RAINWATER HARVESTING PROGRAM

GREEN STREETS & GREEN ALLEYS DESIGN GUIDELINES STANDARDS

1ST EDITION • SEPTEMBER 4, 2009

CITY OF LOS ANGELES
SANITATION
DEPARTMENT OF PUBLIC WORKS

WATERSHED PROTECTION
CITY OF LOS ANGELES

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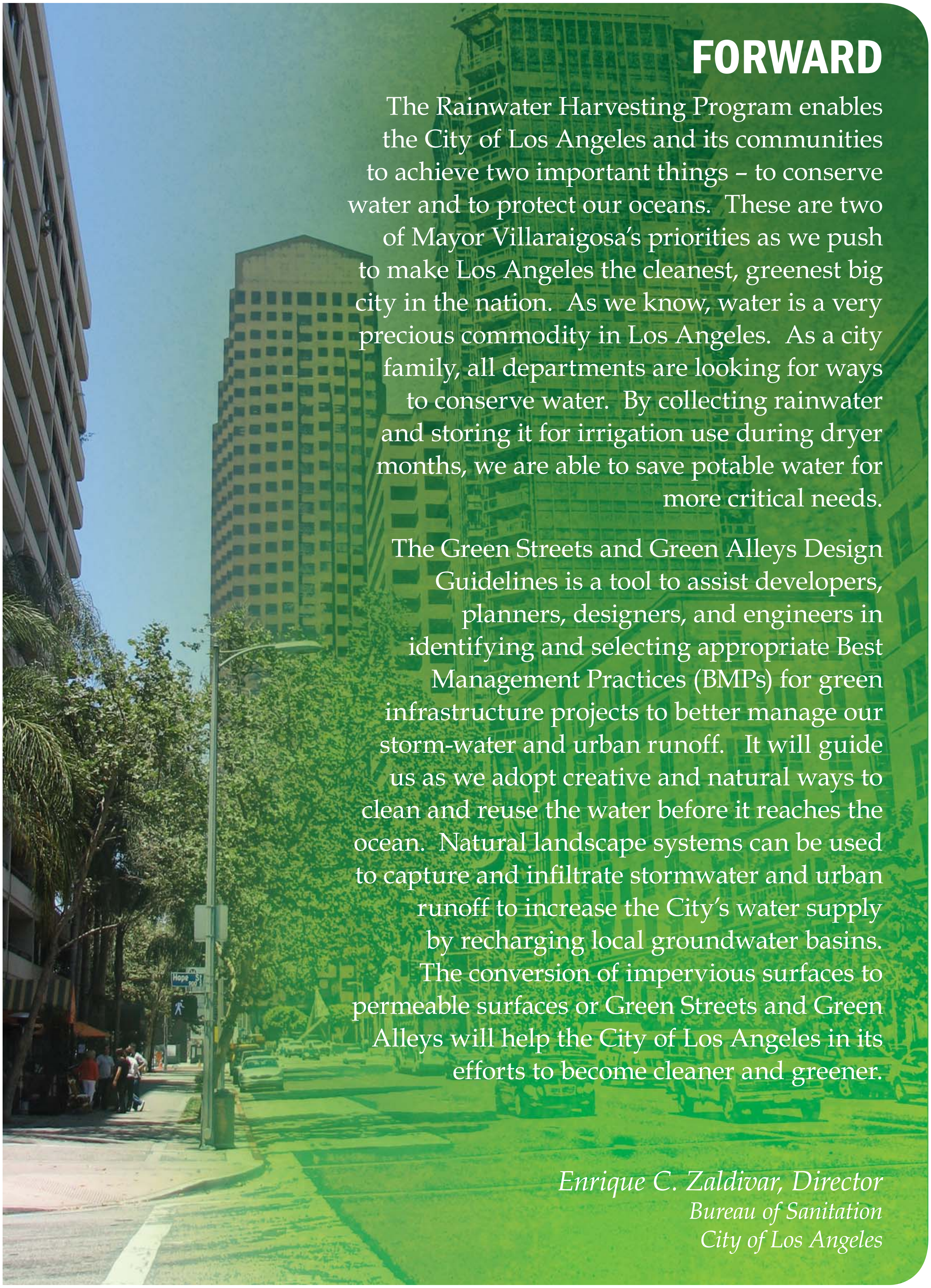
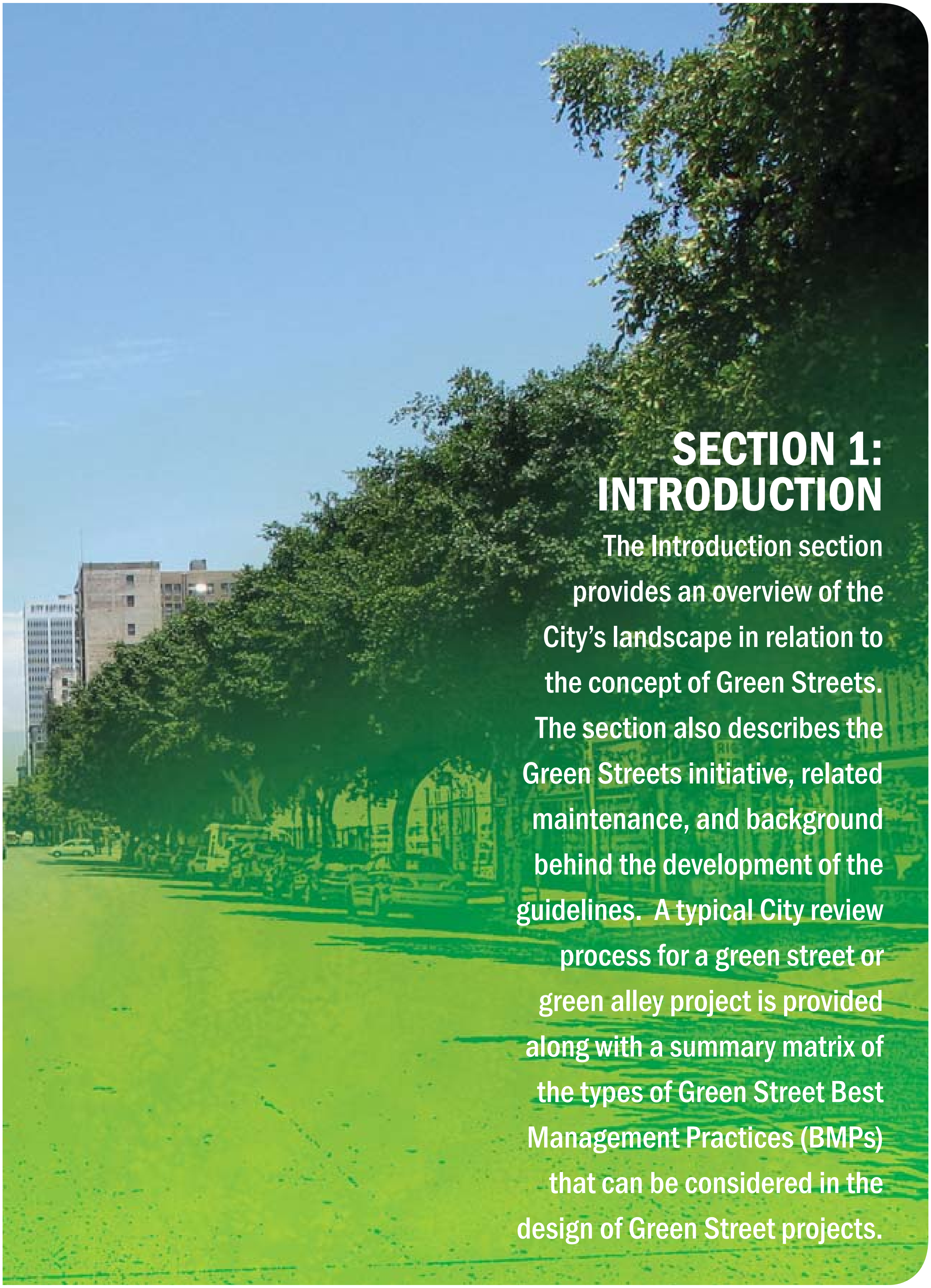


FORWARD

The Rainwater Harvesting Program enables the City of Los Angeles and its communities to achieve two important things – to conserve water and to protect our oceans. These are two of Mayor Villaraigosa's priorities as we push to make Los Angeles the cleanest, greenest big city in the nation. As we know, water is a very precious commodity in Los Angeles. As a city family, all departments are looking for ways to conserve water. By collecting rainwater and storing it for irrigation use during dryer months, we are able to save potable water for more critical needs.

The Green Streets and Green Alleys Design Guidelines is a tool to assist developers, planners, designers, and engineers in identifying and selecting appropriate Best Management Practices (BMPs) for green infrastructure projects to better manage our storm-water and urban runoff. It will guide us as we adopt creative and natural ways to clean and reuse the water before it reaches the ocean. Natural landscape systems can be used to capture and infiltrate stormwater and urban runoff to increase the City's water supply by recharging local groundwater basins. The conversion of impervious surfaces to permeable surfaces or Green Streets and Green Alleys will help the City of Los Angeles in its efforts to become cleaner and greener.

Enrique C. Zaldivar, Director
Bureau of Sanitation
City of Los Angeles



SECTION 1: INTRODUCTION

The Introduction section provides an overview of the City's landscape in relation to the concept of Green Streets. The section also describes the Green Streets initiative, related maintenance, and background behind the development of the guidelines. A typical City review process for a green street or green alley project is provided along with a summary matrix of the types of Green Street Best Management Practices (BMPs) that can be considered in the design of Green Street projects.

