7 Stormwater Reduction Techniques

Once the estimated stormwater runoff reduction volume has been quantified, it is necessary to understand the stormwater reduction techniques available in order to develop a strategy to address the volume reduction goal. The techniques discussed below focus on volume reduction of stormwater runoff.

Pause

Now is an excellent time to rely on partners who are planners, stormwater managers, engineers, technicians, or resource managers for their insight

7.1 Low Impact Development

LID is an approach to stormwater management that makes use of a variety of techniques to replicate the natural hydrologic function of the landscape especially by focusing on micro-scale management of land development. Micro-scale management is done through the emphasis of parcel-level management on replicating predevelopment processes such as evapotranspiration, infiltration, filtration and storage to minimize the flow of stormwater to connected conveyance systems. In addition to being an effective strategy, LID techniques are cost effective and save in construction time. A 2007 EPA study of 17 LID case studies found that life cycle costs of LID overall are less than conventional practices with total capital cost savings reaching up to 80%[8].

> For every inch of rain that falls on a 1,200 square foot area, approximately 748 gallons of stormwater runoff is produced.

> When trying to preserve the health of the local watershed, the best place to start is to enhance and preserve the natural stormwater treatment areas such as marshes, wetlands, and coastal forests.

[8] Environmental Protection Agency. (2007). Reducing stormwater costs through Low Impact Development (LID) strategies and practices. Publication Number: EPA 841-F-07-006. Retrieved from http://www.epa.gov/sites/production/files/2015-10/documents/2008_01_02_nps_lid_costs07uments_reducingstormwatercosts-2.pdf

The key elements of LID highlight the use of creative site management and small, decentralized planning approach to infiltration techniques to minimize stormwater runoff (Figure 7-1). The key elements of LID are versatile and can be applied to most types of land uses including industrial, commercial, residential, mixed use development, individual lots, public lands, roads and parking facilities.

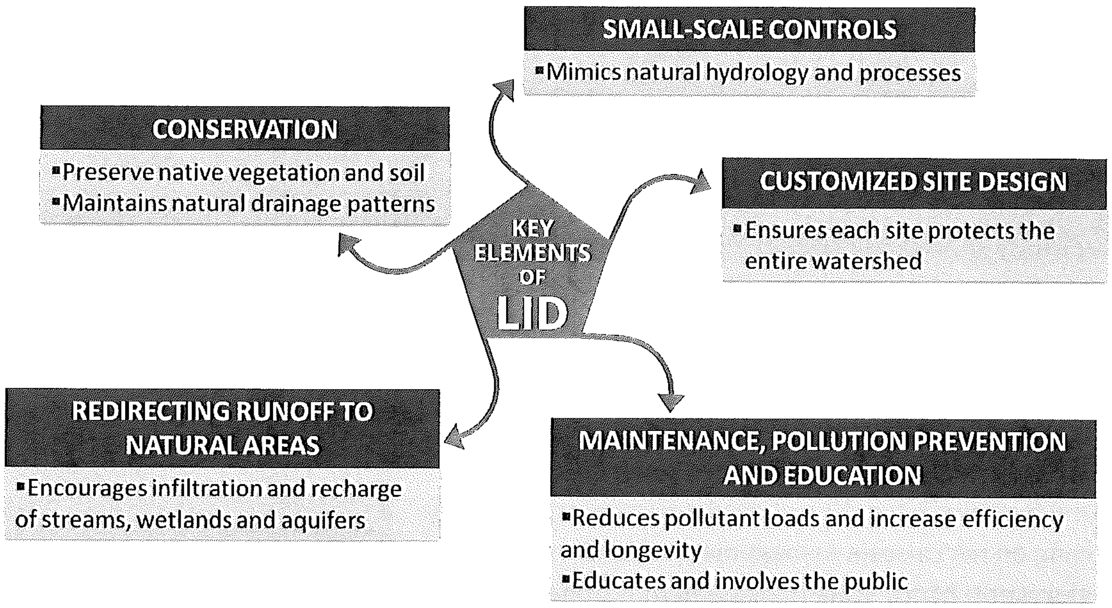

Figure 7-1. The five Key Elements of LID.

