City of La Mirada

Green Streets Manual

DRAFT: October 2013

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SECTION 1 – INTRODUCTION

WHAT ARE GREEN STREETS?

Roads present many opportunities for green infrastructure application. One principle of green infrastructure involves reducing and treating stormwater close to its source. Urban transportation right-of-ways integrated with green techniques are often called "green streets." Green streets provide source controls for stormwater runoff and pollutant loads. In addition, green infrastructure approaches complement street facility upgrades, street aesthetic improvements, and urban tree canopy efforts that also make use of the right-of-way and allow it to achieve multiple goals and benefits. Using the right-of-way for treatment of stormwater runoff links green with grey infrastructure by making use of the engineered conveyance of roads and providing connections to conveyance systems when needed.

Green streets are beneficial for new road construction and retrofits. They can provide substantial economic benefits when used in transportation applications. Coordinating green infrastructure installation with broader transportation improvements can reduce the cost of stormwater management by including it within larger infrastructure improvements. A large municipal concern regarding green infrastructure use is maintenance access; using roads and right-of-ways as locations for green infrastructure not only addresses a significant pollutant source, but also alleviates access and maintenance concerns by using public space. Also, right-of-way installations allow for easy public maintenance.

Green streets can incorporate a wide variety of design elements including street trees, permeable pavements, bioretention, and swales. Although the design and appearance of green streets will vary, the functional goals are the same; provide source control of stormwater, limit its transport and pollutant conveyance to the collection system, restore pre-development hydrology to the maximum extent practicable, and provide environmentally enhanced roads. Successful application of green techniques will encourage soil and vegetation contact and infiltration and retention of stormwater.

WHY ARE GREEN STREETS BEING REQUIRED?

This Green Streets Manual provides guidance to help achieve the goals of the MS4 Permit (Order Number R4-2012-0175)which requires that jurisdictions in Los Angeles County reduce contaminants in runoff to improve water quality in waterways. These requirements stem from the National Pollutant Discharge Elimination System (NPDES) requirements of the Clean Water Act (CWA).

The MS4 Permit requires Green Streets strategies to be implemented for transportation corridors. Transportation corridors represent a significant percentage of the impervious area within Los Angeles and therefore generate a substantial amount of runoff from storm events. The altered flow regime from traditional roadways, increased runoff volume, and high runoff peak flows, are damaging to the environment and a risk to property downstream.

Traditionally, street design has focused on removing water from the street as quickly as possible and transferringit to storm drains, channels, and water bodies. Stormwater runoff can contain bacteria and other pollutants, and isthereby regulated at the state and local level (refer to *Table 1* for a list of pollutants typical of roads). Green Streets will help to transform the design of streets from the conventional method of moving water off-site as quickly as possible to a method of storing and treating water on-site for a cleaner discharge into the waters of the U.S.

Street and road construction applies to major arterials, state routes, highways, or rail lines used for the movement of people or goods by means of bus services, trucks, and vehicles, and transportation corridors within larger projects. Projects which are required under the MS4 permit (Order Number R4-2012-0175) to follow this Green Streets Guidance Manual include the following:

1. Public Street and road construction of 10,000 square feet or more of impervious surface area within a transportation corridor. (Private street and road construction activities are subject to separate development planning provisions of the MS4 permit).
2. Street and road redevelopment resulting in the creation or addition or replacement of 5,000 square feet or more of impervious surface area on an already developed site. Redevelopment does not include routine maintenance activities that are conducted to maintain original line and grade, hydraulic capacity, original purpose of facility or emergency redevelopment activity required to protect public health and safety. Impervious surface replacement, such as the reconstruction of parking lots and roadways which does not disturb additional area and maintains the original grade and alignment, is considered a routine maintenance activity. Redevelopment does not include the repaving of existing roads to maintain original line and grade.
3. For projects not listed above, as determined by the Director of Public Works.

Table 1: Examples of Stormwater Pollutants Typical of Roads (*Managing Wet Weather With Green Infrastructure Municipal Handbook: Green Streets, 2008*).

Pollutant	Source	Effects
Trash	Littering	Physical damage to aquatic animals and fish, release of poisonous substances
Sediment/solids	Construction, unpaved areas	Increased turbidity, increased transport of soil bound pollutants, negative effects on aquatic organisms reproduction and function
Metals (Copper,Zinc,Lead,Arsenic)	Vehicle brake pads,vehicle tires, motor oil, vehicle emissions and engines,vehicle emissions, brake linings, automotive fluids	Toxic to aquatic organisms and can accumulate in sediments and fish tissues
Organics associated with petroleum (e.g., PAHs)	Vehicle emissions, automotive fluids, gas stations	Toxic to aquatic organisms
Nutrients	Vehicle emissions, atmospheric deposition	Promotes eutrophication and depleted dissolved oxygen concentrations

PLANNING AND DEVELOPMENT

Ideally, a site would be designed to capture and use or infiltrate the entire runoff volume of a storm, however site and design constraints make it difficult to achieve that goal. This Green Streets Manual is designed to provide guidance with BMP selection based on site constraints typical to street design. Streetscape geometry, topography, and climate determine the types of controls that can be implemented. The initial step in selecting a stormwater tool is determining the available open space and constraints. Stormwater controls should be selected using the hierarchy represented in *Figure 1*, the site guidelines represented in *Table 2*, and the location opportunities listed in *Table 3*.