SECTION 1
INTRODUCTION

Figure 1. Oros Green Street

Figure 2. Green Street on 11th & Hope streets in downtown Los Angeles

The City of Los Angeles has approximately 6,500 miles of streets with 10,000 miles of sidewalk, 900 linear miles of alleys, and 34,000 catch basins. The streets are currently constructed of concrete and asphalt and often contribute to urban blight. They are also part of the City's storm drain system. Storm water runoff flows down the streets into catch basins that are connected to storm drain lines that flow directly into channels, rivers, lakes and the ocean. As the storm water is not treated prior to being discharged into the receiving water bodies, all pollutants, including trash, grease, oil, and sediments, are carried into the ocean causing pollution in the waterways and along the shores. Contaminated stormwater runoff is the number one source of ocean pollution in Southern California, and the city's street infrastructure plays a major role in flushing these pollutants out to sea.

All of these streets and alleys have the potential to be converted from impervious surfaces to permeable surfaces or Green Streets. The public right-of-way provides a large area where infiltration swales or other types of pervious surfaces can be constructed to collect, retain, or detain storm water runoff. The transformation of the City's existing paved streets into Green Streets can alleviate many of the storm water pollution issues while providing greener city streets and a sustainable urban environment. Green Street programs have already been adopted in various cities such as Chicago, Illinois; Seattle, Washington; Portland, Oregon; and San Mateo County, California.

A Green Street is designed with a landscape system to capture and infiltrate or filter storm water runoff through a natural system. The parkway area between the roadway and the sidewalk is an ideal location for the landscape infiltration swale. As the parkway is generally located directly adjacent to the roadway, storm water runoff can easily be directed from the streets into the parkways. The landscape parkways also provide a buffer zone between vehicular traffic in the streets and the pedestrians on the sidewalks.

Green Street parkways generally consist of depressed planters that are capable of capturing and retaining storm water and urban runoff. They minimize the impacts of storm water runoff on the receiving water bodies by reducing the volume of polluted storm water that currently flows untreated into City's storm drain system. The reduction of the storm water flow is achieved by allowing the storm water in the infiltration swales to percolate into the ground below or to be filtered through the soil matrix. Green Street parkways also provide adequate space for street trees to mature and develop significant canopy coverage which will improve air quality as well as reduce the heat island effect from urban pavements.

Green Streets Initiative

The Green Street Initiative (Initiative) is an aggressive, proactive measure that aims not only to meet water quality objectives but also to address multiple beneficial uses such as infiltration to recharge groundwater aquifers, using "green" BMPs such as landscaping to provide aesthetics as well as reducing the heat island effect, and to implement these objectives with minimum impact to the environment. The Initiative aims to utilize natural landscape systems to capture and infiltrate storm water and urban runoff. The areas of focus to install such systems are the parkway areas between the roadway and sidewalk where storm water can be easily directed from the streets and sidewalks into the parkways.

Successful implementation of this Initiative requires that various action items be completed. The City of Los Angeles Department of Public Works is the lead in carrying out these action items, which include: preparation of design guidelines, standard plan adoption, development of policies, identifying priority projects, and identifying funding sources.

Developing and constructing Green Street elements, such as infiltration swales, bio-swales, and permeable pavement, in the public right-of-way will address many environmental issues within the City and will:

- Reduce the amount of storm water runoff currently flowing untreated into storm drains
- Improve the water quality of stormwater runoff that flows to the ocean
- Increase the City's water supply by recharging local ground water basins
- Improve air quality and reduce the heat island effect of street pavement
- Enhance pedestrian use of sidewalks and encourage alternate means of transportation
- Increase community pride and positive perception of an area, which may draw more business

Correctly implemented, this Initiative will also help conserve the City's limiting and ever-decreasing water supply. Water use in the City of Los Angeles in the 2007-2008 fiscal year was well over 650,000 acre-feet. While demand continues to grow, recent drought years have put a tremendous strain on the City's water supply. To address this problem, the City's Department of Water & Power implemented a plan to enhance storm water capture and expand ground water storage. This Green Street Initiative will help towards achieving the goals of the water conservation plan.

The Green Street Initiative will address the new NPDES Permit requirements, reduce stormwater runoff, improve water quality, supplement the City's water supply via groundwater recharge (where applicable), improve air quality through reduction of heat island effects from street pavement, and provide a more aesthetically pleasing environment.

Maintenance

Currently, the streets and alleys are maintained by the City's Department of Public Works, Bureau of Street Services. However, sidewalks and parkways are required to be maintained by the abutting private property owners per the California Street and Highways Code (State of California Improvement Act of 1911). This includes the installation and maintenance of the irrigation systems for the parkway vegetation.

In July of 1974, Ordinance No. 146,040 which amended Los Angeles Municipal Code section 62.104, exempted homeowners from the responsibility for sidewalk repairs caused by City tree root growth and placed the responsibility for these repairs on the Department of Public Works, Bureau of Street Services. In 2000-2003, the City funded a Sidewalk Repair Program to repair approximately 164 miles of the most damaged sidewalks.

The Green Streets Guidelines are a planning tool designed to assist project engineers with identifying and selecting appropriate BMPs for their respective Green Infrastructure projects.

The maintenance cost of Green Street improvements is difficult to determine at this time. It is anticipated that maintenance funds will be required to maintain the additional trees, landscaping, irrigation systems, and curb inlets and to provide for general trash removal. Where Green Street improvements are constructed as part as a required condition of a private development, the City can require the developer to file a covenant and agreement with the City to guarantee maintenance the Green Street improvements. Where Green Streets are constructed as part of a City project or as part of street/sidewalk repair work, the Bureau of Street Services will be required to maintain the improvements.

Green Street Guidelines

On October 15, 2008 the Board of Public Works (BPW) adopted the report recommending City Council undertake actions to include Green Infrastructure elements into new and pending Capital Improvement Projects and to support the Green Street Committee in their efforts to implement Green Infrastructure elements. The Green Streets Guidelines are a planning tool designed to assist project engineers with identifying and selecting appropriate BMPs for their respective Green Infrastructure projects. Each guideline gives detailed information to the type of BMPs, its applicability, potential water quality treatment effectiveness, and estimated construction/installation cost. This document provides an array of design options for streets, parkways, sidewalks, and medians incorporating "Green Streets" elements for implementation as part of standard plans.

HOW TO USE THIS DOCUMENT

This document is organized into seven major sections. Each section is described below.

Section 1: Introduction

The Introduction section provides an overview of the City's landscape in relation to the concept of Green Streets. The section also describes the Green Streets initiative, related maintenance, and background behind the development of the guidelines. A typical City review process for a green street or green alley project is provided along with a summary matrix of the types of Green Street Best Management Practices (BMPs) that can be considered in the design of Green Street projects.

Section 2: Design Strategies for Green Streets and Parking Lots

This section provides a series of fact sheets on Green Street BMPs. Each fact sheet contains a description of the BMP, benefits, design considerations, constraints, typical applications, operations and maintenance, and a profile.

Section 3: Design Strategies for Green Alleys

This section provides an overview of green alleys within the context of the City of Los Angeles. Six design scenarios are presented to illustrate possible design implementation solutions.

Section 4: Design Examples for the City of Los Angeles

This section provide specific examples of Green Street applications in the City of Los Angeles. The purpose of this section is to provide a broad range of siting and varying scale applications that can be reproduced in other suitable locations throughout the City.

Section 5: Implementing Green Streets and Parking Lot Projects

This section provides practical guidance in the implementation of Green Street and parking lot projects in terms of reducing project costs, creating incentives, reaching the public, and understanding project scale.

Section 6: Conclusion and Acknowledgements

This section highlights the partnerships, collaboration, and expected results of the Green Streets Initiative.

Section 7: References

This section provides a list of useful publications, documents, and websites to further assist in the planning, design, and implementation of Green Streets and Green Alleys projects.

Appendix A: Key Design and Construction Details

This section contains useful design/construction considerations and details.

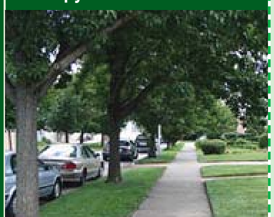
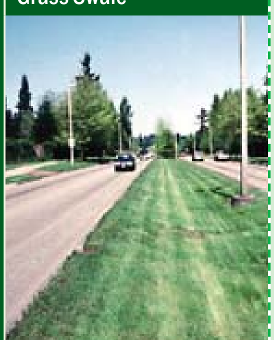
Appendix B: City of Los Angeles Standard Urban Stormwater Mitigation Plan Infiltration Requirements & Guidelines

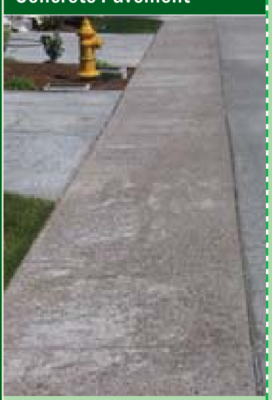
Appendix C: City of Los Angeles Department of Building and Safety Guidelines for Storm Water Infiltration

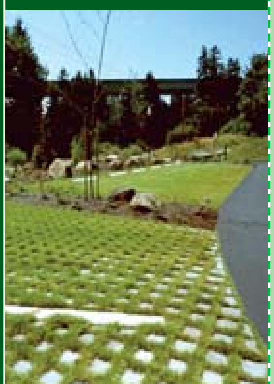
This section provides a series of fact sheets on Green Street BMPs with design-related guidance in the following areas:

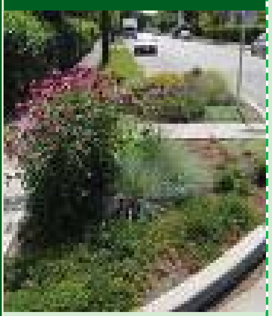
- Description
- Benefits
- Design Considerations
- Constraints
- Typical Applications
- Operations and Maintenance (O&M)
- Profile with description

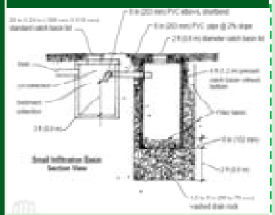
The Green Streets BMP summary matrix that follows provides an overview of each BMP including a brief description of the BMP, application, cost, effectiveness, and challenges.