LID techniques should be used for new development projects and to reduce existing volumes of stormwater runoff. LID site design for new development includes identifying important natural features, strategically placing buildings, roads and parking areas, as well as designing a stormwater management system that works with the site to maintain or mimic the predevelopment hydrology. The attention to natural hydrology, stormwater micromanagement and integrated use of the landscape results in a more attractive, multifunctional landscape. Unlike conventional strategies that treat stormwater as a secondary component of site design, LID incorporates the natural slope, soils and hydrology into the site design during the conceptual design phase. In 2015, the Governors South Atlantic Alliance released the Coastal Water Quality Best Management Practices Compendium, a resource for professionals working on land based activities that contribute to nonpoint source pollution, particularly in the southeastern U.S. coastal region. In North Carolina, the DEQ has a Stormwater Best Management Practices Manual. See Appendix G for LID design and retrofit techniques.

7.2 LID PRACTICES

The goal of simple stormwater reduction measures is to use the soil, plants and stormwater collection techniques to capture the rain before it has a chance to become polluted runoff. Some techniques, such as rain gardens, absorb the runoff, while others, such as rain barrels, catch the runoff for later use. It is important to note that many of the techniques discussed below complement one another and may be implemented concurrently, such as the creation of a rain garden and the use of native vegetation.

The following sub-sections are a selection of popular methods and features (Table 7-1).

Table 7-1. Stormwater reduction techniques (in alphabetical order).

Practice	Description
Bioswale	Open, linear channels with dense vegetation, used in place of curb and gutter systems
Box Planters	Often used in highly developed areas with minimal space, box planters are intended to store excess stormwater from roadways, sidewalks or rooftops
Cisterns	Form of rainwater harvesting utilizing cisterns that collect rooftop runoff through downspouts; cisterns are located either above or below ground; ideal residential, commercial and industrial rooftops
Constructed Wetland	Utilizing hydric soils and wetland plants that is inundated for a majority of the year; used to retain stormwater and create habitat
Disconnection	Disconnecting conveyances, decentralize the movement of stormwater; slow the conveyance of stormwater
Downspout Retrofit	The use of downspout extenders to redirect stormwater from flowing on impervious surfaces (like driveways) to permeable areas, such as lawns and rain gardens.
Dry Well	A gravel medium backfilled well that is connected below ground to a down spout or the down spout is redirected to the dry well to capture rooftop runoff
Green Roofs	Using vegetation coverage on rooftops to retain rainfall
Impervious Area Management	Manage impervious areas by reducing the square footage by focusing of parking lots, street or sidewalk. Disconnect impervious areas by transporting stormwater to LID or BMP structures instead of using

	curb and gutter systems that directly transport stormwater to the nearest receiving waters.
Infiltration Basin	Flat, permeable basin used to retain stormwater for a short period of time to allow infiltration into the soil allowing for the settling and removal of pollutants
Low Berms	Raised berm used to directly impede the flow of stormwater that is flowing to areas of low elevation; stormwater will collect behind the berm, retaining it on land for a longer period of time allowing for the opportunity for infiltration to occur
Native Vegetation	Native vegetation is more adept as surviving and creating habitat for birds and small animals. Vegetative coverage has been shown to generate much less runoff than open, grassy lawns
Natural Drainage Systems	Conveyance systems that utilize natural features such as vegetation, wetland zones and lower elevation to convey stormwater over permeable surface instead of pipe systems
Permeable Pavement	Porous pavement or pavers often used with grass, gravel or porous medium; used as an alternative to roadways, sidewalks or parking lots
Preservation	Limiting the removal of natural vegetation and tree coverage and minimizing the loss of hydrologic function by minimizing land disturbance
Rain Barrels	Form of rainwater harvesting utilizing barrels that collect rooftop runoff through downspouts; ideal for single-family homes
Rain Garden	Type of bioretention area, indicative of a shallow ponding area with select vegetation and permeable soils
Sand Filter Basin	Like an infiltration basin, the basin is used to retain stormwater for a short period of time but utilizes sand medium for stormwater to infiltrate through this is an option used when underlying soils have poor infiltration qualities
Shade Trees	Utilized to slow the transport of stormwater; aids in filtration and preventing erosion
Site Fingerprinting	A practice that uses the site design as a stormwater management tool by reducing land disturbance, preserving soil structure, and using use natural areas for runoff management
Vegetation Buffers	Dense vegetation can be used to filter stormwater and slow the transportation of stormwater downstream

7.2.1 Disconnect Impervious Surfaces

Rooftops, parking lots and other impervious surfaces often drain directly to pipe systems or ditches, thereby increasing runoff and preventing rainwater from soaking into the ground.