Site Considerations

Specific elements which should be given special consideration in the site assessment process for applicable Green Streets include:

- **Ownership of land adjacent to right of ways.** The opportunity to provide stormwater treatment may depend on the ownership of land adjacent to the right-of-way. Acquisition of additional right-of-way and/or access easements may be more feasible if land bordering the project is owned by relatively few land owners. If the adjacent land is not publicly owned, treatment implementation options may be significantly limited.
- **Location of existing utilities.** The location of existing storm drainage utilities can influence the opportunities for Green Streets infrastructure. For example, stormwater planters can be designed to overflow along the curb-line to an existing storm drain inlet, thereby avoiding the infrastructure costs associated with an additional inlet. The location of other utilities may limit the allowable placement of BMPs to only those areas where a clear pathway to the storm drain exists.
- **Grade differential between road surface and storm drain system.** Some BMPs require more head from inlet to outlet than others; therefore, allowable head drop may be an important consideration in BMP selection. Storm drain elevations may be constrained by a variety of factors in a roadway project (utility crossings, outfall elevations, etc.) that cannot be overcome and may override stormwater management considerations.
- **Longitudinal slope.** The suite of BMPs which may be installed on steeper road sections is more limited. Specifically, permeable pavement and swales are more suitable for gentle grades. Other BMPs may be more readily terraced to be used on steeper slopes.
- **Soil suitability.** Infiltration BMPs require specific types of soil. The site assessment should determine the type of soils on the site and the infiltration rate of the soils if infiltration BMPs are proposed.
- **Potential access opportunities.** A significant concern with installation of BMPs in major right of ways is the ability to safely access the BMPs for maintenance considering traffic hazards. Vehicle travel lanes and specific areas potentially hazardous for maintenance crews should be identified during the site assessment. The Green Streets WQMP should provide subsequent steps to avoid placing BMPs in the identified hazardous areas.

Design Considerations

The drainage patterns of the project should be developed so that drainage can be routed to areas with BMP opportunities before entering storm drains. For example, if a median strip is present, a reverse crown should be considered, where allowed, so that stormwater can drain to a median swale. Likewise, standard peak-flow curb inlets should be located downstream of areas with potential for stormwater planters so that water can first flow into the planter, and then overflow to the downstream inlet if capacity of the planter is exceeded. It is more difficult to apply green infrastructure after water has entered the storm drain.

Green Streets project share not required to treat off-site runoff; however treatment of comingled off-site runoff may be used to off-set the inability to treat areas within the project for which significant constraints prevent the ability to provide treatment.

BMP Sizing for Applicable Green Streets Projects

An 85th percentile standard design storm should be used to determine the appropriate size, slope, and materials of each facility. After identifying the appropriate stormwater facilities for a site, an integrated approach using several BMPs is encouraged. To increase water quality and functional hydrologic benefits, several stormwater management BMPs can be used in succession. This is called a treatment train approach. The control measures should be designed using available topography to take advantage of gravity for conveyance to and through each facility. All Green Streets designs must be based off of a published design standard.

The following steps should be used to size BMPs for applicable Green Streets projects:

1. Delineate drainage areas tributary to BMP locations and compute imperviousness.
2. Look up the recommended sizing method for the BMP selected in each drainage area and calculate target sizing criteria.
3. Design BMPs per a published design standard.
4. Attempt to provide the calculated sizing criteria for the selected BMPs.
5. If sizing criteria cannot be achieved, document the constraints that override the application of BMPs and provide the largest portion of the sizing criteria that can be reasonably provided given constraints. If BMPs cannot be sized to provide the calculated volume for the tributary area, it is still important to design the BMP inlet, energy dissipation, and overflow capacity for the full tributary area to ensure that flooding and scour is avoided. It is strongly recommended that BMPs which are designed to less than their target design volume be designed to bypass peak flows.

Alternative Compliance Options for Applicable Green Streets Projects

Alternative compliance programs should be considered for applicable Green Streets projects if on-site green infrastructure approaches cannot practicably treat the design volume. The primary alternative compliance option for applicable Green Streets projects is the completion of off-site mitigation projects. The proponent would implement a project to reduce stormwater pollution for other portions of roadway or similar land uses when being reconstructed to the project in the same hydrologic unit, ideally as close to the project as possible and discharging to the same outfall.

Infiltration Considerations

Appropriate soils, infiltration media, and infiltration rates should be used for infiltration BMPs. If infiltration is proposed, a complete geotechnical or soils report should be undertaken to determine infiltration rates, groundwater depth, soil toxicity and stability, and other factors that will affect the ability and the desirability of infiltration. At a minimum, the infiltration capacity of the underlying soils shall be deemed suitable for infiltration (0.3 inches per hour or greater), appropriate media should be used in the BMP itself, the groundwater shall be located at a depth of ten feet or greater.

