4 SITE DESIGN BMP OPTIONS

4.1 Introduction

This chapter provides general site design BMP options that can be implemented as part of all project types, although **only Tier 3 projects** are required to consider the BMPs in this chapter. Project applicants and designers should review this chapter before choosing the specific BMP(s) for their site, identified in Chapters and 5 and 6. This chapter provides an understanding of the overall "big picture" site design requirements that support and ensure the success of the specific BMP designs in Chapters 5 and 6.

The basic BMPs in Chapter 5 incorporate specific site design and storm water runoff BMPs that are directly applicable to smaller residential projects. Some of the basic BMPs in Chapter 5 can also be used in Tier 3 projects. Chapter 6 provides design guidance for storm water runoff BMPs applicable to Tier 3 projects. It is the City's goal for LID practices, such as these site design BMPs, to be implemented into projects of every tier.

4.1.1 Goals and Objectives

Site design BMPs are designed to minimize the hydrologic impacts created by site development and are based on the principles and practices of LID, see Section 1.2.1. LID practices attempt to preserve a site's essential natural hydrologic functions and mimic pre-development hydrology by using techniques that treat, store, infiltrate, and evaporate runoff close to its source. Site design BMPs achieve LID goals by:

- Conserving and restoring natural areas as much as possible;
- Maintaining, restoring, and using natural flowpaths for runoff; thereby increasing the amount of time it takes runoff to reach a street, main channel, or drain;
- Reducing the impacts of development by minimizing soil disturbance and compaction;
- Reducing the amount of impervious area and directing runoff from impervious areas to pervious areas to promote local infiltration and evapotranspiration;
- Integrating landscape and storm water management objectives; and
- Siting storm water runoff BMPs on infiltrative soils.

Site design BMPs, when used in conjunction with small-scale basic and storm water runoff BMPs distributed throughout a site, allow for significant minimization of hydrologic impacts (see Chapters 5 and 6 for more information on basic and storm water runoff BMP options). By addressing issues locally and tailoring the site design, basic BMPs, and storm water runoff BMPs to be site specific, the result is a functional landscape that maintains the critical natural hydrologic and ecological functions of the developed site and the local watershed to the maximum extent practicable. A variety of site design, basic BMPs, and storm water runoff BMPs are available, providing options for designers to achieve site specific customization based on (1) site specific constraints (e.g., soils, topography), (2) pollutants of concern based on land use type, (3) low impact development principles and practices, (4) meeting the post-construction storm water requirements based on the project tier (see Section 1.3), (5) cost considerations, and (6) long-term maintenance considerations. Site design should also consider the receiving water beneficial uses and water quality objectives found in the Water Quality Control Plan for the Central Coast Basin (Basin Plan) and other local plans to ensure that all watershed planning objectives are met. In addition, the Central Coast Water Board has outlined requirements, including the use of LID practices for SWMPs, to achieve the following conditions:

- Maximizing the infiltration of clean storm water,
- Minimizing runoff volume and rate (i.e., velocity),
- Protecting riparian areas, wetlands, and their buffer zones,
- Minimizing pollutant loadings, and
- Providing long-term watershed protection.

4.2 Conserve and Restore Natural Areas

The first step in integrating existing hydrology into the design of a site is to identify sensitive areas that affect the essential hydrology of the site. These sensitive areas include streams and their buffers, floodplains, wetlands, steep slopes, high permeability soils, and woodland conservation zones. In addition, areas that may be restored or revegetated either during construction or later, should also be identified. Once the natural areas of importance are identified, they should be cordoned off with necessary buffer area to protect them during the development activities, which leaves the remaining area for development, thereby defining the “development envelope” in which development may occur. By conserving vital natural areas at the beginning of the process, it is easier to minimize the hydrologic impacts of development by developing the areas that will have the least impact. This strategy not only minimizes the amount of runoff that will need to be captured and/or treated, thereby reducing costs, but also provides for aesthetically pleasing post-development landscaping. The City of Santa Barbara is noted for extensive incorporation of trees and landscaping within the urban landscape and their General Plan policies and ordinances support site design criteria to conserve natural areas (City of Santa Barbara, 2007). Buffer zones (a minimum of 25 feet) should be used to preserve and protect sensitive areas such as riparian areas and stream corridors. Additional trees and vegetation should be planted where possible.

4.3 Maintain, Restore and Utilize Natural Flow Paths

Conventional development decreases the time of concentration, T_c, which is the time it takes for runoff to travel from the farthest point in a drainage area (also known as tributary area) to the drainage area outlet. The decrease in the T_c is caused by increasing impervious surfaces and installing drainage pipes, which transport water off-site more efficiently than natural flow paths. The smaller T_c present at conventionally-developed sites leads to greater runoff velocities and higher peak flow rates, which result in increased transport rates of sediment and other pollutants, increased erosion, and decreased groundwater recharge. Unlike conventional development that incorporates storm drains into designing a site, LID promotes the incorporation of natural flow paths.

By designing a site layout to preserve the natural hydrology and drainage ways on the site, it reduces the need for grading and disturbance of vegetation and soils (GSMM, 2001). By siting buildings and impervious surfaces away from steep slopes, drainageways, and floodplains also limits the amount of grading, clearing, and disturbance as well as reduces the hydrologic impact.