Disconnected impervious areas are those that divert or direct stormwater to naturally vegetated areas. This reduces pollution by slowing down runoff and increasing filtration, allowing runoff to filter through vegetation. Sloping parking lots, roofs and sidewalks into landscaped areas are examples of this technique. This includes creating LID designs that avoid the use of curb-and-gutter systems or in developed areas, removing sections of curb to allow runoff to be conveyed into natural areas like bioswales, rain gardens or constructed wetlands. As a retrofit, the process of removing sections of curb is sometimes referred to as "curb cuts" to allow for runoff flow into vegetation. During small storms, disconnected impervious areas can reduce runoff volume by 30 to 100 percent. In addition to reduced runoff, disconnected impervious surfaces can also reduce the need for irrigation, provide better aesthetics, and lower infrastructure costs.

7.2.2 Site Fingerprinting

Site Fingerprinting is a practice that uses the site design as a stormwater management tool by reducing land disturbance, preserving soil structure, and using use natural areas for runoff management. Rather than grading land to fit a desired development type, the type of development is dictated by the existing conditions of the site, resulting in developed sites which use the land to maintain and protect the natural balance of the surrounding ecosystem. Site

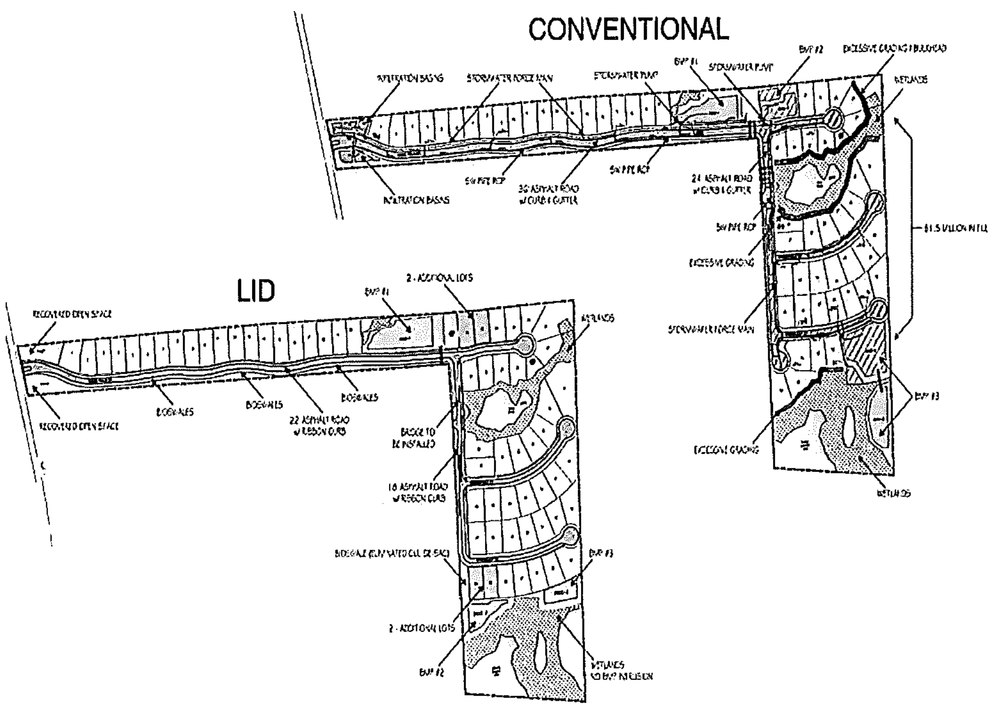

Figure 7-2. Schematics of the Ridgefield Redesign in New Hanover County using various techniques, including site fingerprinting