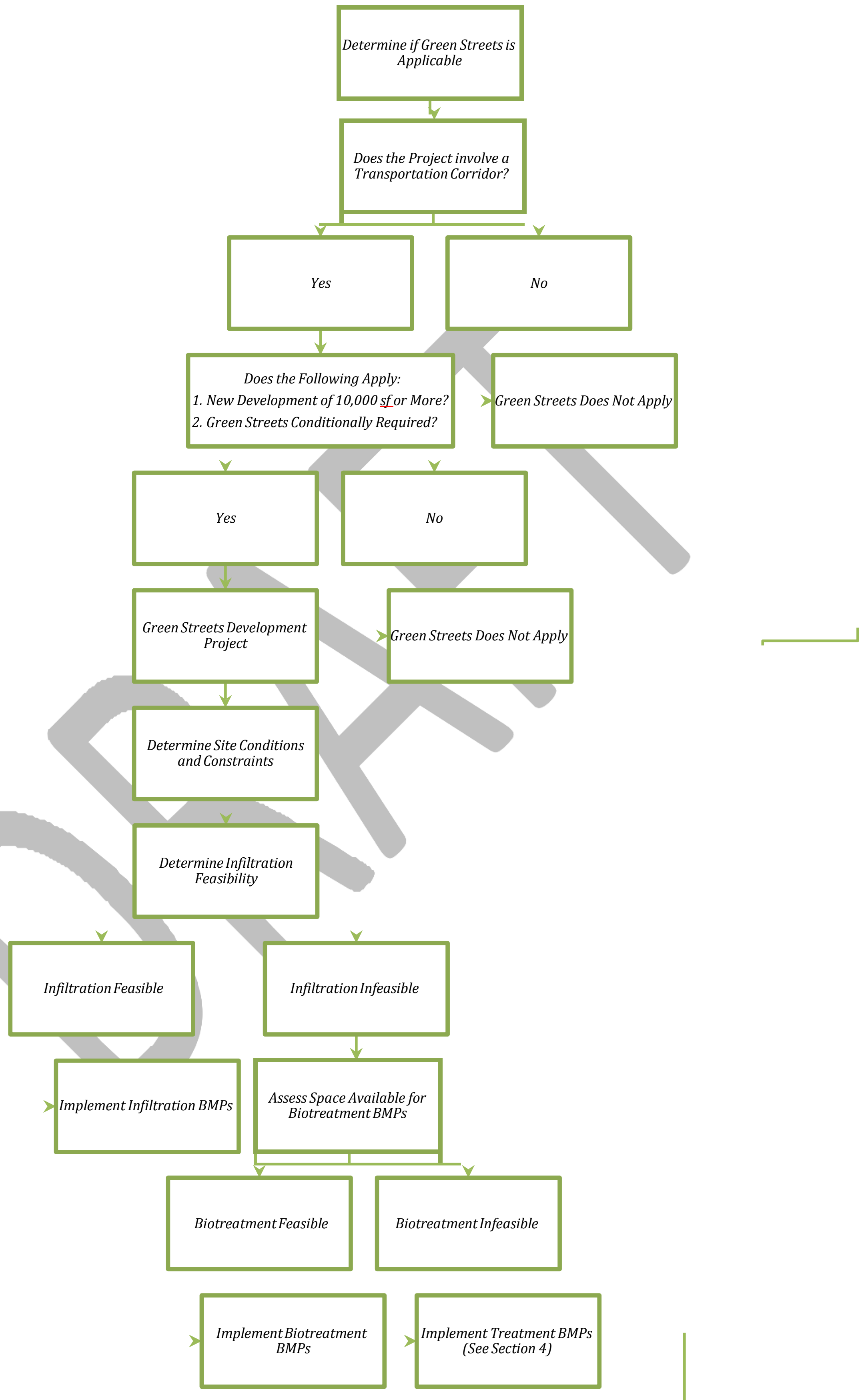

Figure 1: BMP Selection Flow Chart.

Table 2: BMP Selection by Street Context (*Model for Living Streets Design Manual, 2011*).

	STREET CONTEXT	BIORETENTION			DETENTION		PAVING	INLET PROTECTIONS		
		Swales	Planters	Vegetated Buffer Strips	Rain Gardens	Infiltration Trenches & Dry Wells	Permeable Pavement	Storm Drain Inlet Screens	Storm Drain Filter Inserts	Pipe Filter Inserts
Commercial	Downtown Commercial		✓			✓	✓	✓	✓	✓
	Commercial Throughway		✓	✓		✓	✓	✓	✓	✓
	Neighborhood Commercial		✓	✓	✓	✓	✓	✓	✓	✓
Residential	Downtown Residential	✓	✓		✓	✓	✓	✓	✓	✓
	Residential Throughway	✓	✓		✓	✓	✓	✓	✓	✓
	Neighborhood Residential	✓	✓		✓	✓	✓	✓	✓	✓
Industrial And Mixed-Use	Industrial	✓	✓		✓	✓	✓	✓	✓	✓
	Mixed-Use		✓	✓	✓	✓	✓	✓	✓	✓
Special	Sidewalk Furniture Zone	✓	✓		✓	✓	✓	✓	✓	✓
	Park Edge	✓	✓		✓	✓	✓	✓	✓	✓
	Boulevard	✓	✓		✓	✓	✓	✓	✓	✓
	Ceremonial (Civic)						✓	✓	✓	✓
Small	Alley		✓			✓	✓	✓	✓	✓
	Shared Public Way		✓			✓	✓	✓	✓	✓
	Walk Street		✓	✓		✓	✓	✓	✓	✓

Table 3: BMP Location Opportunity Summary.