The utilization of pervious vegetated flow paths instead of concrete-lined conveyances such as storm water conveyance systems (i.e., storm drain inlets and pipe) reduces the cost of constructing these conveyances and reduces the need for land disturbance and grading. In addition, due to the benefits of natural systems, T_c increases, peak discharges decrease, on-site storage increases, some of the runoff infiltrates, and the concentration of pollutants in runoff decreases. Natural flowpaths may be enhanced by installing a vegetated swale filter in place of a curb and gutter system on a street right-of-way. When used in street rights-of-way, swales not only provide a flow path but also provide room for storage, reduced velocities, increased infiltration, and treatment of storm water. In the past, roadside ditches have suffered from erosion, standing water, and road disintegration; however, designs have been improved and those problems minimized when properly designed swales are implemented under the appropriate site conditions.

Existing natural drainage divides and depressions should be maintained to direct and store water on-site to the maximum extent practicable. By maximizing sheet flow, or shallow evenly dispersed flow over vegetated areas, the water is filtered, allowed to infiltrate, and its velocity decreased. Sheet flow may occur naturally or by using a flow spreader such as a level spreader or disperser. In addition, check dams could be incorporated into open flow paths to slow the runoff velocity. Decreasing slopes (to a certain extent and within site constraints) slows velocities, which decreases the potential of erosion. Roughened surfaces (e.g., creating tracks perpendicular to the direction of flow or by planting denser or taller vegetation) increase flow path lengths and therefore, T_c. Avoiding or minimizing the use of hard conveyances such as curbs, gutters, and pipes decreases the efficiency at which runoff is transported, which increases the T_c. In heavily developed areas, it is still possible to incorporate the use of natural flow paths to decrease runoff velocities and peak flow rates during retrofit/redevelopment activities. Buffer areas may be used to allow runoff to dissipate and reduce T_c. In addition, disconnecting impervious areas (as discussed in Section 4.7) may be used to increase the T_c.

4.4 Site BMPs on Infiltrative Soils

LID is guided by the preservation of a site's existing hydrology, including the site's infiltration capacity. Conventional development decreases a site's ability to infiltrate runoff by increasing the amount of impervious area, connecting impervious surfaces together, and directing runoff from impervious surfaces to the storm water conveyance system for efficient conveyance of storm water off-site. The effects of development on the infiltration of runoff can be mitigated by reducing the amount of impervious area, disconnecting impervious areas from each other and the storm water conveyance system, and, where feasible, siting infiltration storm water BMPs on infiltrative soils (or conversely siting the impervious area on the least infiltrative site soil).

Infiltrative soils may be preserved by minimizing and carefully planning clearing and grading activities to minimize compaction of infiltrative soils (see Section 4.5), reserving areas with A and B Hydrologic Soil Group soils for either open space or infiltration BMPs (see Section 4.2 and 4.4), and by directly reducing the amount of impervious area (see Section 4.6). Once the impervious area is minimized, the effects of the remaining imperviousness may be reduced by installing infiltration BMPs to maximize infiltration of runoff on-site.

4.5 Minimize Soil Disturbance and Compaction

Once the development envelope is clearly delineated, as discussed in Section 4.2, soil should be disturbed and compacted only within the development envelope. Site fingerprinting, a planning and development practice that focuses on minimizing soil disturbance and compaction, includes techniques such as:

- Delineating a development envelope to reduce compaction of highly infiltrative soils;
- Delineating and flagging the development envelope to minimize soil compaction outside of these areas and restricting storage of construction equipment outside of the development envelope;
- Minimizing the size of the construction easements and material storage areas, and siting stockpiles within the development envelope;

Figure 4-1: Example of soil disturbance minimization

- Utilizing existing open space and maintaining existing topography and existing drainage divides to encourage dispersed flow;
- Limiting clearing and grading activities to the delineated development envelope;
- Avoiding the removal of existing trees and valuable vegetation, where possible; and
- Disconnecting impervious surfaces to increase infiltration and reduce runoff volumes.

Locating the development in areas that are not as sensitive to disturbance (e.g., highly erodible soils, steep slopes, etc.) or not as vital to the hydrologic function (e.g., natural drainageways, stream corridors, wetlands, highly infiltrative soils, dense vegetation, etc.), aids in the preservation of the essential hydrology and efficiently utilizes the existing site to prevent and mitigate impacts due to storm water runoff. Siting development away from steep slopes and on less steep terrain that is more amenable to building not only reduces the amount of disturbance but also reduces construction costs due to minimizing cut and fill procedures. Limiting the amount of clearing and grading of native vegetation conserves the soil permeability (i.e., infiltration rate), natural slopes, and drainages as well as existing vegetation.

4.6 Minimize Impervious Surfaces

Conventional development decreases a site's ability to infiltrate runoff by increasing the amount of impervious area. By decreasing the amount of imperviousness, the associated runoff and pollutants generated are automatically reduced. To maintain the essential hydrologic and ecological functions of a site, many different techniques for reducing the overall site imperviousness may be employed, including using alternative layouts for neighborhood design, reducing the building footprints, reducing the impervious area for parking, reducing setbacks and frontages, and increasing permeability of existing soils by amending soils and re-vegetating bare areas. The greatest source of imperviousness in urbanized areas is the transportation network including roadways, sidewalks, and parking, including driveways.

