Chapter 6: Green Streets (Low Impact Development)

The content and images in this chapter were adapted from the Los Angeles County Model Design Manual for Living and San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook.

For much of the last century, drainage systems have been engineered to quickly collect runoff in underground pipes and carry it away using an "out of sight, out of mind" approach. This design philosophy treats rainfall runoff as a waste, and many people are unaware of the stormwater flowing in pipes underneath city streets when it rains.

A "green street" utilizing a Low Impact Development (LID) approach treats rainfall runoff as a valuable resource. It is based on balancing urban development while preserving natural hydrological functions. Mimicking the natural hydrologic function of healthy ecosystems in street landscapes can dramatically reduce pollution, decrease runoff volume, reduce runoff temperature, protect aquatic habitat, and create more interesting places to live.

Figure 1: The green street utilizes a vegetated swale to accept stormwater from the street. It also uses sidewalks made from pervious concrete. (Nevue Ngan Associates)

ISSUES WITH TRADITIONAL DESIGN: THE CASE FOR GREEN STREETS

The issues associated with traditional design are caused or exacerbated by the amount of impervious surface in a developed area. Streets and parking lots, which often account for 30-50% of a city's total land area, have traditionally been constructed with impervious material. This high percentage of impervious surface has contributed to increased runoff and pollutants from vehicles and other urban sources. The problem is exacerbated when increased stormwater runoff reaches a creek channel that is not capable of handling increased flows without significant erosion and degradation. Three of the most significant impacts attributed to traditional design are erosion and flooding and pollution.

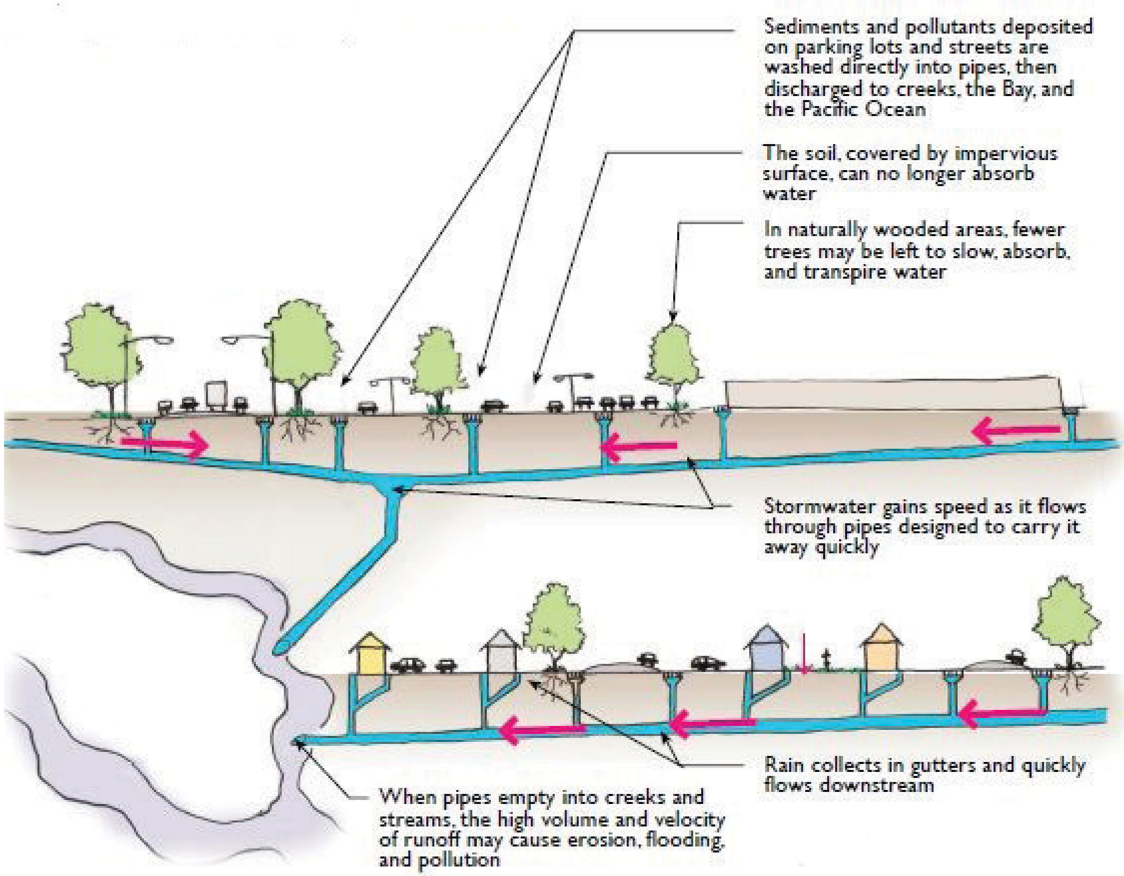

Figure 2: Traditional Design (Nevue Ngan Associates)