BMP	Location Opportunity Summary

Bioretention	• Adjacent to traveled way and in frontage or furniture sidewalk zones • Can be located in curb extensions, medians, traffic circles, roundabouts, and any other landscaped area • Suitable for constrained locations
Infiltration Trench/Dry Well	• Can be located under sidewalks and in sidewalk planting strips, curb extensions, roundabouts, and medians
Rain Gardens	• Can be integrated medians, islands, circles, street ends, chicanes, and curb extensions • Can be located at the terminus of swales in the landscape
Permeable Pavement	• Suitable for parking or emergency access lanes • Can be located in furniture zones of sidewalks especially adjacent to tree wells • Cannot be placed in areas with large traffic volume or heavy load lanes • Avoid steep streets • Cannot be placed within 20 feet of sub-sidewalk basements • Cannot be within 50 feet of domestic water wells
Flow-Through Planters	• Above-grade planters should be structurally separate from adjacent sidewalks • At-grade planter systems can be installed adjacent to curbs within the frontage and/or furniture zones
Vegetated Swales	• Can be located adjacent to roadways, sidewalks, or parking areas • Can be integrated into traffic calming devices such as chicanes and curb extensions • Can be placed in medians where the street drains to the median • Can be placed alongside streets and pathways • Should be designed to work in conjunction with the street slope
Vegetated Buffer Strips	• Can be located in multi-way boulevards, park edge streets, or sidewalk furniture zones

	• Can serve as pre-treatment
Treatment BMPs	• Can be located in a catch basin, manhole, or vault • Can be installed on an existing outlet pipe or at the bottom of an existing catch basin with an overflow • Can be placed on existing curbside catch basins and flush grate openings • Can be installed on the existing wall of a catch basin and on the curb side wall of a catch basin • Minimum set-backs from foundations and slopes should be observed if the BMP is not lined
Street Trees	• Can be placed on sidewalks, in furniture zones, and on medians • Adequate spacing must be provided between trees and street lights,pedestrian lights, accessible parking spaces, bus shelters, awnings, canopies, balconies, and signs

SECTION 2 – INFILTRATION

Infiltration systems utilize rock, gravel, and other highly permeable materials foron-site infiltration. In these systems, stormwater runoff is directed to the system and allowed to infiltrate into the soils for on-site retention and groundwater recharge. During small storm events, infiltration systems can result in significant or even complete volume reduction of stormwater runoff.

Infiltration should be used to the maximum extent practicable. Biotreatment BMPs should be consideredif infiltration is found to be infeasible due to low infiltration rates, soil instability, high groundwater, or soil contamination.

Infiltration BMPs may become damaged by stormwater carrying high levels of sediment, therefore pre-treatment features should be designed to treat street runoff prior to discharging to infiltration features. Media filters, filter inserts, vortex type units, bioretention devices, sumps, and sedimentation basins are several pre-treatment tools effective at removing sediment.

INFILTRATION TRENCHES AND DRY WELLS

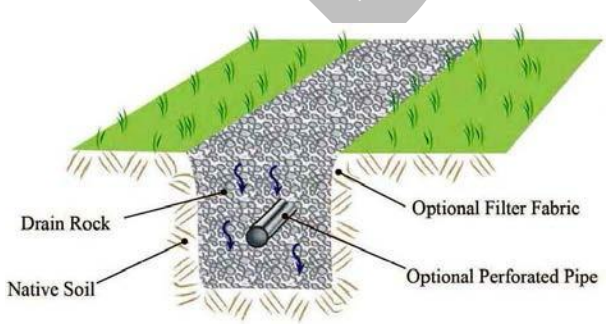

Figure 2: Infiltration Trench (*Model for Living Streets Design Manual, 2011*).

Description

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 stormwater 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.

Location and placement guidelines

Infiltration trenches and dry wells typically have small surface footprints so they are potentially some of the most flexible elements of landscape design. However, because they involve sub-surface excavation, these features may interfere with surrounding structures. Care needs to be taken to ensure that surrounding building foundations, pavement bases, and utilities are not damaged by infiltration features. Once structural soundness is ensured, infiltration features may be located under sidewalks and in sidewalk planting strips, curb extensions, roundabouts, and medians. When located in medians, they are most effective when the street is graded to drain to the median. Dry wells require less surface area than trenches and may be more feasible in densely developed areas.