Figure 4-2: Example of minimizing impervious surfaces by implementing bioretention in a parking lot

Photo Credit: Low Impact Development Center

Using alternative layouts for neighborhood design may not only reduce the overall amount of impervious area but also may decrease costs associated with developing a site (i.e., cut and fill, paving areas, etc.). Laying out roadways with loops and lollipops rather than in a gridiron can decrease the total site imperviousness by up to 26 percent. Narrowing and shortening road sections will reduce imperviousness and will maintain the width of the right-of-way while decreasing the paved portion by replacing the curbs and gutters with a roadside swale. By eliminating curbs and gutters, the capital cost of construction for the street is decreased while increasing aesthetics, water quality, and reducing runoff volume and rate. By limiting sidewalks and on-street parking areas to one side of the road, imperviousness is reduced.

Another method for reducing imperviousness is cluster development which is a technique commonly used for preserving open space and lot yield. This technique requires a thorough walkthrough of the site and examination of hydrologic features and natural resources for delineation of the open space. Once the open space is delineated, the remaining area is divided into lots that are clustered together with the natural areas preserved as common or non-common open space. Cluster development helps to maintain connectivity between forest patches, preserve interior forest habitat, and avoid impacts to sensitive areas by creating buffer zones between the developed and conserved natural areas (Low Impact Development Center, 2006). In addition, the conserved natural areas can integrate trail systems for use by local residences.

Figure 4-3: Example of minimizing impervious surfaces in a parking lot

Photo Credit: Low Impact Development Center

Building footprints are a major contributor to imperviousness, while lot size may provide some indication of the site's imperviousness, this is also dictated by setbacks and easements required. The impervious area due to buildings may be mitigated by building up, or vertically, rather than out, or horizontally (i.e., a two-story house with 1500 sq. ft. may have about half the impervious area of a single-story ranch style 1500 sq. ft house.)

There are numerous strategies to reduce the amount of imperviousness used for parking. Residential driveways may employ paved strips for tires (See Section 5.11 Ribbon Driveways) rather than a paved pad, a shared driveway arrangement, limited width and/or length, minimized setbacks and materials such as permeable pavement to reduce the amount of imperviousness. Parking lots are slightly more complex due to their larger areas and higher traffic yield. In parking lots, the number and size of the parking spaces may be reduced, shared parking arrangements implemented, structured parking decks built, and alternative permeable pavement installed to reduce the imperviousness. In addition, by designing a parking lot for its projected average peak demand rather than its overall peak demand will use the space more efficiently and decrease its overall footprint and therefore imperviousness. To supplement the reduced size, permeable pavement may be installed adjacent to the lot to accommodate overflow during brief periods of extremely high demand. Sharing parking areas, if feasible, allow for more efficient use of parking space. For example, a church's peak parking demand is on the evenings and on the weekends, whereas a business's peak parking demand may be during weekdays; if they shared a parking lot it would be available for both when needed. Structured parking lots are another alternative that creates more parking spaces while decreasing the amount of imperviousness. Incorporation of landscaped parking lot islands, or regions within or along the edge of a parking lots not only function as aesthetically pleasing landscaping but also function to reduce the overall impervious cover of the lot, and allow for integration of storm water runoff BMPs that increase runoff treatment and assist in maintaining natural hydrologic function by increasing the filtration and detention of runoff before it infiltrates, evapotranspires (i.e., evaporates or is taken up by plants), and/or is directed into a stream or storm water facility. Bioretention areas, tree box filters, vegetated filter strips, and swales can all be used in parking lot islands.

4.7 Disconnect Impervious Surfaces and Utilize Pervious Areas

Connected impervious areas efficiently transport runoff without allowing infiltration. Often in urban areas, runoff from connected impervious surfaces is immediately directed into a storm water conveyance system where it is further connected and efficiently transported to an outfall (storm water conveyance system outlet). For example, roofs and sidewalks commonly drain onto roads, and the runoff is conveyed by the roadway curb and gutter to the nearest storm inlet. Efficient transport due to connected impervious surfaces significantly decreases T_c while, at the same time, increasing peak runoff discharge rate and volume. Runoff from numerous impervious drainage areas may converge, combining the volumes, peak runoff rates, and pollutant loads. By disconnecting impervious areas and directing runoff to pervious areas, runoff velocities and volumes decrease and treatment and infiltration occur, thereby increasing T_c, and potentially reducing pollutant loads due to filtering and infiltration. One of the simplest methods to disconnect impervious surfaces is to disconnect downspouts from roofs and redirect the roof runoff to a pervious area. Disconnection of roof downspouts, roadways, and other impervious areas from storm water conveyance systems allows runoff to be collected and managed on-site or dispersed onto the landscape, thereby reducing the runoff volume and rate and allowing for treatment of pollutants.

Figure 4-4: Disconnected Downspout Directed to a Pervious Area

Photo Credit: Portland Bureau of Environmental Services

4.8 Site Design Examples

This section presents five site design examples that illustrate how site design, basic, and storm water runoff BMPs, may be integrated together for different land use types to achieve the principles of LID. The examples are intended to illustrate how BMP strategies may be incorporated into different types of sites and do not imply any specific requirements as to how a site must be designed. In practice, each site will require a unique combination of site design, basic, and storm water runoff BMPs. Basic BMPs are the only BMP type required for Tier 2 residential projects although the use of site design BMPs as well as storm water runoff BMPs are encouraged, where applicable and practicable. All BMP types are voluntary for Tier 1 projects. Combining several different BMPs distributed across the site and, where feasible, connecting BMPs so the outflow from one BMP is directed to another in a "treatment train", allows for multiple opportunities to increase infiltration, water storage, and filtration. The examples shown in this section are:

- Single-family residential
- Multi-family residential
- Commercial development
- Office building
- Residential Street
- Parking lots are included in several of these examples.