Erosion and Flooding

There is no mechanism to slow water as it travels through underground pipes. As a result, fast moving water can cause erosion and flooding at outlets. Creeks with tributary areas having greater than 10% impervious surfaces are likely to have degraded water quality and habitat.

Gutters are designed to move large volumes of water off the streets and into storm drains quickly. However, if filled with debris, stormwater inlets may become clogged and flood the street.

Figure 3: An example of the type of trash that can clog inlets and pollute water bodies (Nevue Ngan Associates)

Pollution

The storm drain system throughout the Central Coast was designed to prevent local flooding by channeling stormwater runoff ultimately into the Monterey Bay or the Pacific Ocean. This system provides no inherent water quality treatment. Pollutants build up on impervious surfaces and wash directly into pipes that lead out to these major bodies of water. Stormwater runoff accounts for a majority of the pollutants entering local creeks and the Monterey Bay. Potential pollutants include:

- Oil, grease, antifreeze, heavy metals from leaking and deteriorating cars and trucks, and brake pad and tire wear
- Pesticides, herbicides, and fertilizers from our residential and commercial landscapes
- Solvents and household chemicals (e.g., paint thinner, detergents, and paint)
- Animal waste, litter, decomposing vegetation, and sewage from leaks
- Construction debris, such as fresh concrete or mortar

Certain creeks, coastlines, and water bodies of the Central Coast have been identified under the Clean Water Act's section 303(d) as impaired by specific types of pollutants, such as sediment. Sediment impairment of creeks is often caused by "nonpoint" sources associated with past and current land use practices. Conventional development practices may degrade the environment at a substantial cost to the larger community.

GREEN STREETS A LOW IMPACT DEVELOPMENT APPROACH

Unlike the traditional approach to stormwater management, Green Streets are designed with a landscape and/or paving system that captures, slows, filters, and potentially infiltrates stormwater runoff. Green streets provide stormwater reduction and water quality benefits to runoff before discharging to local creeks. Green streets are most commonly thought of as introducing some type of low impact design stormwater treatment measure (e.g. vegetated swale, planter, rain garden, etc.) to actively capture and manage surface runoff at its source. It is important to consider your stormwater treatment measures early in the design process to ensure a successful, cost effective implementation.