Infiltration features should be sited on uncompacted soils with acceptable infiltration capacity. They are best used where soil and topography allow for moderate to good infiltration rates (0.3 inches per hour or better) and the depth to groundwater is at least 10 feet. Prior to design of any retention or infiltration system, proper soil investigation and percolation testing shall be conducted to determine appropriate infiltration design rates, depth to groundwater, and if soil will exhibit instability as a result of infiltration. Any site with potential for previous underground contamination shall be investigated. Infiltration trenches and dry wells can be designed as stand-alone systems when water quality is not a concern or may be combined in series with other stormwater tools.

Perforated pipes and piped inlets and outlets may be included in the design of infiltration trenches. Cleanouts should be installed at both ends of any piping and at regular intervals in long sections of piping, to allow access to the system. Access ports are recommended for both trenches and wells and can be combined with clean-outs. If included, the overflow inlet from the infiltration trench should be properly designed for anticipated flows.

RAIN GARDENS

Figure 3: Rain garden (*Model for Living Streets Design Manual, 2011*).

Description

Rain gardens are vegetated depressions in the landscape. They have flat bottoms and gently sloping sides. Rain gardens can be similar in appearance to swales, but their footprints may be any shape. Rain gardens hold water on the surface, like a pond, and have overflow outlets. The detained water is infiltrated through the topsoil and subsurface drain rock unless the volume of water is so large that some must overflow. Rain gardens can reduce or eliminate off-site stormwater discharge while increasing on-site recharge.

Location and Placement Guidelines

Rain gardens may be placed where there is sufficient area in the landscape and where soils are suitable for infiltration. Rain gardens can be integrated with traffic calming measures installed along streets, such as medians, islands, circles, street ends, chicanes, and curb extensions. Rain gardens are often used at the terminus of swales in the landscape.

PERMEABLE PAVEMENT

Figure 4: Permeable pavement during a storm event (*Model for Living Streets Design Manual, 2011*).

Description

Permeable pavement is a system with the primary purpose of slowing or eliminating direct runoff by absorbing rainfall and allowing it to infiltrate into the soil. Permeable pavement also filters and cleans pollutants such as petroleum deposits on streets, reduces water volumes for existing overtaxed pipe systems, and decreases the cost of offsite or onsite downstream infrastructure. This BMP is impaired by sediment-laden run-on which diminishes its porosity. Care should be taken to avoid flows from landscaped areas reaching permeable pavement. Permeable pavement is, in certain situations, an alternative to standard pavement. Conventional pavement is designed to move stormwater off-site quickly. Permeable pavement, alternatively, accepts the water where it falls, minimizing the need for management facilities downstream.

Location and Placement Guidelines

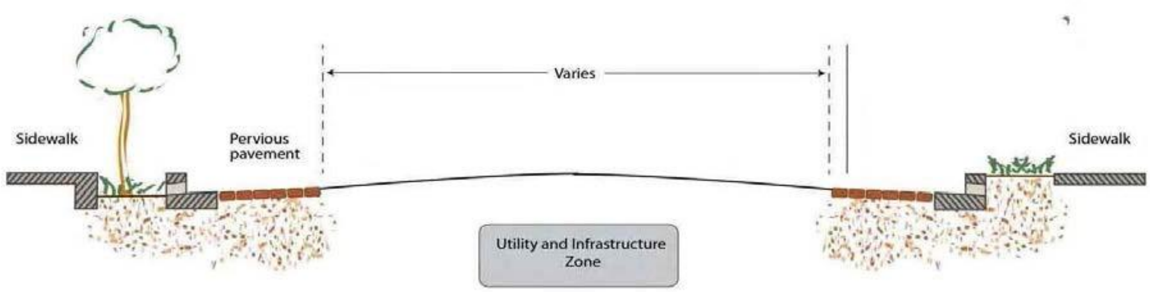

Figure 5: Possible pervious pavement design layout (*Model for Living Streets Design Manual, 2011*).

Conditions where permeable pavement should be encouraged include:

- Sites where there is limited space in the right-of-way for other BMPs;
- Parking or emergency access lanes; and
- Furniture zones of sidewalks especially adjacent to tree wells

Conditions where permeable pavement should be avoided include:

- Large traffic volume or heavy load lanes;
- Where runoff is already being harvested from an impervious surface for direct use, such as irrigation of bioretention landscape areas;
- Steep streets;
- Gas stations, car washes, auto repair, and other sites/sources of possible chemical contamination;
- Areas with shallow groundwater;
- Within 20 feet of sub-sidewalk basements; and
- Within 50 feet of domestic water wells.

Material and Design Guidelines

A soil or geotechnical report should be conducted to provide information about the permeability rate of the soil, load-bearing capacity of the soil, the depth to groundwater (10 feet or more required), and if soil will exhibit instability as a result of implementation. Infiltration rate and load capacity are key factors in the functionality of this BMP. Permeable pavement generally does not have the same load-bearing capacity as conventional pavement, so this BMP may have limited applications depending on the underlying soil strength and pavement use. Permeable pavement should not be used in general traffic lanes due to the possible variety of vehicles weights and heavy volumes of traffic.