Sect.	BMP	Description	Application	Cost*	Effectiveness	Challenges
2.1	Canopy Trees 	Trees placed in urban areas along the street provide environmental benefits. The tree's canopy intercepts stormwater and the soil absorbs additional runoff and allow for infiltration.	Low initial capital cost. Can be used in high pedestrian traffic areas and where parkway/ sidewalk areas are limitted	$2,000 - $2,200 each (48" box tree)	Medium	• Maintenance cost potentially high • Tree roots may have adverse impacts to sidewalk, curbs and gutters, and underground utilities
2.2	Vegetated Swale  www.duluthstreams.org	A vegetated swale is a broad, shallow channel with a dense stand of vegetation covering the side slopes and bottom. Vegetated swales are designed to treat stormwater primarily through filtration, and plant uptake before conveying the flow to a downstream discharge location. The vegetation helps in reducing flow velocity to prevent erosion.	Relatively inexpensive. Typically used on residential sites and highway medians	$8/sf - $26/sf	Low - medium	• Tributary area should be limited to no more than a few acres • Impractical in steep topography or when flows are high • Prone to channelization
2.2	Grass Swale  www.clean-water.uwex.edu	Grass swales are designed to treat stormwater runoff through infiltration, sedimentation, and filtration. The grass covering the side slops and channel bottom provide a filtration surface as the runoff is slowly conveyed to a downstream discharge location. The grass also serves to reduce flow velocities to prevent erosion.	Relatively inexpensive. Typically used on residential sites and highway medians	$6/sf - $19/sf	Low - medium	• Tributary area should be limited to no more than a few acres • Impractical in steep topography or when flows are high • Prone to channelization

Sect.	BMP	Description	Application	Cost*	Effectiveness	Challenges
2.3	Infiltration Planter 	They provide stormwater treatment as well as peak flow attenuation through storage and filtration/infiltration, and adsorption. Stormwater is captured and treated via filtration/infiltration through the soil media and evapotranspiration through the planted vegetation.	Infiltration planters are used where native soil is relatively porous and allow for sufficient infiltration	$25/sf - $65/sf	High	• Planters are designed to treat roof runoff and small tributary areas. Treating street runoff will required multiple installations in series. • Should not be constructed near building footprints • Not suitable on fill sites • Infiltration rate depends on site condition • Requires geotechnical investigation • Not applicable where groundwater depth is less than 10 ft below ground surface • Not applicable where project is located in hillside areas or where areas are subject to slides or unstable soil
2.3	Flow-Through Planter  City of Seattle	Flow through planters provide stormwater treatment through filtration and adsorption. Stormwater is captured and treated via filtration through the soil media and root zone and evapotranspiration through the planted vegetation before entering the perforated pipe at the bottom of the planter and discharge back to the storm drain system.	Flow through planters are used where native soil does not allow for infiltration, is contaminated, or where groundwater table is within 10 ft of the surface.	$25/sf - $67/sf	Medium - High	• Planters are designed to treat roof runoff and small tributary areas. Treating street runoff will required multiple installations in series.
2.4	Pervious Asphalt/ Concrete Pavement  www.concretenetwork.com	Pervious concrete or asphalt is an open void material designed to allow rainwater to filter through the paved surface into the ground or a storage container rather than settling on the surface. It's two main objectives are runoff peak flow attenuation while providing stormwater treatment. Site specific design of the retention/ recharge area include an initial soils site survey, and site specific storm water calculations for volume and duration	Well suited for commercial, industrial, and ultra urban environments. Limited use in residential and highway/road applications	$13/sf - $26/sf	Medium - High	• Not suitable on fill sites • Infiltration rate depends on site condition • Requires geotechnical investigation • Not applicable where groundwater depth is less than 10 ft below ground surface Not applicable where project is located in hillside areas or where areas are subject to slides or unstable soil

Sect.	BMP	Description	Application	Cost*	Effectiveness	Challenges
2.4	**Pervious Joint Unit Pavers**  *(Source: Unigroupusa.org)* blogspot.com	Similar to the porous pavement, unit pavers provide a hardscape alternative to stormwater treatment BMPs. Unit pavers, or paving stones, are impermeable blocks made of brick, stone, or concrete, set on a prepared sand base. The joints between the blocks are filled with sand or stone dust to allow water to percolate downward.	Well suited for commercial, industrial, and ultra urban environments. Limited use in residential and highway/road applications	$12/sf - $25/sf	Medium	• Not suitable on fill sites • Infiltration rate depends on site condition • Requires geotechnical investigation • Not applicable where groundwater depth is less than 10 ft below ground surface Not applicable where project is located in hillside areas or where areas are subject to slides or unstable soil
2.4	**Reinforced Grass Grid Paver**  picasaweb.google.com	Similar in concept and function to the porous concrete pavements and unit pavers, the grass pavers are "landscapted" alternatives designed to allow infiltration of stormwater runoff to the underlaying soil media. Grass pavers, or turf blocks, are a type of open-cell unit paver whereby the cells are filled with soil and planted with turf. The cell matrix are typically made of concrete or synthetic material.	Similar in function to the porous pavement and pavers but with an aesthetic advantage	$10/sf - $23/sf	Medium	• Not recommended for high traffic areas • Clogging can reduce effectiveness • Not suitable on fill sites • Infiltration rate depends on site condition • Requires geotechnical investigation • Not applicable where groundwater depth is less than 10 ft below ground surface • Not applicable where project is located in hillside areas or where areas are subject to slides or unstable soil
2.4	**Recycled Rubber Sidewalk**  www.rubbersidewalks.com	Originally used as alternatives to cracked sidewalks from protruding tree roots, rubber sidewalks are considered as another form of porous pavers to infiltrate runoff. Typically made of recycled rubber from waste tires,	Recycled Rubber sidewalk are used to replace tree damaged concrete sidewalk. Its use as stormwater quality improvement is currently very limited. Its main benefit is the use of recycled rubber from tires.	$22/sf - $35/sf	Very low - Low	As with any infiltration BMPs, the following must be considered: • Not suitable on fill sites • Infiltration rate depends on site condition • Requires geotechnical investigation • Not applicable where groundwater depth is less than 10 ft below ground surface • Not applicable where project is located in hillside areas or where areas are subject to slides or unstable soil

Sect.	BMP	Description	Application	Cost*	Effectiveness	Challenges
2.5	**Infiltration Trench**  www.ricecreek.org	An infiltration trench is a long, narrow, rock-filled trench bordered on each side by a grass or vegetated buffer. Runoff is stored in the void space between the stones and infiltrates through the bottom into the soil matrix. The buffer strips provide pretreatment to limit the amounts of coarse sediments entering the trench which can cause clogging.	Infiltration trenches are appropriate for urban application, especially in right of ways and/or street medians due to its long, narrow configuration.	$14/sf - $43/sf	High	• Tributary area should be limited to 5 acres • Clogging can reduce effectiveness • Not suitable on fill sites • Infiltration rate depends on site condition • Requires geotechnical investigation • Not applicable where groundwater depth is less than 10 ft below ground surface • Not applicable where project is located in hillside areas or where areas are subject to slides or unstable soil
2.6	**Stormwater Curb Extensions**  www.flickr.com	A curb extension is similar to infiltration or flow-through planters in that it captures stormwater runoff from nearby streets and driveways. Plants and soil slow the water down and help to filter contaminants.	Similar in function to the flow-through or infiltration planters, curb extension can be applied as supplement or alternatives to planters where parkway or sidewalk areas are limited	$22/sf - $67/sf	Medium - High	• Potential traffic impact and loss of parking space • Not suitable on fill sites • Infiltration rate depends on site condition • Requires geotechnical investigation • Not applicable where groundwater depth is less than 10 ft below ground surface • Not applicable where project is located in hillside areas or where areas are subject to slides or unstable soil
2.7	**Biotreatment Curb Inlet**  www.stormh2o.com	Biotreatment curb inlets are installed upstream of an existing CB. It treats runoff via filtration through the engineered soil media before discharging to the downstream existing CB. Biotreatment curb inlets are well suited for the urban environment. They add green space while providing stormwater runoff treatment.	Well suited for commercial, industrial, and ultra urban environments.	$15,000-$22,000 ea.	Medium - High	• Requires careful selection of plant palette as the majority of these installations do not include irrigation system. • Native drought tolerant plants are preferred

Sect.	BMP	Description	Application	Cost*	Effectiveness	Challenges
2.7	Percolation Curb Inlet  www.abe.msstate.edu	Percolation curb inlets are modified catch basins that allow infiltration of runoff. New catch basins can be designed and constructed with either perforated or no bottom. Existing catch basins can be retrofitted by drilling holes onto the floor.	Applicable where native soil exhibit suitable infiltration rate. For use in urban areas	$4,000-$12,000 ea.	High	• Not suitable on fill sites • Infiltration rate depends on site condition • Requires geotechnical investigation • Not applicable where groundwater depth is less than 10 ft below ground surface • Not applicable where project is located in hillside areas or where areas are subject to slides or unstable soil

**Opinion of Probable cost of construction*

Process for Implementing a Green Street or Green Alley Project

The following section provides a flow diagram outlining the process one would go through to implement a Green Street or Green Alley Project in the City of Los Angeles. Definitions of the acronyms used in the flow diagram are also provided below. An applicant checklist to help track the City's review process is also provided.

Green Infrastructure Projects

Process Flowchart & Checklist

Definition

A-Permit: Required for minor street construction. Minor street construction is construction or repair of broken curbs, broken sidewalks, broken driveway approaches, new driveways requiring alteration of existing curbs, and curb drain core drills. Construction is further limited to work that will not alter an established water flowline of a gutter, nor alter the existing grade of a sidewalk or street. No design plans are required.

B-Permit: Any street construction that is not minor, as defined above, may be considered major. Major street construction includes extensive projects, such as street widening, changing of existing street or sidewalk grades, alteration of water flowlines of a gutter, construction of an alley, and the installation of sewer lines, storm drains, street lighting, and traffic signals. These construction projects require design plans prepared by a licensed engineer. Work that exceeds the limits of minor street construction may require a B-Permit. The B-Permit is issued for both the design (BD-Permit) and the construction (BC-Permit) of major street improvements.