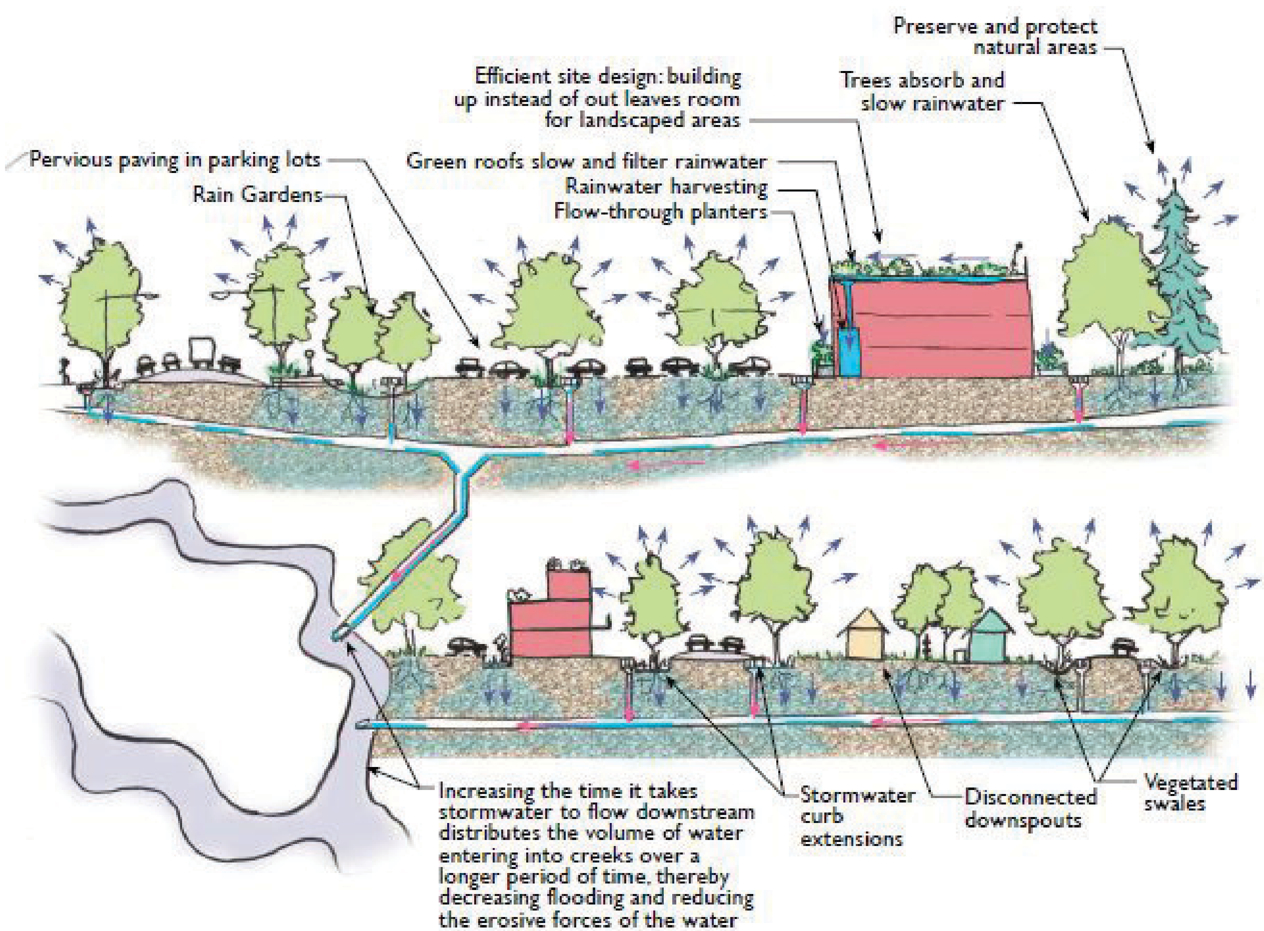

Figure 4: Low Impact Development Approach (Nevue Ngan Associates)

Green Streets Stormwater Management Goals

Low impact development (LID) offers a sustainable approach to stormwater management. It not only addresses the issues caused by traditional design but also provides opportunities to enhance the streetscape with landscaping while improving the urban ecosystem. Low impact development strives to achieve the following three goals to the greatest extent possible:

- **Water quality**
- **Flow reduction**
- **Volume reduction**

Figure 5: Landscape-based stormwater facilities, such as this stormwater curb extension, can capture urban debris before it gets into creeks and other waterways

(Kevin Robert Perry – City of Portland)

Water Quality

Stormwater facilities should filter and remove excess sediments and other pollutants from runoff. By allowing water to interact with plants and soil, water quality improvements are achieved through a variety of natural physical and chemical processes. Even if soils are not conducive to infiltration, or if there is a high water table, water quality is still enhanced through pollutant settling, absorption into the soil, and uptake by plants.

Figure 6: Stormwater facilities filter sediments and other pollutants in runoff; which results in improved water quality (Kevin Roberts Perry – City of Portland)

Flow Reduction
Stormwater facilities should slow the velocity of runoff by detaining stormwater in the landscape. Flow rate reduction can often be achieved by integrating design strategies (such as pervious paving, planter boxes, swales, and rain gardens) that provide stormwater detention. By detaining and delaying runoff, peak flow rates are attenuated and downstream creeks are protected from erosive flows. Conveying runoff through a system of naturalized surface features mimics the natural hydrological cycle and minimizes the need for underground drainage infrastructure.

Figure 7: Stormwater facilities slow the flow of stormwater runoff through the interaction fo the water with plants and soil (Nevue Ngan Associates)

Volume Reduction
Whenever possible, facilities should collect and absorb stormwater to reduce the overall volume of runoff. Retention facilities offer long-term stormwater collection and storage for reuse or groundwater recharge. Plants contribute to retention capacity by intercepting rainfall, taking up water from the soil, and assisting infiltration by maintaining soil porosity. Volume reduction does not require stormwater facilities to be extremely deep. In fact, it is usually best to employ a highly integrated and interconnected system of shallow stormwater facilities.