When used as a road paving, permeable pavement that carries light traffic loads typically has a thick drain rock base material. Pavers should be concrete as opposed to brick or other light-duty materials. Other possible permeable paving materials include porous concrete and porous asphalt. These surfaces also have specific base materials that detain infiltrated water and provide structure for the road surface. Base material depths should be specified based on design load and the soils report.

Plazas, emergency roads, and other areas of limited vehicular access can also be paved with permeable pavement. Paving materials for these areas may include open cell paver blocks filled with stones or grass and plastic cell systems. Base material specifications may vary depending on the product used, design load, and underlying soils.

When used for pedestrian paths, sidewalks, and shared-use paths, appropriate materials include those listed above as well as rubber pavers and decomposed granite or something similar (washed or pore-clogging fine material). Pedestrian paths may also use broken concrete pavers as long as ADA requirements are met. Paths should drain into adjoining landscapes and should be higher than adjoining landscapes to prevent run-on. Pavement used for sidewalks and pedestrian paths should be ADA compliant, especially smooth, and not exceed a 2 percent slope or have gaps wider than 0.25 inches. In general, tripping hazards should be avoided.

Design considerations for permeable pavement include:

- The location, slope and load-bearing capacity of the street, and the infiltration rate of the soil;
- The amount of storage capacity of the base course;
- The traffic volume and load from heavy vehicles;
- The design storm volume calculations and the quality of water; and
- Drain rock, filter fabrics, and other subsurface materials.

Maintenance Guidelines

Maintenance of permeable pavement systems is essential to their continued functionality. Regular vacuuming and street sweeping should be performed to remove sediment from the pavement surface. The bedding and base material should be selected for long life and sufficient infiltration rates.

SECTION 3 – BIOTREATMENT

Biotreatment BMPs are landscaped, shallow depressions that capture and filter stormwater runoff. These types of BMPs are an increasingly common type of stormwater treatment device that are installed at curb level and filled with a bioretention type soil. They are designed as soil and plant-based filtration devices that remove pollutants through a variety of physical, biological, and chemical treatment processes. They typically consist of a ponding area, mulch layer, planting soils, and plants. Stormwater is directed to the system and pollutants are treated as the stormwater drains through the planting soil and either infiltrated or collected by an underdrain and directed to a collection system.

Biotreatment should only be used in cases where infiltration has been proven infeasible due to low infiltration rates, soil instability, high groundwater, or soil contamination.

BIORETENTION

Figure 6: Bioretention system (*Model for Living Streets Design Manual, 2011*).

Description

Bioretention is a stormwater management process that cleans stormwater by mimicking natural soil filtration processes as water flows through a bioretention BMP. It incorporates mulch, soil pores, microbes, and vegetation to reduce and remove sediment and pollutants from stormwater. Bioretention is designed to slow, spread, and, to some extent, infiltrate water. Each component of the bioretention BMP is designed to assist in retaining water, evapotranspiration, and adsorption of pollutants into the soil matrix. As runoff passes through the vegetation and soil, the combined effects of filtration, absorption, adsorption, and biological uptake of plants remove pollutants.

For areas with low permeability or other soil constraints, bioretention can be designed as a flow-through system with a barrier protecting stormwater from native soils. Bioretention areas can be designed with an underdrain system that directs the treated runoff to infiltration areas, cisterns, or the storm drain system, or may treat the water exclusively through surface flow. Examples of bioretention BMPs include swales, planters, and vegetated buffer strips.

Location and Placement Guidelines

Bioretention facilities can be included in the design of all street components; adjacent to the traveled way and in the frontage or furniture sidewalk zones. They can be designed into curb extensions, medians, traffic circles, roundabouts, and any other landscaped area. Depending on the feature, maintenance and access should always be considered in locating the device. Bioretention systems are also appropriate in constrained locations where other stormwater facilities requiring more extensive subsurface materials are not feasible.

If bioretention devices are designed to include infiltration, native soil should have a minimum permeability rate of 0.3 inches per hour and at least 10 feet to the groundwater table. Sites that have more than a 5 percent slope may require other stormwater management approaches or special engineering.

FLOW-THROUGH PLANTERS

Figure 7: Flow-through planter (*Model for Living Streets Design Manual, 2011*).

Description

Flow-through planters are typically above-grade or at-grade with solid walls and a flow-through bottom. They are contained within an impermeable liner and use an underdrain to direct treated runoff back to the collection system. Where space permits, buildings can direct roof drains first to building-adjacent planters. Both underdrains and surface overflow drains are typically installed with building-adjacent planters.

At-grade street-adjacent planter boxes are systems designed to take street runoff and/or sidewalk runoff and incorporate bioretention processes to treat stormwater. These systems may or may not include underdrains.

Location and Placement Guidelines

Above-grade planters should be structurally separate from adjacent sidewalks to allow for future maintenance and structural stability per local department of public works' standards. At-grade planter systems can be installed adjacent to curbs within the frontage and/or furniture zones.