Revocable Permit (R-Permit): Grant conditional encroachment of the public right-of-way by private parties not authorized to occupy the right-of-way. The R-Permit review process ensures that encroachments are checked for compliance with the City's specifications for design, use, material, and inspection.

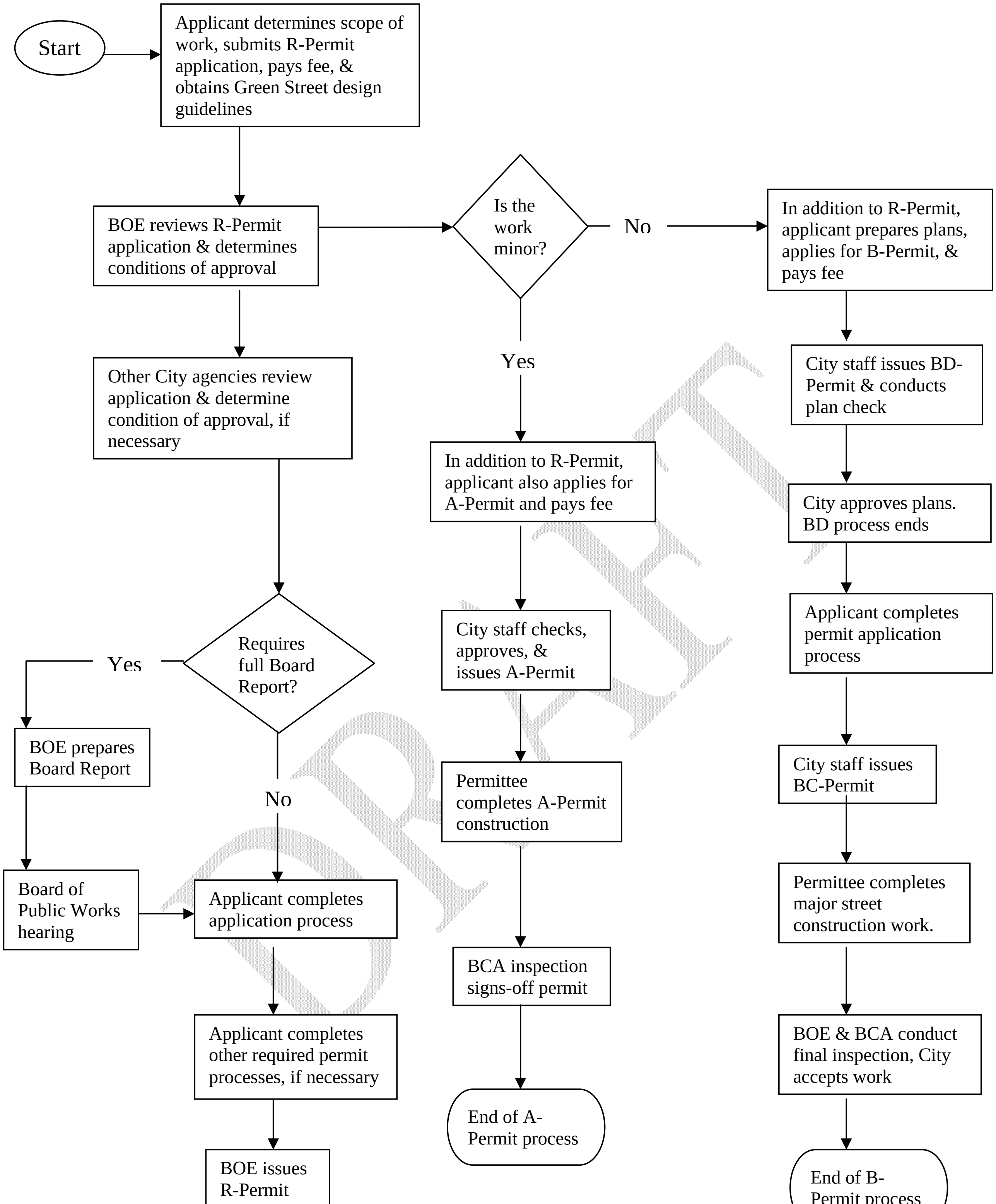
Depending on the complexity of work, other permits may be required. These may include:

Excavation Permit (E-Permit): If you are a private entity without the authority to occupy the public right-of-way, you will need an Excavation Permit (E-Permit) to cut street pavement and excavate a trench.

Utility Permit (U-Permit): If you are utility company or company with a franchise agreement with the City and you want to cut street pavement and excavate a trench, a Utility Permit (U-Permit) is required.

Sewer and Storm Drains Connections Permit (S-Permit): Any construction work related to a sewer connection, sewer service lateral, investigation of a condition related to a sanitary sewer, or any construction work related to the connection of the storm drain system will require an S-Permit.

Watercourse Permit (W-Permit): Construction or modification of a watercourse will require a W-Permit



R-Permit + **A-Permit** or **B-Permit**

2

Additional Permit information and detailed flowcharts can be found at http://eng.lacity.org/techdocs/permits/index.htm

Below are checklist items designed to assist the applicant in the implementation of Green Infrastructure Projects:

R-Permit

- [ ] Applicant obtains copy of Green Infrastructure BMP Design Guidelines from any public counters or at www.lastormwater.org
- [ ] Applicant submits R-Permit application and pays fees
- [ ] Applicant submits encroachment plan
- [ ] Applicant obtains plan check & approval from BOS
- [ ] City staff checks R-Permit application and determines appropriate permit type and fees. If work is minor, applicant is also directed to obtain A-Permit. If work involve major street improvements, applicant to obtain B-Permit in lieu of A-Permit (please see respective permit sections below).
- [ ] Applicant pays fees
- [ ] BOE staff conducts field investigation if required
- [ ] BOE staff reviews R-Permit application and determines conditions of approval.
- [ ] Other city agencies review R-Permit application & determine conditions of approval, if necessary (BSS, DOT, BSL, etc)
- [ ] BOE prepares full Board Report, if necessary
- [ ] Board of Public Works conducts public hearing and approves R-Permit, if necessary
- [ ] Applicant completes Waiver of Damages Agreement and provides liability insurance including covenant and agreement for the BMPs with O&M
- [ ] Applicant completes other required permit processes, if necessary
- [ ] BOE issues R-Permit

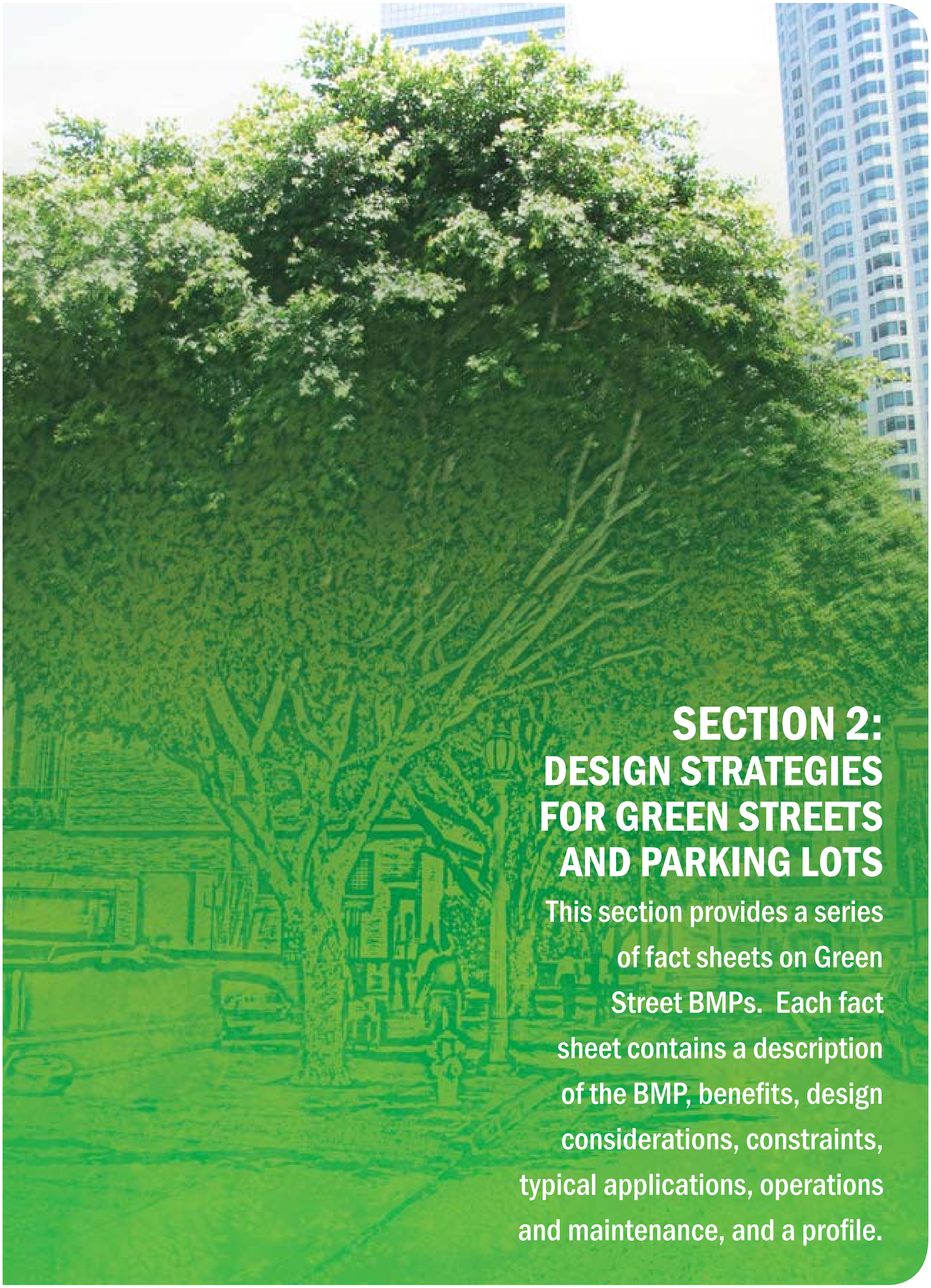
A-Permit (minor repair/replacement work)