Fingerprinting can be done during the planning process for no additional cost and can often lead to lower infrastructure costs. For example, the Ridgefield Redesign of residential housing in New Hanover County, North Carolina, utilized site fingerprinting (Figure 7-2). From diverting stormwater to natural areas to incorporating LID techniques, the project was able to gain four additional lots, save $1 million in fill and grading, eliminate five infiltration basins and five monitoring wells, which resulted in savings and reduced construction time. See Appendix I for more design schematics. **Error! Reference source not found.Error! Reference source not found.**

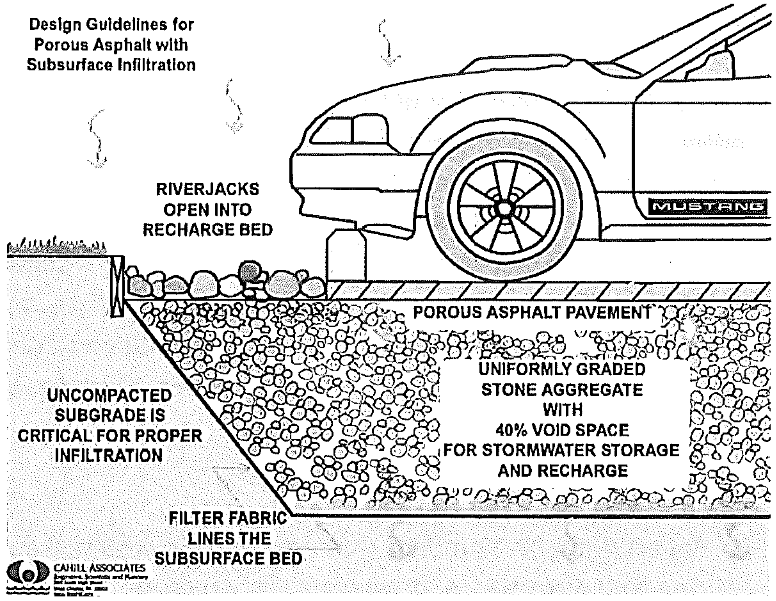

Figure 7-3. Diagram of the use of porous asphalt pavement in a parking lot.

7.2.3 Permeable Pavement

Permeable pavement is any paving material that allows rainwater to soak through the pavement and infiltrate the soil (Figure 7-3). Permeable paving comes in various forms – pervious concrete, pervious asphalt, and concrete pavers are some of the most popular materials. The permeable paving system utilizes a washed stone base that aids in increasing water runoff storage volume as well as structural support. Permeable pavements can be used in conjunction with underground detention or rainwater harvesting systems to gain additional stormwater reduction benefits. Benefits of permeable pavement increased infiltration which reduced runoff without loss of parking, and the option of artistic design with pavers. Permeable pavement is a great option for a retrofit project. See Appendix I for more design schematics.

7.2.4 Reroute Downspouts

Downspouts directed to driveways, sidewalks or parking lots increase the volume of polluted runoff by an average of 50 percent (Figure 7-4). Instead of contributing to stormwater pollution, rain water can be put to good use by rerouting downspouts for use in lawn and garden maintenance. Rerouting downspouts is a simple retrofit that disconnects impervious surfaces. Direct downspouts to areas that water can infiltrate the ground at least five feet from a structure's foundation. This technique reduced stormwater volume in Portland Oregon by 1.3 *billion gallons per year* when the city disconnected over 56,000 downspouts from 1993-2011 through their Downspout Disconnection Program.

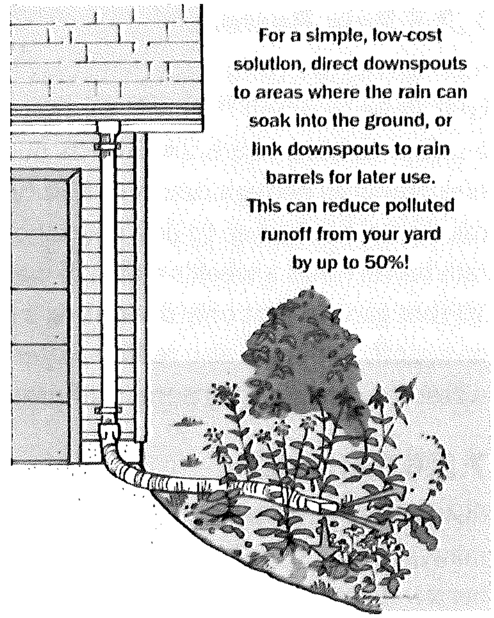

Figure 7-4. An example of rerouting a downspout that dumps onto an impermeable surface so that it dispels water onto vegetation.