4.8.1 Single-Family Residential

Single-family residential properties offer many opportunities for the implementation of LID principles and practices. Whether the project is a single single-family residence or a neighborhood of single-family residences, site design BMP options used in combination with basic BMP options and storm water runoff BMP options can allow for integration of LID principles and practices that are applicable for various site conditions and storm water, water conservation, and landscaping objectives, cost, and aesthetic goals.

When designing a sub-division, more care must be taken to consider all of the constraints of implementing BMP options. Long-term maintenance and public health and safety are major concerns. Some simple practices that may be incorporated into each lot are all of the site design BMP options discussed in this chapter, as well as disconnected downspouts, soil amendments, and larger scale storm water runoff BMPs. Smaller lot scale BMPs may be implemented but require more homeowner education including how on-lot BMPs function, which BMPs are appropriate, what kinds of maintenance are required, and the frequency that maintenance inspections should be conducted. Figure 4-5 illustrates a single-family residential example with the following BMP options:

Site design BMP options (Chapter 4) illustrated:

- Conserve and restore natural areas
- Maintain, restore and utilize natural flowpaths
- Site BMPs on infiltrative soils
- Minimize impervious surfaces
- Disconnect impervious surfaces and utilize pervious areas

Basic BMP options (Chapter 5) illustrated:

- Disconnect Downspouts
- Flow Spreading
- Rainwater Garden
- Rain Barrels
- Soil Amendments

Storm water runoff BMP options (Chapter 6) illustrated:

- Bioretention
- Vegetated Swale Filter
- Permeable Pavement

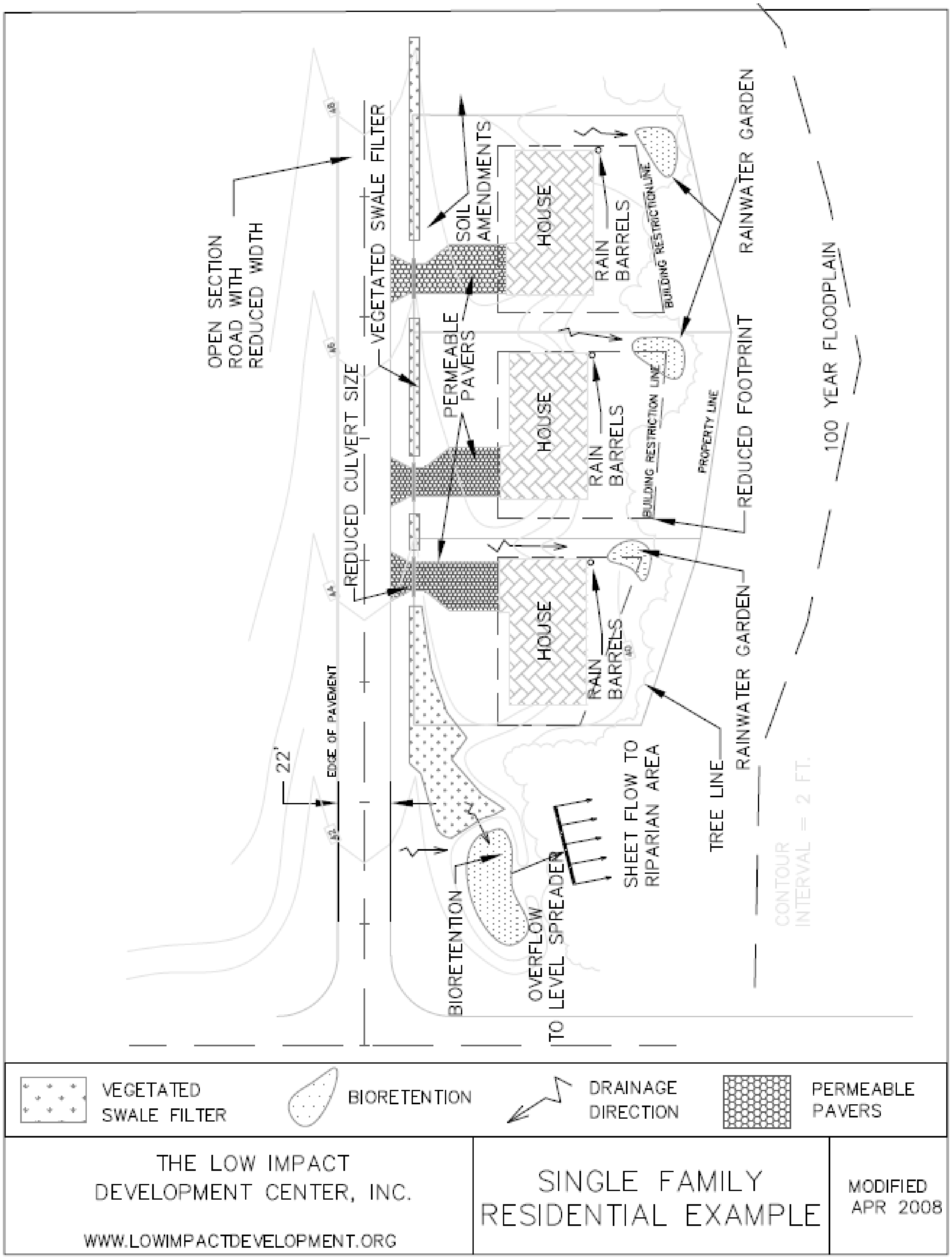

Figure 4-5: Single-Family Site Design Example

4.8.2 Multi-Family Residential

Multi-family residential sites present challenges and opportunities similar and dissimilar to single-family residential sites. Multi-family residential lots tend to have a higher impervious to pervious ratio and are usually larger in scale; thereby limiting the value of implementing some smaller scale basic BMP options, such as rain barrels and rainwater gardens. However, due to the larger impervious surfaces of buildings and parking lots, there are additional storm water runoff BMPs that may be considered (i.e., cisterns and permeable pavement). By utilizing cisterns (large aboveground rain barrels or underground storage tanks), downspouts are disconnected and the large impervious area becomes a valuable, multi-benefit water conservation tool for storing runoff water for later use in irrigating landscaped areas. The additional space available makes multi-family residential sites more amenable to vegetated swale filters that may border the site providing landscaping and storm water filtering, infiltration, and conveyance. Figure 4-6 illustrates a multi-family residential example with the following BMP options:

Site design BMP options (Chapter 4) illustrated:

- Conserve and restore natural areas
- Maintain, restore and utilize natural flow paths
- Minimize impervious surfaces
- Disconnect impervious surfaces and utilize pervious areas

Basic BMP options (Chapter 5) illustrated:

- Disconnect Downspouts
- Soil Amendments

Storm water runoff BMP options (Chapter 6) illustrated:

- Bioretention
- Vegetated Swale Filter
- Permeable Pavement
- Planter Box
- Green Roof