- [ ] Applicant applies for A-Permit
- [ ] Applicant pays fees
- [ ] City staff checks & approves A-Permit
- [ ] City staff issues A-Permit
- [ ] Applicant & City staff sign permit
- [ ] Applicant calls BSA prior to start of construction
- [ ] Applicant completes construction
- [ ] Applicant calls BCA for final inspection
- [ ] BCA inspection signs off permit

B-Permit (major street improvement work)

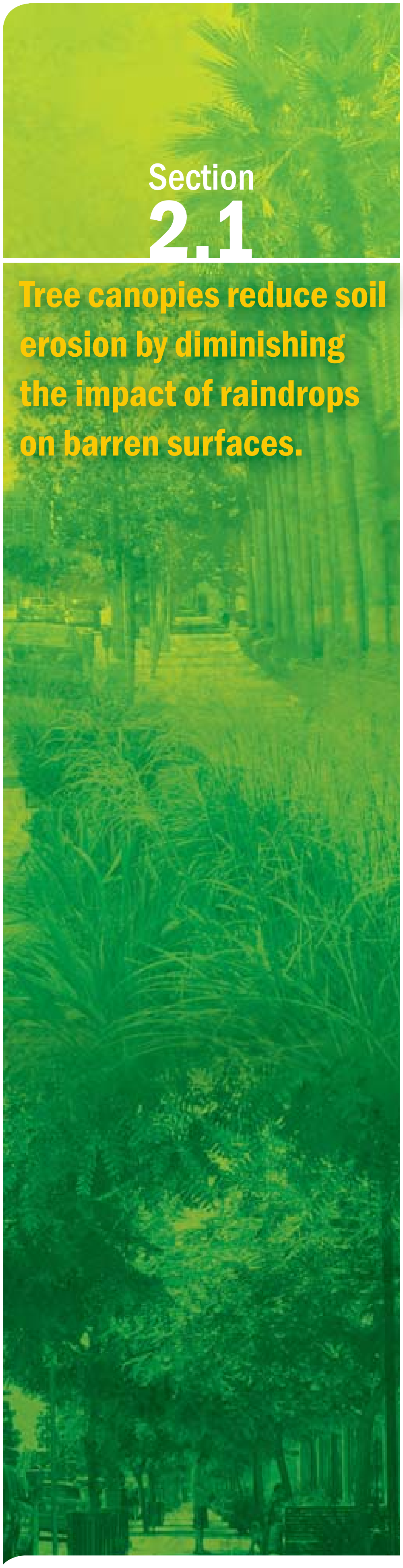
- [ ] Applicant hires Licensed Private Engineer to prepare B-Permit Plans and application
- [ ] Applicant's Private Engineer applies for B-Permit

- [ ] Applicant/Private Engineer pays fee deposit
- [ ] City staff issues BD-Permit
- [ ] Applicant/Private Engineer posts bond and pays total plan check fee amount
- [ ] City staff checks, approves, and transmits approved plans to Private Engineer
- [ ] Applicant obtains liability insurance for construction work and pays inspection fees deposit
- [ ] City staff issues BC-Permit
- [ ] Applicant's contractor calls BCA to begin work
- [ ] Contractor completes major street construction work.
- [ ] BOE & BCA conducts final inspection, City accepts work
- [ ] Private Engineer submits "As-Built" plans to City



SECTION 2: DESIGN STRATEGIES FOR GREEN STREETS AND PARKING LOTS

This section provides a series of fact sheets on Green Street BMPs. Each fact sheet contains a description of the BMP, benefits, design considerations, constraints, typical applications, operations and maintenance, and a profile.



Section

2.1

CANOPY TREES

Tree canopies reduce soil erosion by diminishing the impact of raindrops on barren surfaces.

Description

Urban tree canopy (UTC) is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above. In urban areas, the UTC provides an important stormwater management function by intercepting rainfall that would otherwise run off of paved surfaces and be transported into local waters though the storm drainage system, picking up various pollutants along the way. Studies have shown that an average tree can intercept and absorb hundreds of gallons of water a day.UTC also reduces the urban heat island effect, reduces heating/cooling costs, lowers air temperatures, reduces air pollution, increases property values, provides wildlife habitat, and provides aesthetic and community benefits such as improved quality of life. The City of Los Angeles currently has a tree canopy cover of 21%. The national average for tree canopy cover is 27%.

Trees should be a fundamental element in green street projects. Trees improve stream quality and watershed health primarily by decreasing the amount of stormwater runoff and pollutants that reaches our local waters. Trees reduce stormwater runoff by capturing and storing rainfall in the canopy and releasing water into the atmosphere through evapotranspiration. In addition, tree roots and leaf litter create soil conditions that promote the infiltration of rainwater into the soil. This helps to replenish our groundwater supply and maintain stream flow during dry periods.

The presence of trees also helps to slow down and temporarily store runoff, which further promotes infiltration, and decreases flooding and erosion downstream. Trees reduce pollutants by taking up nutrients and other pollutants from soils and water through their roots, and by transforming pollutants into less harmful substances. In general, trees are most effective at reducing runoff from smaller, more frequent storms.

Benefits

Energy Benefits: Trees provide natural cooling benefits by evaporating water and providing direct shading of surfaces. Planting more trees can help reduce summer air temperatures.

Air Quality Benefits: Trees act as natural filters to remove air pollutants, such as ozone, nitrogen oxides, sulfur dioxide, and ammonia. They also serve as a reduction to global warming through carbon sequestration.

Economic Benefits: Studies have shown that mature trees and well-maintained landscaping can significantly increase property values, as well as, provide a more enjoyable experience in business and shopping districts. Mature existing trees should influence how and where stormwater facilities are designed because trees are often able to soak up water at a rate comparable to a stormwater facility's infiltration. Therefore, it is usually worth reducing stormwater facility size in order to save a mature tree.

Trees protect water resources.

A healthy urban forest can reduce the amount of runoff and pollutant loading in receiving waters in four primary ways:

1) Through evapotranspiration, trees draw moisture from the soil ground surface, thereby increasing soil water storage potential.

2) Leaves, branch surfaces, and trunk bark intercept and store rainfall, thereby reducing runoff volumes and delaying the onset of peak flows.

3) Root growth and decomposition increase the capacity and rate of soil infiltration by rainfall and reduce overland flow.

4) Tree canopies reduce soil erosion by diminishing the impact of raindrops on barren surfaces.

Design Considerations

The Bureau of Street Services is the City department that manages the portion of the urban forest in the public right-of-way of the City of Los Angeles. The Bureau is responsible for determining the proper tree species to be planted, the container size of the tree, and spacing between trees. Bureau forces perform new tree planting, tree removal, and replacement. The Bureau also directs and permits developers, non-profit and community groups, and individuals in tree planting projects. All trees planted require a no-fee plant permit that ensures that the Bureau may maintain the street tree inventory and manage new tree plantings.

Selecting the proper tree species for a particular location is the most critical factor when planting in the public right-of-way. The size of the tree well or parkway, climatic zone, spacing between trees, and proximity to buildings all must be taken into account. Potential impacts to utilities should be identified and reviewed with the appropriate agency. During construction of paved surfaces, the soil around street trees often becomes compacted and minimize as underground utilities intrude on root space. By providing adequate soil volume and a good soil mixture, the benefits obtained from a street tree multiply. To obtain a healthy soil volume, trees can simply be provided larger tree boxes, or structural soils, root paths, or "silva cells" can be used under sidewalks or other paved areas to expand root zones. These allow tree roots the space they need to grow to full size.

A Bureau arborist will conduct an on-site inspection and consultation to determine the proper tree species. The Bureau provides a Street Tree Selection Guide that lists one hundred fifty species approved for the public right-of-way. The guide may be accessed on-line at http://bss.lacity.org/UrbanForestryDivision/StreetTreeSelectionGuide.htm or at the Urban Forestry Division public counter, 1149 South Broadway Street, Suite 1000, Los Angeles, 90012. This list is not all inclusive and other species may be considered.

City of Los Angeles street trees shall be planted using the most current industry standards. Newly planted trees must be staked and tied, provided with a watering moat, and properly watered. Fact sheets regarding proper planting, staking and tying, and watering will be provided with the tree planting permit. These fact sheets and other arboricultural information are available on-line or at the Urban Forestry Division public counter.

Constraints

Along with benefits there are also challenges related to the addition of canopy trees in an urban area. Due to the little space they are given to grow, the most common challenge is that tree roots may have adverse impacts to sidewalk, curbs and gutters, and underground utilities.

Typical Applications

Canopy Trees can be used in high pedestrian traffic areas and where parkway/ sidewalk areas are limited.

O&M

For a 48" box tree, the initial capital cost is typically $2,000 - $2,200. The maintenance cost may be potentially high depending on construction details.

Profile w/description

Section
2.2

VEGETATED SWALES

Swales can be described as landscaped depressions planted with dense vegetation or grass that treat stormwater runoff from rooftops, streets, and parking lots.

Description

Swales can be described as landscaped depressions planted with dense vegetation or grass that treat stormwater runoff from rooftops, streets, and parking lots. As the runoff flows along the length of the swale, the vegetation reduces the flow velocity to prevent erosion and allows it to permeate into the soil. Swales may often include check dams and weirs to help slow and detain the flow, allowing sediments and associated pollutants to settle out. When soils do not drain well, swales are typically lined and convey the flow to a downstream discharge location. This flow typically travels more slowly than it would through pipes in a traditional stormwater conveyance system. Vegetated swales are planted with a mix of native vegetation, such as native trees, shrubs, grasses, and ground cover while grass swales are only planted with dense grass mix.