Figure 8: Stormwater facilities collect and absorb stormwater to reduce the overall volume of runoff (Kevin Robert Perry – City of Portland)

Low Impact Development Measures for Green Streets

There are many tools and best management practices (BMPs) for managing stormater sustainably. Most popular are devices and practices that encourage water percolation on-site to the maximum degree practicable (given soil conditions, pollutant levels, etc.). The LID measures mentioned in this chapter are highly customizable and can be integrated into a variety of different types of spaces in any of the street types. They can be implemented alone or in concert with one another to achieve cumulative benefits. Opportunity sites include medians, corner and midblock curb extensions, roadway and park edges, front building edges, and surrounding street trees. Selecting the appropriate BMP is very dependent on street type and site conditions. High traffic commercial streets have different parameters than smaller residential streets.

Vegetated Swales

Vegetated swales are long, narrow landscaped depressions, with a slight longitudinal slope. They are primarily used to convey stormwater runoff on the land's surface while also providing water quality treatment. As water flows through a vegetated swale, it is slowed by the interaction with plants and soil, allowing sediments and associated pollutants to settle out. Some water soaks into the soil and is taken up by plants, and some may infiltrate further if native soils are well drained. The remaining water that continues to flow downstream travels more slowly than it would through pipes in a traditional stormwater conveyance system. Vegetated swales are typically built very shallow and contain runoff that is only a few of inches deep.

Figure 9: Before - an overly wide sidewalk zone (Nevue Ngan Associates)

Figure 10: After - an attractive swale (Nevue Ngan Associates)

Infiltration and Flow-Through Planters
Planters are narrow, flat-bottomed, often rectangular, landscape areas used to treat stormwater runoff. Their most distinguishing feature is that the side slopes typically used in swales are replaced with vertical side walls. This allows for more storage volume in less space.

There are two types of planters used for stormwater management: infiltration and flow-through planters. Infiltration planters depend on native soil conditions that allow runoff to soak into the underlying soil. Flow-through planters are completely contained systems that only allow runoff to soak through the planter's imported soil bed and then into an underdrain system. Infiltration planters are more desirable because they allow for greater volume reduction and further ease the burden on local storm drain facilities. Flow-through planters should be used where native soil conditions are unfavorable to infiltration, where there is underlying soil contamination, and/or where the seasonal high water table is within 10 feet of the landscape surface.

Figure 11: Planter along an urban street (Kevin Robert Perry – City of Portland)

Rain Gardens
Rain gardens are large, shallow, vegetated depressions in the landscape. They can be any size or shape, and are often molded to fit in "leftover" spaces in parking lots, along street frontages, and in situations where streets intersect at odd angles. They are also typically designed to be flat-bottomed without any longitudinal slope in order to maximize storage potential for stormwater.

Rain gardens retain stormwater, thereby attenuating peak flows and overall volume. They can also allow for infiltration, depending on the capacity of the native soil. Although rain gardens can share certain characteristics with swales and planters (they can be designed with vertical curbs or side slopes), they differ from swales in that their primary function is the maximum storage of runoff, not conveyance.

Rain gardens can be planted with a variety of trees, shrubs, grasses, and groundcovers depending on the site context and conditions. Generally, locations with soil infiltration rates that exceed or meet the accepted standard of 0.5"/hr are suitable for using infiltrative rain gardens.

Figure 12: This rain garden next to an elementary school collects runoff from adjacent neighborhood streets and the school's parking lot (Kevin Robert Perry – City of Portland)

Figure 13: This rectangular rain garden area receives runoff from both a parking lot and the building's rooftop (Nevue Ngan Associates)

Stormwater Curb Extensions
Stormwater curb extensions are landscape areas that extend into the street and capture stormwater runoff. Conventional curb extensions (a.k.a. bulb outs, chokers, chicanes) are commonly used to increase pedestrian safety and help calm traffic. A stormwater curb extension shares these same attributes plus adds a stormwater benefit by allowing water to flow into the landscape space. This landscape space can be designed with the physical characteristics of vegetated swales, planters, or rain gardens depending on the available space and specific site conditions.