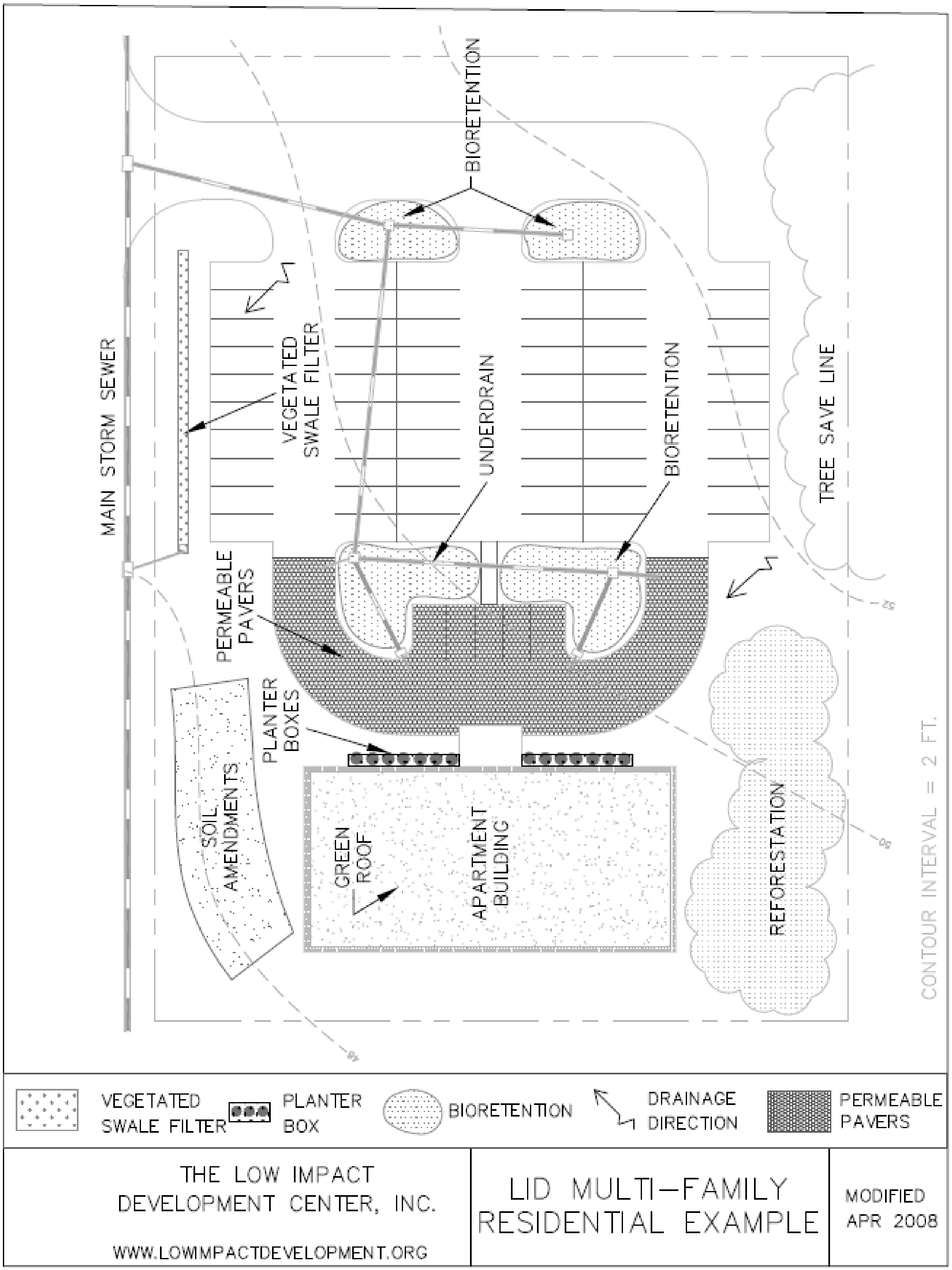

Figure 4-6: Multi-Family Residential Site Design Example

4.8.3 Commercial Development

Commercial developments offer numerous opportunities for implementing LID principles and practices, especially in parking areas and on rooftops. Commercial lots have large areas devoted to providing parking for employees and customers and, with a few modifications, become excellent locations for implementing site design, basic, and storm water runoff BMPs and also enhancing the aesthetics of the site. The largest reduction in impervious area created by installing parking lots may be accomplished by using a permeable pavement option, such as permeable asphalt, pervious concrete, or permeable pavers. Permeable designs and products must be chosen carefully, as some can warp and/or shift in high traffic areas or areas where vehicles frequently turn. In addition, impervious parking lots may be designed to drain into landscaped islands designed to house bioretention facilities that provide not only volume reduction, slowing of runoff, and water treatment but also shade for the parked cars as well as enhance the aesthetics of an otherwise sun exposed, impervious landscape lacking aesthetic appeal. Landscaped areas may also be incorporated around buildings and in courtyards, thereby reducing imperviousness as well as creating areas for employee use and/or screening around the property.

Commercial rooftops may be installed as green roofs (vegetated roofs) to absorb some of the precipitation and reduce runoff volumes. Rooftops may also be constructed with traditional gutters that direct water to downspouts; however, the downspouts may be connected to planter boxes or cisterns for direct or indirect irrigation of landscaping. Figure 4-7 illustrates a commercial development example with the following BMP options:

Site design BMP options (Chapter 4) illustrated:

- Conserve and restore natural areas
- Site BMPs on infiltrative soils
- Minimize impervious surfaces
- Disconnect impervious surfaces and utilize pervious areas

Basic BMP options (Chapter 5) illustrated:

- Disconnect Downspouts

Storm water runoff BMP options (Chapter 6) illustrated:

- Bioretention
- Vegetated Swale Filter
- Permeable Pavement
- Cistern
- Planter Box
- Green Roof
- Proprietary Devices