Benefits

Vegetated Swales are a widely-accepted stormwater strategy that are simple to construct and are generally low cost to implement. They prevent erosion and convey stormwater runoff while also providing water quality treatment.

Design Considerations

Vegetated swales are typically built very shallow and contain runoff a few inches deep. Longer swales yield a greater residence time for slowing and filtering stormwater runoff. They require a minimum 7′ width to provide an adequate area for infiltration while also maintaining a mild slope. As the street slope increases, the ability to retain and convey the stormwater diminishes. A vegetated swale can be used for streets with up to a 5% longitudinal slope for swales. Check dams should be used for swales above a 2% slope to help slow the water flow and maximize retention.

Constraints

Swales are impractical in steep topography or when flows are high as they may be prone to channelization. They need long, continuous spaces which can be difficult to find in retrofit conditions. Utilities in the area may potentially impact the location and it's difficult to incorporate other streetscape elements within swales, such as lighting and signage. Because of their length, it's more difficult to provide good pedestrian circulation through swales. They are also commonly designed to be too deep and, as a result, are not aesthetically pleasing.

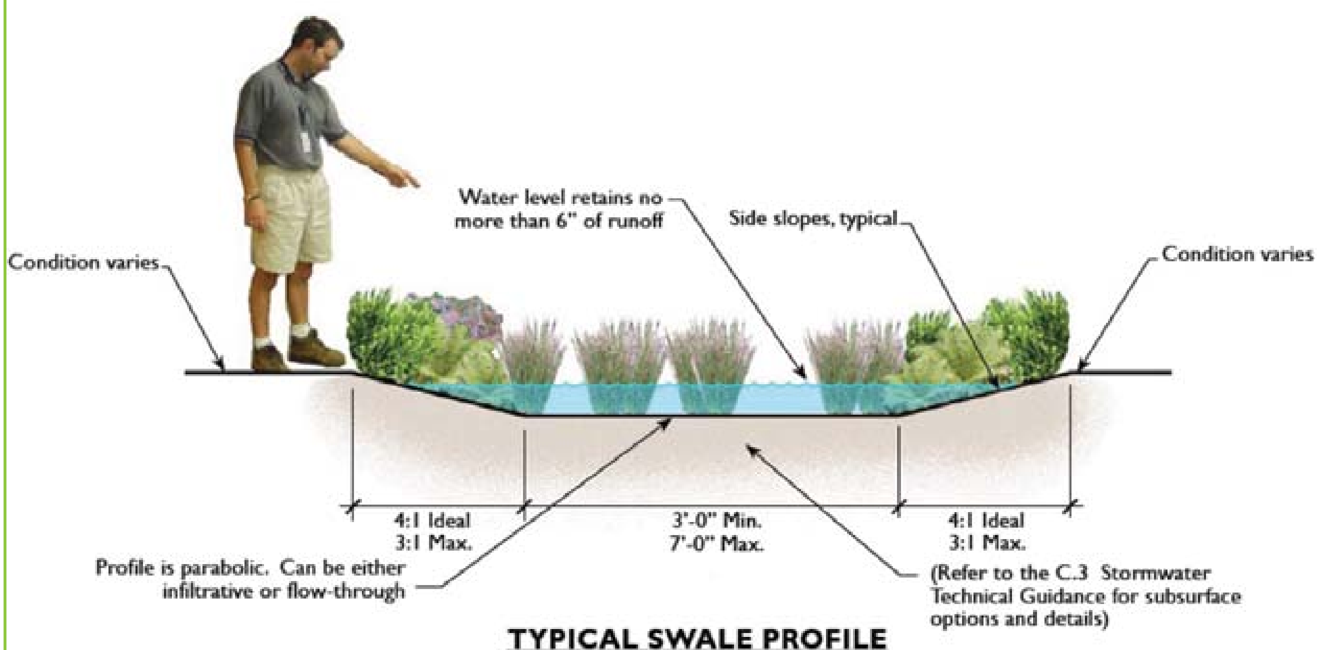
Typical Applications

Swales are ideal for residential and commercial streets with long, continuous space to support a functioning landscape system or oversized parking lots. They are also used for arterial streets and boulevards with unplanted median strips. Many existing streets have unutilized right-of-way space that may be converted into a swale. Parking lot swales are typically situated within the interior and along the perimeter of existing parking lot landscaping. They can also be constructed from leftover space in front of angled parking configurations.

O&M

Swales have an initial cost of 5-15 dollars a square foot. The maintenance cost is relatively low. Adequate plant coverage is necessary to guard against soil erosion. If there is adequate coverage of the swale soils, not all plants that fail to thrive will need to be replaced. Plantings should be replaced if patches of the bare soil begin to emerge. If groups of plants are lost, a different species may need to be considered. It is important to maintain the mulch layer for both moisture retention and weed control. Spring and Fall are excellent times to mulch and prune trees and shrubs where needed. Once plants are established and thriving, periodic trimming, thinning and pruning of plantings and trees may be necessary to ensure that the swale edge is not completely obscured. This is particularly important on narrow rights-of-way so that pedestrians, bicyclists and drivers are aware of the change in elevation between the roadway and the swale.

Profile w/description



Section
2.3

INFILTRATION/ FLOW-THROUGH PLANTERS

Planters are vegetated (i.e., landscaped) shallow depressions that provide storage, infiltration, and evapotranspiration.

Description

Planters are vegetated (i.e., landscaped) shallow depressions that provide storage, infiltration, and evapotranspiration. Planters also remove pollutants by filtering stormwater through plants adapted to the local climate and soil moisture conditions with an engineered soil mix. They are very similar to swales except that the side slopes typically used in swales are replaced with vertical side walls. These walls allow for more storage volume in less space.

There are two types of planters used for stormwater management--infiltration and flow-through planters. Infiltration planters provide stormwater treatment as well as peak flow attenuation and are used where native soil is relatively porous and allow for sufficient infiltration. These planters are more desirable because they allow for greater volume reduction and further ease the burden on local storm drain facilities. For flow-through planter systems, stormwater is captured and treated via filtration through the soil media and root zone and evapotranspiration through the planted vegetation before entering the perforated pipe at the bottom of the planter and discharge back to the storm drain system. Flow-through planters are ideal for areas with steep slopes or low permeability native soils that do not allow for infiltration, contamination, or where the groundwater table is within 10 ft of the surface. They are designed with an underdrain system that routes the treated runoff to the storm drain system rather that depending on infiltration.

Benefits

Stormwater planters are a well-adopted stormwater management strategy that have both volume and flow benefits. They provide a great landscape solution for ultra-urban conditions as they can be used with or without on-street parking and are easily incorporated into retrofit conditions in places where space is limited. Planters can fit between other streetscape elements, such as trees, utilities, and signage, and are highly versatile in shape and size. Their vertical side walls also allow the planters to retain runoff at a maximum volume.

Design Considerations

Planters are typically planted with a palate or mixture of sedges, rushes, trees and shrubs. Because planters have vertical walls, the vegetation used should grow as tall as the planter's walls for aesthetic purposes. They can be used in both relatively flat conditions and in steep conditions if they are appropriately terraced. The soil type used determines whether the planter has an infiltration or flow-through/ underdrain system.

Constraints

Planters are generally more expensive than swales due to increased hardscape infrastructure. If designed to treat roof runoff, multiple installations in series may be required. For streets that require on-street parking, planters need to allow adequate space for people to access their vehicles and sidewalks. They are not applicable near building footprints, fill sites, hillside areas, or where areas are subject to slides or unstable soil. Planters are not a suitable BMP at locations where the seasonal high groundwater table is within 10 feet of the bottom of the facility or the facility is within 100 feet of a drinking water well.

Typical Applications

Planters are most commonly implemented in commercial streets and parking lots where space is often constricted. They are perfect for dense urban streets because they can be built to fit between driveways, rooftops, utilities, trees and other existing site elements. Areas within loop roads, cul-de-sacs, and landscaped parking lot islands are also a common application for planters because they can fit into narrow conditions adjacent to the street curb. Parking lot planters can take the place of a few parking spots or they often are placed in the long, narrow spaces between the front-ends of parking stalls.

O&M

The initial cost usually ranges from 30 to 50 dollars a square foot. Planters require annual plant, soil, and mulch layer maintenance to ensure optimum infiltration, storage, and pollutant removal capabilities. This may include repairing structural damage to flow control structures including inlet, outlet and overflow structures. If an underdrain is present, it should be cleaned periodically to alleviate ponding. Maintenance instructions are provided:

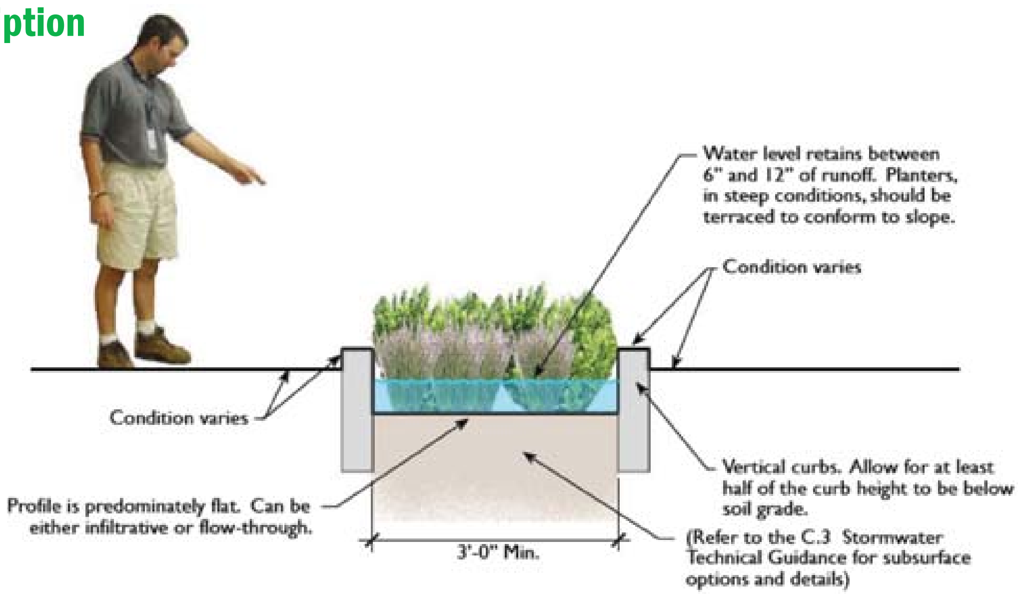
1. **After a major storm (within 24 hours):**

- The planter should drain within 48 hours.
- Remove collected trash.
- Inspect integrity and operations of structural components
- Check if plants are all still firmly rooted.
- Clear debris from inlet and outlet drains.