Stormwater curb extensions are particularly advantageous in retrofit situations because they can often be added to existing streets with minimal disturbance. The small footprint of stormwater curb extensions allows for an efficient stormwater management system that often performs very well for a relatively low implementation cost.

Figure 14: Stormwater curb extension (Kevin Robert Perry – City of Portland)

Permeable Paving
Permeable paving systems allow rain water to pass through their surface and soak into the underlying ground. While these systems help reduce the amount of stormwater runoff by creating a pervious surface, they are not considered a treatment measure. Permeable paving must be designed to not only manage stormwater runoff adequately, but also maintain the same load bearing capacity as conventional paving in order to support the weight and forces applied by vehicular traffic.

The most desirable approach to using permeable paving is to combine this strategy with landscape-based stormwater management whenever possible. Permeable paving is primarily used on roadways with low-traffic speeds and volumes, but there are successful examples of pervious asphalt and concrete employed on high-traffic streets. Permeable paving should not be used in situations with known soil contamination or high groundwater tables.

Figure 15: Permeable concrete after a rain event (Neil Shapiro)

Street Trees
Trees contribute significantly to the slowing, absorbing, and filtering of rainwater. They intercept water on leaf surfaces, as well as "drink" water that does infiltrate into the soil. An averaged size tree can intercept and absorb hundreds of gallons of water a day depending on the tree species.

It is important to preserve existing, healthy trees whenever possible. Mature existing trees should influence how and where stormwater facilities are designed. If the location of an existing mature tree is in direct conflict with the location of a proposed stormwater facility, it might be more advantageous to alter the design of the stormwater facility in order to preserve and protect the existing tree. Mature trees are often able to soak up water at a rate comparable to what can be infiltrated in a stormwater facility. In terms of overall stormwater benefit, it is usually worth reducing stormwater facility size in order to save a mature tree.

Figure 16: Tree-Lined Commonwealth Ave, Boston (Ariana Green)

Figure 17: Water Interception (funwallz.com)

Vegetated Buffer Strips
Vegetated buffer strips are sloping planted areas designed to treat and absorb sheet flow from adjacent impervious surfaces. These strips are not intended to detain or retain water, only to treat it as a flow-through feature. They should not receive concentrated flow from swales or other surface features, or concentrated flow from pipes.