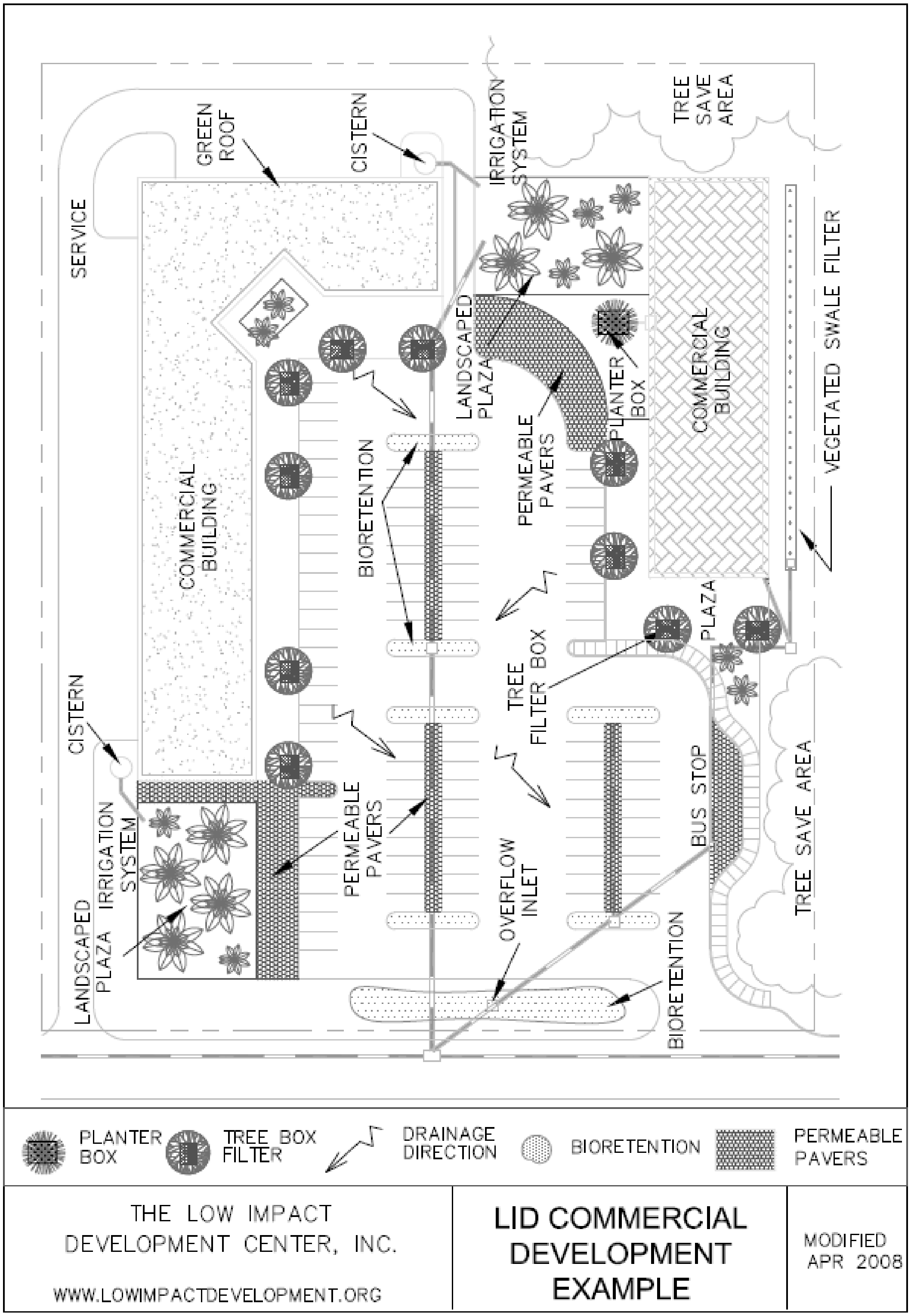

Figure 4-7: Commercial Site Design Example

4.8.4 Office Building

Office parks, like commercial developments, have numerous opportunities for implementing onsite storm water management techniques during new development and redevelopment projects. Areas such as courtyards that may have been paved/cemented when initially installed may be redeveloped and in the process natural areas restored. An area surrounding the development that may have been compacted and/or damaged during the construction may be restored. These surrounding areas offer a great opportunity in that they are not currently being used and may be an eyesore. By amending the soil, which may only involve tilling and planting native vegetation, increases the infiltration capacity of the site. In addition, like commercial developments, office parks have large areas comprised of rooftops and parking lots (see section 4.8.3) that may be used to integrate storm water management techniques. Figure 4-8 illustrates an office building example with the following BMP options:

Site design BMP options (Chapter 4) illustrated:

- Conserve and restore natural areas
- Maintain, restore and utilize natural flowpaths
- Site BMPs on infiltrative soils
- Minimize impervious surfaces
- Disconnect impervious surfaces and utilize pervious areas

Basic BMP options (Chapter 5) illustrated:

- Disconnect Downspouts
- Flow Spreading
- Rainwater Garden
- Rain Barrels
- Soil Amendments

Storm water runoff BMP options (Chapter 6) illustrated:

- Bioretention
- Vegetated Swale Filter
- Permeable Pavement

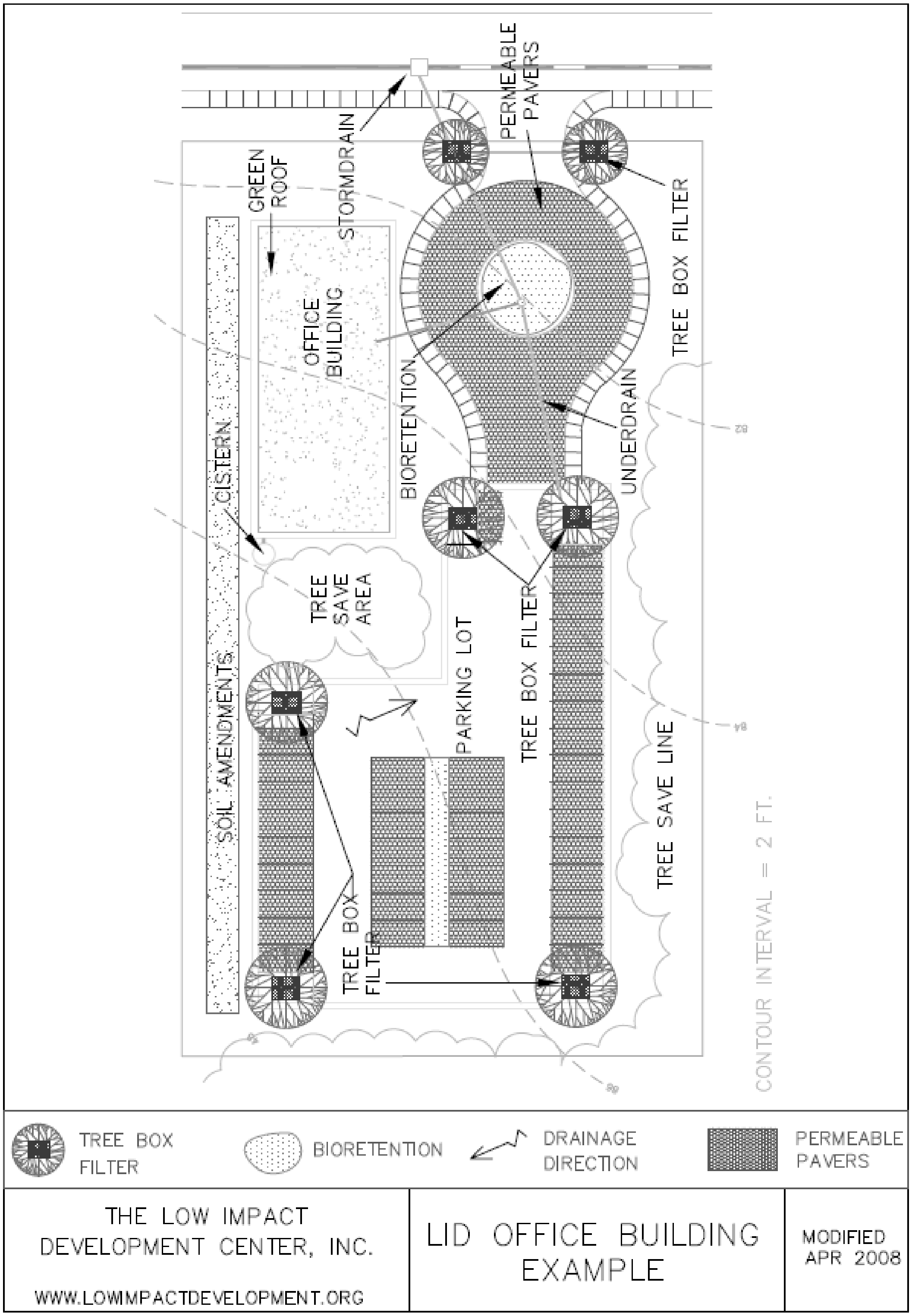

Figure 4-8: Office Building Site Design Example

4.8.5 Residential Street

Residential streets may incorporate storm water management techniques for treating residential runoff. For example, a roadside ditch may be easily converted into a swale that will treat runoff as it is conveyed to the storm water conveyance system or other storm water management facility. An alternative method is to use a portion of the street in a way that enhances the aesthetics of the neighborhood, reduces impervious area, acts as a traffic calming device and treats local runoff. An example (Figure 4-9) of how the street may be used is shown below. The figure shows how a "planter box" was created on the side of the street by the addition of a curb that has openings on it to let storm water in at one end and along the way, and out at the other. This flow-through type planter box acts as a pretreatment step before the storm water enters the storm water conveyance system. In addition, it decreases the velocity and time of concentration.

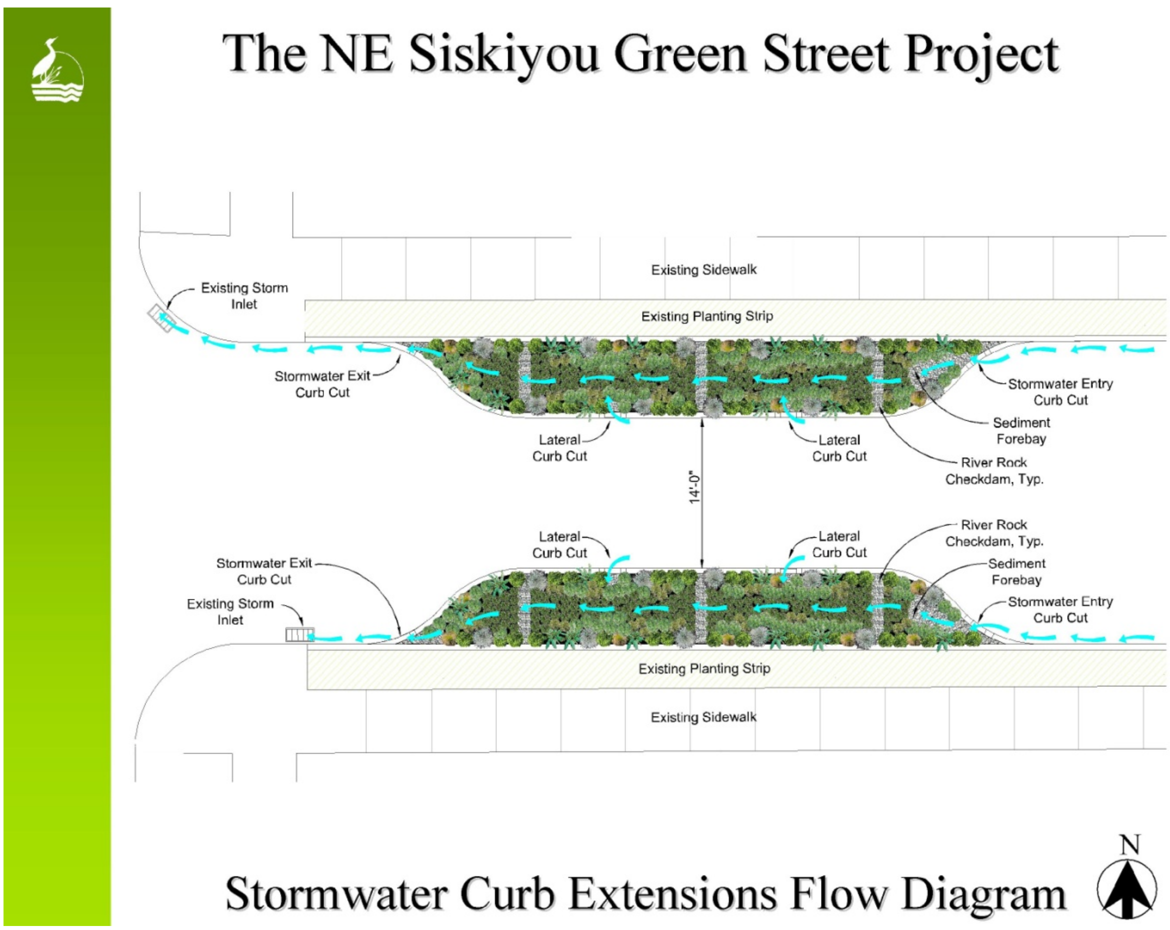

Figure 4-9: Residential Street Design Example