2. **Regular maintenance (4 times annually, minimum):**

- Remove trash, debris, and sediment accumulation to minimize clogging of infiltration media and interference with plant growth.
- Identify eroded areas and repair with soil and plants.
- Replace mulch annually.
- Plants should be irrigated. The irrigation system should be inspected and maintained as defined by the project specifications.
- Fertilizers should be avoided.
- If infiltration rates have slowed or ponding occurs, excavate and replace planting media, including mulch, soil, and gravels

Profile w/description



TYPICAL PLANTER PROFILE

Section
2.4

PERVIOUS PAVEMENT

Pervious paving systems provide a durable surface that allows rainfall to percolate into an underlying layered structure that stores the water prior to infiltration or drainage to an overflow system.

Description

Pervious paving systems provide a durable surface that allows rainfall to percolate into an underlying layered structure that stores the water prior to infiltration or drainage to an overflow system. They are not considered a treatment measure and 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. Each pavement system is distinctive by methods the surface is made permeable. The process for pouring, setting, and curing these permeable pavements also differ from the impervious versions. All of the pavement systems have a common aggregate foundation which provides load bearing support, stormwater runoff storage, and filtration for pollutant removal. There are four types of pavers that are mentioned in this factsheet which include, pervious concrete or asphalt, joint unit pavers, grass grid pavers, and recycled rubber sidewalks. Pervious concrete and asphalt are formulated with stable air pockets that allow water to drain to the base. Permeable joint pavers allow stormwater to infiltrate through evenly spaced gaps between the pavers' edges. Reinforced grass grid systems also allow rainwater to soak into open pore spaces in the soil medium. Rubber sidewalks infiltrate runoff while providing an alternative to cracked sidewalks resulting from protruding tree roots. The most desirable approach to using pervious paving is to combine these strategies with landscape-based stormwater management whenever possible. Pervious 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.

Pervious Asphalt and Concrete:

Pervious asphalt and concrete is an open void material designed to allow rainwater to filter through paved surface into the ground or a storage container rather than settling on the surface. Their production is similar to that of standard asphalt and concrete. The major disparity is that the fines are left out of the aggregate added to the mixture. The reduced fines result in air pockets within the paving that allows water to drain through the surface. A problem that may arise with using pervious asphalt or concrete paving is that sometimes the forces applied by wheels turning, stopping, and starting tore up the surface and create depressions within parking lot stalls. However, the technology of pervious paving systems is constantly improving, and this may not be as much of an issue with current technology. Pervious asphalt has been used successfully on interstates and other limited access roads where there are no turning vehicles. Compared to conventional asphalt, the use of pervious asphalt on high-speed roads reduces the accumulation of puddles and the danger of hydroplaning. It is also generally less expensive to install than pervious concrete. Pervious concrete is more expensive than conventional concrete; hence, it is economically more viable to use in large batches. Pervious concrete works well for parking lot applications and low volume streets. Regular maintenance of pervious asphalt and concrete is required for the long-term viability of the paving system.

Pervious Joint Unit Pavers:

Unit pavers are impermeable blocks made of brick, stone, or concrete that creates a pervious surface if there are spaces between them filled with sand or other porous aggregate to allow water to percolate downward. Unit pavers provide a hardscape alternative to stormwater treatment BMPs and are often designed specifically for stormwater management applications. They allow water to pass through joint gaps that are filled with sand or gravel and infiltrate into a thick gravel subgrade. This system is widely applicable to both small and large paving applications and it offers the flexibility to be repaired because small sections can be removed and replaced. Interlocking concrete unit pavers offer flexibility in color, style, joint configuration, and paving pattern. It is important to note that selected pervious joint pavers along pedestrian walkways must be ADA-compliant and not cause tripping hazards. When installing pervious joint pavers, care should be taken to assure that the base and subgrade is properly constructed in order to minimize the potential for differential settlement. Pervious joint paving tends to be more costly to install than other pervious paving systems.

Reinforced Grass Grid Pavers:

Grass pavers are a type of open-cell unit paving grid whereby the cells are filled with soil and planted with vegetation. The cell matrices are typically made of concrete or a durable synthetic material. In the right situations, grass paving, or other hybrids between paving and planting, can be used to allow infiltration of stormwater runoff to the underlying soil media while providing structural support for the weight of traffic and concentrated loads. These systems may be appropriate in areas of low use and where soil, drainage, sunlight, and other conditions are conducive to plant growth.

Recycled Rubber Sidewalks:

Originally used as alternatives to cracked sidewalks from protruding tree roots, rubber sidewalks are typically made of recycled rubber from waste tires and are considered as another form of porous pavers to infiltrate runoff. Its use as stormwater quality improvement that is currently very limited. Its main benefit is the use of recycled rubber from tires.

Benefits

Pervious paving systems reduce the size of stormwater treatment measures and often are the only viable option in ultraurban conditions or in parking lots that are interiorly drained. In addition to maximizing infiltration, pervious pavers provide retention and slowdown runoff. When implemented into high traffic streets, pervious pavers should decrease vehicular accidents rooted to rainwater due to its minimal impervious land coverage.

Design Considerations

Generally, soil infiltration rates that exceed or meet the accepted standard of 0.5″/hr are suitable for pervious paving systems. When installing pervious asphalt and concrete, it is critical that the subgrade is properly prepared and that the surface is poured correctly. As with conventional paving, if pervious asphalt and concrete are not properly installed, they are prone to failure. Sealant applications should never be used to prevent clogging. Also, once installed, both pervious asphalt and concrete tend to be difficult to patch repair because the paving mixture is typically made in large batches. Pervious paving should not be used in situations with known soil contamination such as fill sites and compacted soil. They also shouldn't be located in areas with a high groundwater table. The bed bottom must be kept level to avoid ponding.

Constraints

Pervious pavers also require well-drained native soil and have limited infiltration effectiveness on street slopes over 5%. The installation cost is relatively high due to the complication of aggregate mixture and setting method. These paving systems can also be difficult to maintain and difficult to repair in small batches if using porous concrete and asphalt.

Typical Applications

Pervious paving systems are ideally used on roadways with low-traffic speeds and volumes, but there are successful examples of pervious asphalt and concrete employed on high-traffic streets. They are also commonly implemented in parking lots, alleys, and trail systems. Residential driveways can adopt these paving systems as well as sidewalks depending on material and ADA-compliance.

O&M

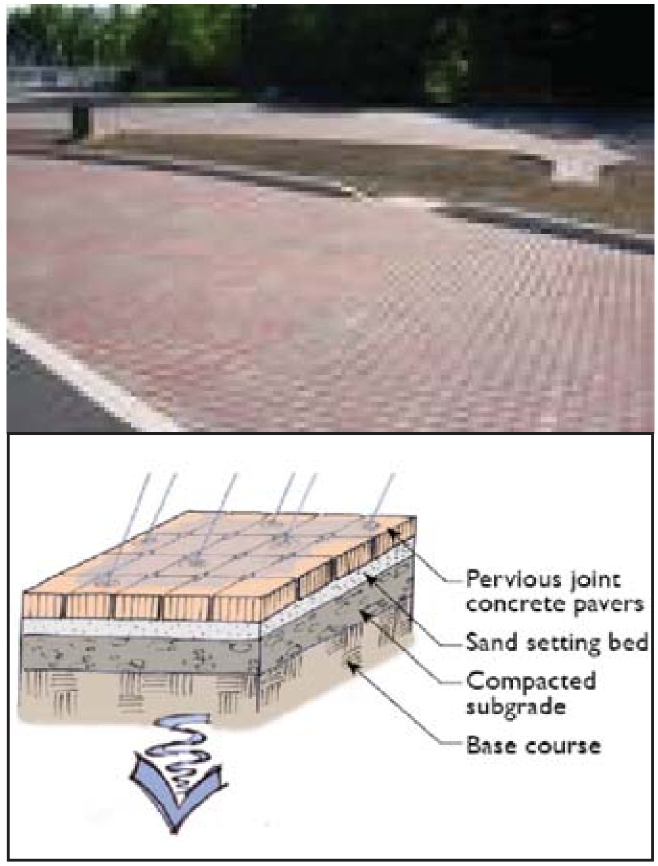
Type of Pervious Pavement	Initial Cost
Concrete or Asphalt	$10/sf - $20/sf
Joint Unit Pavers	$10/sf - $20/sf
Grass Grid Pavers	$5/sf - $10/sf
Recycled Rubber Sidewalk	$24/sf - $30/sf

For maintenance, vacuum cleaning the pervious paving system on a regular basis is imperative to limit the amount of sediment clogging the pore spaces. The surface of pervious asphalt and concrete pavement should be swept with a high-efficiency and should be supplemented with high pressure hosing when necessary. Regular vacuum cleaning of the paver joints will help prevent clogging and extend the longevity of the system. Over the course of use, the paver aggregate may also need replenishment for proper use.