7.2.5 Rain Barrels

Rain barrels are containers that collect and store rainwater from roofs that would otherwise contribute to runoff (Figure 7-5). They typically include a drum, a vinyl hose, PVC couplings and a screen to keep debris and insects out. A quarter inch of rain produces enough runoff to fill a typical, 55 gallons, rain barrel hooked up to one downspout. One and one rain barrel holds a week's worth of water for a 10-foot by 10-foot garden. Not only does using a rain barrel cut down on runoff, but it can also reduce water bills and provide water for plants during periods of drought.

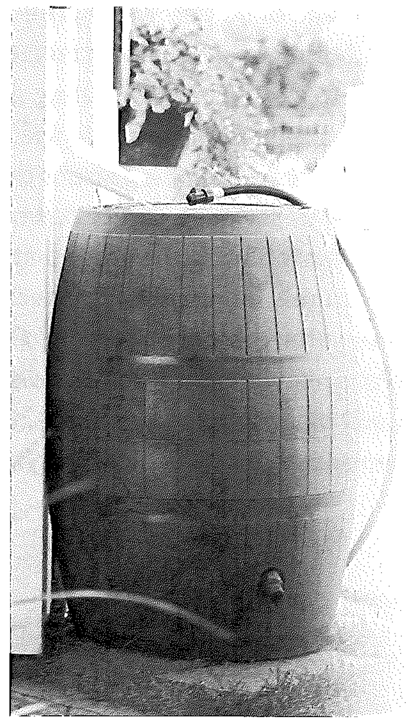

Figure 7-5. An example of a rain barrel receiving water from a downspout.

7.2.6 Cisterns

Cisterns are large water harvesting systems that collect rainwater and store it for later use. In contrast with a rain barrel, cisterns are sized to capture large volumes of water and can be installed above or below ground. The captured water can be reused for larger scale irrigation, industrial processes and/or commercial reuse. There are many benefits to cisterns, including lower water bills, reduced runoff and access to water during drought conditions. For high water consumption users, cisterns can be a financially profitable investment, paying for themselves by reducing or even eliminating water bills for non-potable uses. Be sure to check local building codes before construction/installation.

Cisterns can be used as a retrofit, but if rainwater is to be used inside a building for non-potable uses, dual plumbing systems are needed.

Properties with trees are valuated 5 to 15 percent higher than comparable properties without trees.

7.2.7 Native Landscaping

Native landscaping includes the use of plants that occur naturally in the project area which have adapted to the geography, hydrology, and climate of the region. Native plants are well suited to local soils and will need minimal care once established.

Figure 7-3. A house with a rain garden utilizing native landscaping. Notice the curb cut that allows street runoff to reach the rain garden.

7.2.8 Rain Gardens

A rain garden is a shallow vegetated area where rainwater collects during storms; they are often referred to as bioretention areas. Rain gardens are typically six to 12 inches lower than the surrounding landscape and act as a ponding area that collects runoff Figure 7-7). Ideally, native plants are used in combination with permeable soil mixture of sand, fines and organic matter. The plants and soil soak up the rain water before it becomes polluted runoff. Rain gardens can reduce stormwater runoff by 90 percent. For maximum benefit, observe water flow patterns during rain events to determine potential areas for rain gardens, use native plants for low maintenance and make sure that water from rooftops and driveways is directed to the garden. Rain gardens can also increase the visual appeal of an area.

