tools. Performance research for LID is much more extensive and costly when compared to performance research for conventional tools. This being considered, a review of the major cities (Seattle, Portland, Chicago, Philadelphia, and New York) that have been successful at embracing LID makes it hard to dismiss the value of its utility.

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Additional Resources

Hostetler, M. 2012. Green Leap: A Primer for Conserving Biodiversity in Subdivision Development. University of California Press, Berkeley, CA.

Low Impact Development Center

<http://www.lowimpactdevelopment.org/>

American Society of Landscape Architects (Stormwater Management Case Studies)

<http://www.asla.org/stormwatercasestudies.aspx>

United States Environmental Protection Agency (LID page)

<http://water.epa.gov/polwaste/green/index.cfm>

Manuals and other Literature

Green Leap:

Prince George's County Manual: LID Design Strategies

http://www.lowimpactdevelopment.org/pubs/LID_National_Manual.pdf

Department of Defense Manual

http://www.wbdg.org/ccb/DOD/UFC/ufc_3_210_10.pdf