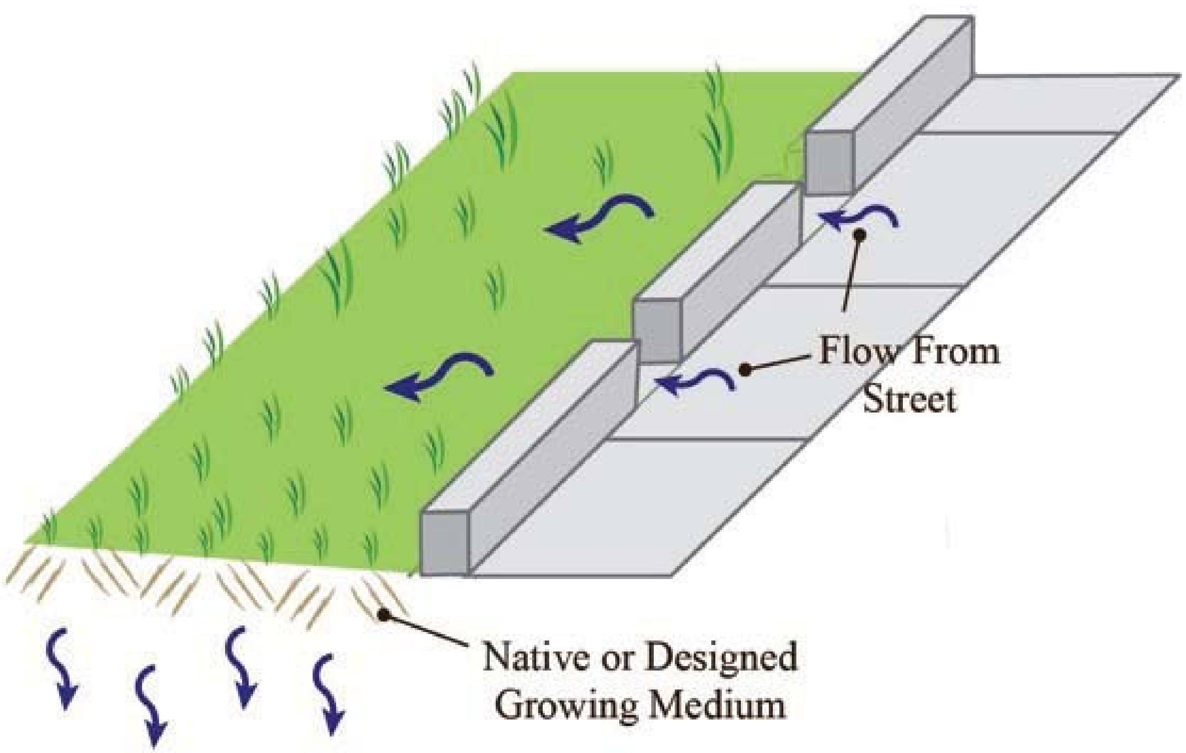

Figure 18: Vegetated buffer strip detail (Julia Campbell and Michele Weisbart)

Infiltration Trenches and Dry Wells
Infiltration trenches are linear, rock-filled features that promote infiltration by providing a high ratio of sub-surface void space in permeable soils. They provide on-site stormwater retention and may contribute to groundwater recharge. Infiltration trenches may accept streetwater from sheet flow, concentrated flow from a swale or other surface feature, or piped flow from a catch basin. Because they are not flow-through BMPs, infiltration trenches do not have outlets but may have overflow outlets for large storm events.

Dry wells are typically distinguished from infiltration trenches by being deeper than they are wide. They are usually circular, resembling a well, and are backfilled with the same materials as infiltration trenches. Dry wells typically accept concentrated flow from surface features or from pipes and do not have outlets.

Infiltration trenches and dry wells are typically designed to infiltrate all flow they receive. In large storm events, partial infiltration of runoff can be achieved by providing an overflow outlet. In these systems, significant or even complete volume reduction is possible in smaller storm events. During large storm events, these systems may function as detention facilities and provide a limited amount of retention and infiltration.

Figure 19: Infiltration trench with perforated pipe during installation (Neil Shapiro)

POST-CONSTRUCTION STORMWATER MANAGEMENT REQUIREMENTS

In 1987, the Environmental Protection Agency amended the Clean Water Act to designate municipal stormwater runoff as a discrete pollution source. This led to the creation of the National Pollutant Discharge Elimination System (NPDES) administered by the State Water Resources Control Board through its nine (9) Regional Boards. Beginning March 6, 2014, the Regional Water Quality Control Board for the Central Coast Region (Region 3) mandates the inclusion of Post-Construction Stormwater Management Requirements for the following transportation projects that create or replace greater than 2,500 square feet of impervious surface area:

- **Removing and replacing a paved surface that results in an alteration of the original line and grade, hydraulic capacity or overall footprint of the road;**
- **Extending the pavement edge, or paving graveled shoulders; and,**
- **Resurfacing by upgrading from dirt to asphalt, or concrete; upgrading from gravel to asphalt, or concrete; or upgrading from a bituminous surface treatment ("chip seal") to asphalt or concrete.**
- **Transportation projects excluded from these requirements include:**
- **Road and Parking Lot maintenance where the original line, grade, and hydraulic capacity are not changed;**
- **Sidewalk, bicycle path or bicycle lane projects, trails and pathways, where no other impervious sur faces are created or replaced, built to direct stormwater runoff to adjacent vegetated areas;**
- **Curb and gutter improvement or replacement projects that do not create or replace additional impervious surface area;**

GREEN STREETS/LOW IMPACT DEVELOPMENT/STORMWATER RESOURCES

Stormwater Technical Guidelines can be found at the Monterey Regional Stormwater Management Program website:
http://www.montereySEA.org

Additional technical support can be found at the Central Coast Regional Water Quality Control Board website:
http://www.waterboards.ca.gov/centralcoast/water_issues/programs/stormwater/docs/lid/lid_hydromod_charette_index.shtml

Additional information and technical guidance for green streets designs and standards can be found at the Central Coast Low Impact Development Initiative website:
http://www.centralcoastlidi.org/Central_Coast_LIDI/LID_Structural_BMPs.htm

Project-specific design requirements are presented in Attachment 1 of Resolution No. R3-2013-0032 (dated July 12, 2013):
http://www.waterboards.ca.gov/centralcoast/water_issues/programs/stormwater/docs/lid/hydromod_lid_docs/2013_0032_attach1_post_construction_requirements.pdf