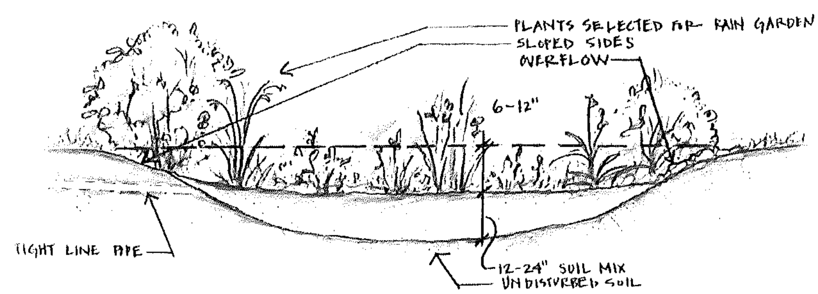

Figure 7-7. Diagram of a rain garden

7.2.9 Constructed Wetlands

Constructed wetlands are artificial wetlands that are created to keep stormwater runoff on land longer and promotes infiltration. Constructed wetlands can range in size from multi-acre community projects to small, sand box sized homeowner projects called backyard wetlands. Backyard wetlands are depressed wet areas that are planted with native wetland plants. They are designed to capture and treat stormwater similar to a rain garden but in locations with high water tables and hydric soils. Constructed wetlands would be ideal in areas that usually remain wet for several days following a rain event. In addition to runoff capture and filtration, backyard wetlands also enhance the landscape and can provide bird and butterfly habitat.

7.2.10 Planter Boxes

Planter boxes are filled with well-draining medium to control and treat runoff from rooftops, small parking lots or roadways. Runoff flows through a sandy soil mix, which traps solids and pollutants. As their name suggests, planter boxes also use vegetation to help absorb the water trapped by the soil. The plants also create a mini ecosystem within the soil, fostering healthy microbes that aid in breaking down oil and grease. There is also the added aesthetic benefit of greenery. Planter boxes are often used in highly developed areas with minimal space.

7.3 Evaluate Options and Management Strategies

Multiple stormwater reduction techniques will likely be implemented over the watershed management plan's life cycle. Different techniques are more feasible for certain situations. The techniques employed will be affected by many variables, such as the timeline of the management plan, cost effectiveness of various techniques, the magnitude of the watershed impairment, soils, proximity to impaired waters, land cover and types of development present. It is also important to prioritize implementation efforts for optimal effectiveness. Since all of these factors will play into which techniques are most likely to be effective, the planning process should consider them all. No matter which techniques are employed, it is important to make sure that the overall flow reduction goals determined in Chapter 6 are met. Chapter 8 provides *Runoff Reduction Scenario Tool* that will assist in determining which techniques or combination of techniques will best reach reduction goal.

The two main variables to consider when prioritizing LID BMP strategies are soil type and proximity to impaired waters. If the soil type at a location is not conducive to water infiltration there may be less effect on runoff volume. Group A and B soils are the best at infiltrating water. Group D soils have the poorest infiltration capabilities and should be considered. Although a recent study from NCSU found that even in poor draining clay soils, simple disconnection of impervious surfaces reduced runoff volumes by up to 90%.

7.3.1 Magnitude of Impairment

Stormwater reduction techniques have different levels of effectiveness in stormwater runoff reduction. The table below shows some common techniques and their effectiveness in different scenarios (Table 7-3). See Appendix G for further details on effectiveness of various techniques.

Table 7-3. Various techniques and their effect on stormwater flow reduction and their ability to be used with a high water table as well as with poorly drained soils.

LID Technique	Effect on Stormwater Flow	Effective with High Water Table	Effective with Poorly Drained Soils
Constructed Wetland	High	Yes	Yes
Disconnect Impervious Surfaces	Medium	Yes	Yes
Permeable Pavement	Low	No	Yes
Plant Trees	Low	No	No
Rain Garden	High	No	No
Rainwater Harvesting	Medium	Yes	Yes
Reroute Downspout	Medium	Yes	Yes
Riparian Buffer	Medium	No	No
Rooftop Disconnect	Medium	Yes	Yes

7.3.2 Cost Effectiveness

The cost of stormwater reduction techniques varies between techniques. Some, such as permeable paving can potentially save money in the long run but may have higher upfront cost. Techniques such as rerouting downspouts are relatively inexpensive (on a per unit basis). LID techniques often costs less overall when factors of life cycle cost, such as planning, design, installation, operation and maintenance are considered.

Table 7-2. Approximate cost per unit of various LID BMP techniques.

LID BMP Technique	Cost per unit
Rain garden	\$3-\$12 per ft^2

Backyard wetland	\$170-\$550 depending on surface area
Rainwater harvesting	\$200/rain barrel \$1,000/1400 gal cistern \$10,000/10,000 gal cistern
Reroute downspout	\$9/downspout
Permeable pavement	\$8-\$12/ft^2 of pavement