All planters should be designed to pond water for less than 48 hours after each storm. Flow-through planters designed to detain roof runoff can be integrated into a building's foundation walls, and may be either raised or at grade.

For at-grade planters, small localized depressions may be included in the curb opening to encourage flow into the planter. Following the inlet, a sump (depression) to capture sediment and debris may be integrated into the design to reduce sediment loadings.

VEGETATED SWALES

Figure 8: Vegetated swale (*Signal hill, CA*).

Description

Swales are linear, vegetated depressions that capture rainfall and runoff from adjacent surfaces. The swale bottom should have a gradual slope to convey water along its length. Swales can reduce off-site stormwater discharge and remove pollutants along the way. In a swale, water is slowed by traveling through vegetation on a relatively flat grade. This gives particulates time to settle out of the water while contaminants are removed by the vegetation.

Location and Placement Guidelines

Swales can be located adjacent to roadways, sidewalks, or parking areas. Roadway runoff can be directed into swales via flush curbs or small evenly-spaced curb cuts into a raised curb. Swale systems can be integrated into traffic calming devices such as curb extensions.

Swales can be placed in medians where the street drains to the median. Placed alongside streets and pathways, vegetated swales can be landscaped with native plants which filter sediment and pollutants and provide habitat for wildlife. Swales should be designed to work in conjunction with the street slope to maximize filtration and slowing of stormwater.

Swales are designed to allow water to slowly flow through the system. Depending on the landscape and design storm, an overflow or bypass for larger storm events may be needed. Curb openings should be designed to direct flow into the swale. Following the inlet, a sump may be built to capture sediment and debris.

VEGETATED BUFFER STRIPS

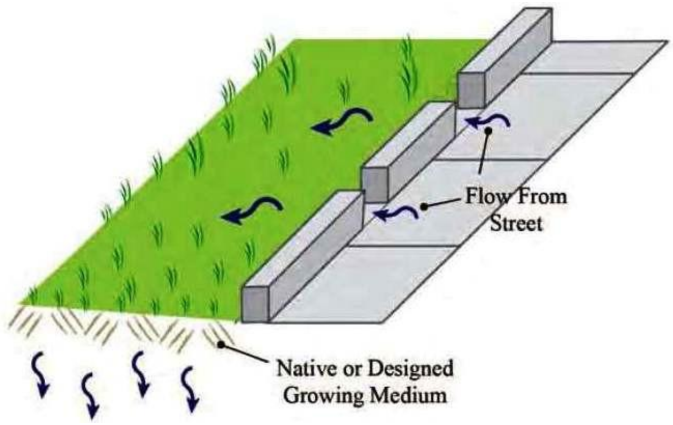

Figure 9: Vegetated buffer strip detail (*Model for Living Streets Design Manual, 2011*).

Description

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.

Location and Placement Guidelines

Vegetated buffer strips are well-suited to treating runoff from roads and highways, small parking lots, and pervious surfaces. They may be commonly used on multi-way boulevards, park edge streets, or sidewalk furniture zones with sufficient space. When selecting potential placement the need for supplemental irrigation should be considered. Vegetated buffers can also be situated so they serve as pre-treatment for another stormwater management feature, such as an infiltration BMP.

SECTION 4 – TREATMENT BMPS

SAND FILTERS&STORM DRAIN INLET PROTECTIONS

As described in Section 1 of this Green Streets Manual, it may be infeasible for specific projects to apply infiltration or biotreatment BMPs. In these cases, sand filters or filter inserts as treatment BMPs can be considered as an alternative. Sand filters and filter inserts can be designed to prevent particulates, debris, metals, and petroleum-based materials conveyed by stormwater from entering the storm drain system. All treatment BMP units should have an overflow system that allows the storm drain to remain functional if the filtration system becomes clogged during rainstorms. All storm drain inlet protections must be of a style and configuration approved by the agency with ownership of the inlet.

Typical maintenance of catch basins includes scheduled trash removal if a screen or other debris capturing device is used. Street sweeping should be performed by vacuum sweepers with occasional weed and large debris removal. Maintenance should include keeping a log of the amount of sediment collected and the data of removal.

The following are examples of possible treatment BMPs:

- **Sand Filters:** Sand filters are designed to filter stormwater through a constructed media bed and to an underdrain system. As stormwater flows through the media pollutants are filtered out of the water. The filtered water is conveyed through the underdrain to a collection system. Pretreatment is necessary to eliminate significant sediment load or other large particles which would clog the system. Minimum set-backs from foundations and slopes should be observed if the facility is not lined. Filters should be designed and maintained such that ponded water should not persist for longerthan 48 hours following a storm event.
- **Cartridge Media Filters:** Cartridge media filters contain multiple modular filters which contain engineered media. The filters can be located in a catch basin,manhole, or vault. The manhole or vault may be dividedinto multiple chambers so that the first chamber may act as a pre-settlingbasin for removal of coarse sediment while the next chamber may act as the filter chamber. Cartridge media filters are recommended for drainage areas with limited available surface area or where surface BMPswould restrict uses.Depending on the number of cartridges, maintenance events can have long durations. Locations should be chosen so that maintenance events will not significantlydisrupt businesses or traffic.Inlet inserts should be sized to capture all debris and should therefore be selected to match the specific size and shape of each catch basin and inlet.Filter media should be selected to target pollutants of concern. A combination of media may be used to remove a variety of pollutants. Systems with lower maintenance requirements are preferred.
- **Storm Drain Inlet Screens:** Inlet screens are designed to prevent large litter and trash from entering the storm drain system while allowing smaller particles to pass through. The screens function as the first preventive measure in removing pollutants from the storm water system. The city's street sweeping department should be consulted to ensure compliance with local specifications and to schedule regular maintenance. Annual inspection of the screen is recommended to ensure functionality. Note that most LA River drainage areas are already protected using connector pipe screens through collective systems.
- **Storm Drain Pipe Filter Insert:** The storm drain outlet pipe filter is designed to be installed on an existing outlet pipe or at the bottom of an existing catch basin with an overflow. This filter removes debris, particulates, and other pollutants from stormwater as it leaves the storm drain system. This BMP is less desirable than a protection system that prevents debris from entering the storm drain system because the system may become clogged with debris. Outlet pipe filters can be placed on existing curbside catch basins and flush grate openings. Regular maintenance is required and inspection should be performed rigorously. Because this filter is located at the outlet of a storm drain system, clogging with debris is not as apparent as with filters at street level. This BMP may be used as a supplemental filter with an inlet screen or inlet insert unit.

SECTION 5 – STREET TREES

STREET TREES

Figure 10: Street trees (*Signal Hill, CA*).

Description

Healthy urban trees are powerful stormwater management tools. Leaves and branches catch and slow rain as it falls, helping it to soak into the ground. The plants themselves take up and store large quantities of water that would otherwise contribute to surface runoff. Part of this moisture is then returned to the air through evaporation to further cool the city. As an important element along sidewalks, street trees must be provided with conditions that allow them to thrive, including adequate uncompacted soil, water, and air.

The goal of adding street trees is to increase the canopy cover of the street, the percentage of its surface either covered by or shaded by vegetation. The selection, placement, and management of all elements in the street should enhance the longevity of a city's street trees and healthy, mature plantings should be retained and protected whenever possible.

Benefits to adding street trees include:

- Creation of shade to lower temperatures in a city, reduces energy use, and makes the street a more pleasant place in which to walk and spend time
- Slowing and capture of rainwater, helping it soak into the ground to restore local hydrologic functions and aquifers
- Improving air quality by cooling air, producing oxygen, and absorbing and storing carbon in woody plant tissues

Guidelines

For guidelines on street tree design refer to the Signal Hill Street Tree Ordinance at http://www.cityofsignalhill.org/DocumentCenter/Home/View/774.

SECTION 6 – DEFINITIONS

Best Management Practice (BMP)
Operating methods and/or structural devices used to reduce stormwater volume, peak flows, and/or pollutant concentrations of stormwater runoff through evapotranspiration, infiltration, detention, filtration, and/or biological and chemical treatment.

Bioretention
Soil and plant-based retention practice that captures and biologically degrades pollutants as water infiltrates through sub-surface layers containing microbes that treat pollutants. Treated runoff is then slowly infiltrated and recharges the groundwater.

Conveyance
The process of water moving from one place to another.

Design Storm
A storm whose magnitude, rate, and intensity do not exceed the design load for a storm drainage system or flood protection project.

Detention
Stormwater runoff that is collected at one rate and then released at a controlled rate. The volume difference is held in temporary storage.

Filtration
A treatment process that allows for removal of solid (particulate) matter from water by means of porous media such as sand, soil, vegetation, or a man-made filter. Filtration is used to remove contaminants.

Furniture Zone
The furniture zone is the area which lies between the curb and pedestrian zones and is intended to house utilities and pedestrian amenities.

Hardscape
Impermeable surfaces, such as concrete or stone, used in the landscape environment along sidewalks or in other areas used as public space.

Infiltration
The process by which water penetrates into soil from the ground surface.

Permeability/Impermeability
The quality of a soil or material that enables water to move through it, determining its suitability for infiltration.

Retention
The reduction in total runoff that results when stormwater is diverted and allowed to infiltrate into the ground through existing or engineered soil systems.

Runoff
Water from rainfall that flows over the land surface that is not absorbed into the ground.

Sedimentation
The deposition and/or settling of particles suspended in water as a result of the slowing of the water.

Stormwater
Water runoff from rain or snow resulting from a storm.

Transportation Corridor
A major arterial, state route, highway, or rail line used for the movement of people or goods by means of bus services, trucks, and vehicles.

SECTION 7 – REFERENCES

1. Los Angeles County. *Model for Living Streets Design Manual*. 2011.
2. U.S. Environmental Protection Agency (EPA). *Managing Wet Weather With Green Infrastructure Municipal Handbook: Green Streets*. December 2008.
3. Orange County. *Technical Guidance Document*. May 2011.