Maintenance instructions are provided:

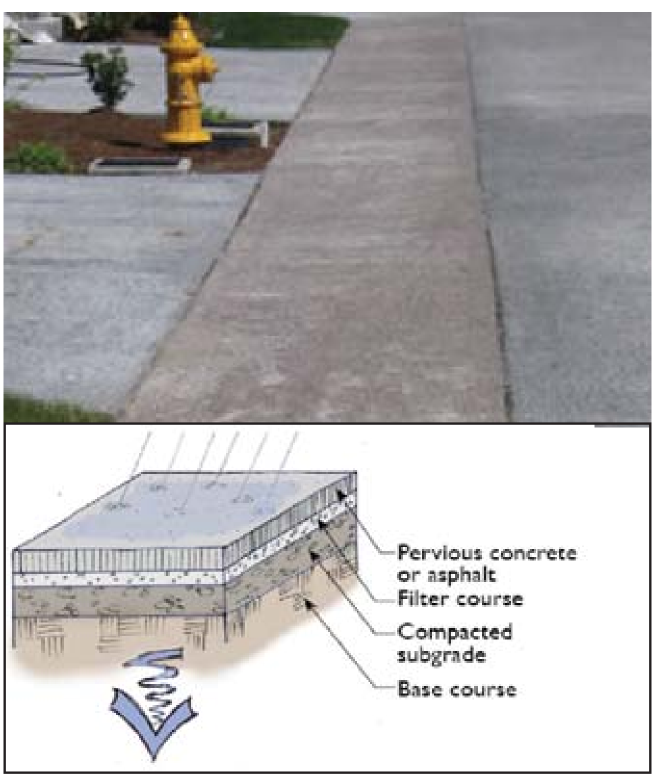
1. After a major storm (within 48 hours):
   - Check for standing water at or below the surface of the permeable pavers.
   - Check surface stability. Repair subgrade if pavers are loose or wobbly.
2. Regular maintenance (4 times annually, minimum):
   - Keep surfaces clean and free of trash, debris, and sediment accumulation.
   - Sweep surfaces regularly
   - Fill joints between pavers with specified granular material.
   - If ponding or poor infiltration persists, remove and replace the subgrade drainage

Pervious Joint Unit Pavers Diagram

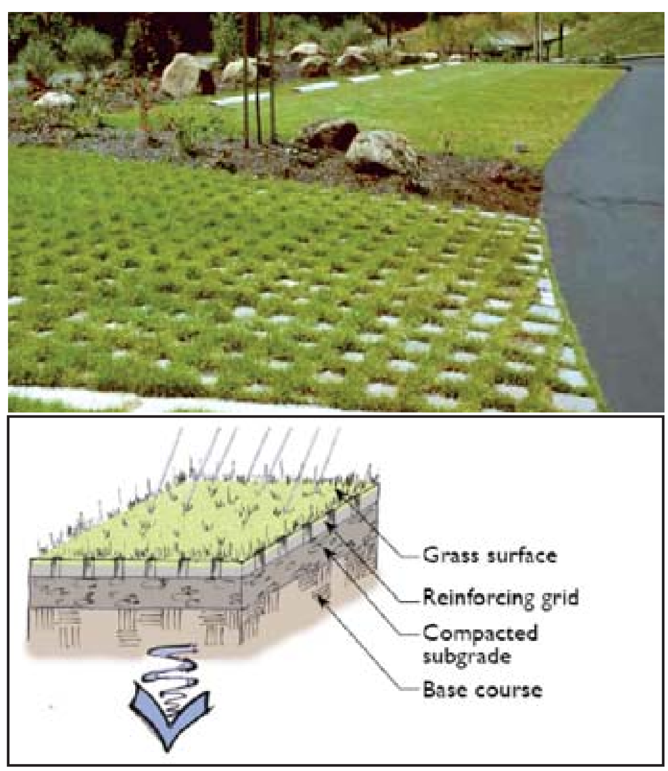


Profile w/description

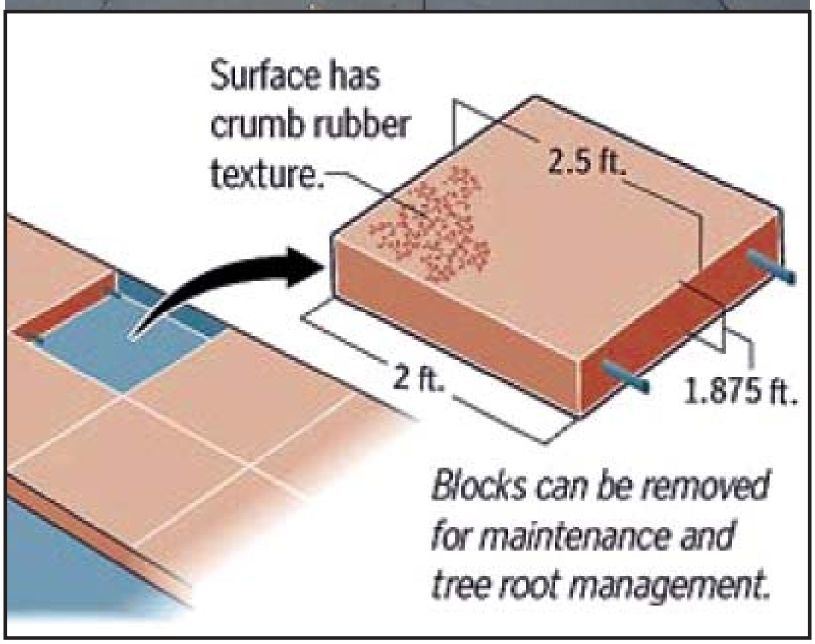
Pervious Concrete/Asphalt Diagram



Reinforced Grass Paving Diagram



Recycled Rubber Sidewalks Diagram



Section
2.5

INFILTRATION TRENCH

An infiltration trench is a long, narrow, rock-filled trench bordered on each side by a grass or vegetated buffer.

Description

An infiltration trench is a long, narrow, rock-filled trench bordered on each side by a grass or vegetated buffer. Runoff is stored in the void space between the stones and infiltrates through the bottom into the soil matrix. Infiltration trenches perform well for removal of fine sediment and associated pollutants. The buffer strips provide pretreatment to limit the amounts of coarse sediments entering the trench which can cause clogging.

Benefits

Infiltration trenches provide a 100% reduction in the load discharged to surface waters. Another important benefit is the approximation of pre-development hydrology during which a significant portion of the average annual rainfall runoff is infiltrated rather than flushed directly to creeks. If the system is adequately sized, infiltration trenches can be useful for providing control of channel forming (erosion) and high efficiency (generally less than the 2-year) flood events. As an underground BMP, infiltration trenches are unobtrusive and have little impact of site aesthetics.

Design Considerations

Sites suitable for infiltration generally have soil percolation rates of 5-10 inches/hour. If the percolation rate is less than 5.0 inches/hour, but the native soil is Hydrologic Soil Group A or B (> 0.5 inch/hour), direct infiltration can still be an effective strategy without soil amendments. A geotechnical investigation should be performed to determine soil infiltration rates and other site conditions. The maximum contributing area to an individual infiltration practice should generally be less than 5 acres. Water quality inlets or catch basins should be provided for pretreatment. The slope of the area should be level or have a 1% maximum slope. Soils should be tested according to set infiltration guidelines to verify that they are not compacted. Discharge should be designed for anticipated flows with a minimum cover over pipe of 12 inches. The trench's top, bottom, and sides should be wrapped with unwoven geotexiles and contain a minimum of 6 inches of topsoil placed over the trench. The trenches are limited to a width of 3 to 8 feet and to a maximum stone depth of 6 feet. Groundwater depths less than 10 feet below ground surface should be avoided.

Constraints

Infiltration trenches have a high failure rate if the site has a soil infiltration rate less than 0.5 inches/hour or have hydrologic soil types C or D. Generally, infiltration trenches are not suitable on fill sites or steep slopes. Projects should not be located in areas on hillsides and areas subject to slides or unstable soil. Infiltration trenches are difficult to restore once they are clogged. The upstream drainage area must be completely stabilized before construction.

Typical Applications

Infiltration trenches are appropriate for urban applications with large roof areas, especially in right-of-ways and/or street medians due to its long, narrow configuration.

O&M

The initial cost for infiltration trenches are approximately $25 per square foot to $50 per square foot. Another cost concern associated with infiltration trenches is the maintenance burden and longevity. If improperly sited or maintained, infiltration trenches have a high failure rate. In general, maintenance costs for infiltration trenches are estimated at between 5 and 20 percent of the construction cost. The principal maintenance objective is to prevent clogging, which may lead to trench failure. Infiltration trenches and any pretreatment BMPs should be inspected after large storm events and any accumulated debris or material removed. A more thorough inspection of the trench should be conducted at least annually. Annual inspection should include monitoring of the observation well to confirm that the trench is draining within the specified time. Cleanouts and inlets should be provided for maintenance. In addition to reduced water quality performance, clogged infiltration trenches with surface standing water can become a nuisance due to mosquito breeding.

Profile w/description

Section 2.6

STORMWATER CURB EXTENSIONS

Trees placed in urban areas can significantly contribute to the slowing, Stormwater curb extensions are similar to infiltration or flow-through planters in that they capture stormwater runoff from streets and driveways nearby.

Description

They are landscaped areas within the parking zone of a street that capture the runoff while seeping into the plants and soil to help filter contaminants. They are enclosed by a curb on the street side, which has openings, called “curb cuts”, that allow street runoff to enter and exit the facility. Extending into the street from the curb narrows the road width which also increases pedestrian safety and helps calm traffic similar to conventional curb extensions (that are commonly known as bulb outs, bulges, chicanes, or chokers). A stormwater curb extension allows water to flow into the landscape stormwater space that can be designed with the physical characteristics of vegetated swales, planters, or rain gardens.

Stormwater curb extensions are attractive additions to the neighborhood, improve the urban environment, and increase pedestrian safety at the intersection. Curb extensions can be implemented in a variety of land uses from low-density residential streets to highly urbanized commercial streetscapes. The small footprint allows for an efficient stormwater management system that often performs very well for a relatively low implementation cost.

Benefits

Stormwater curb extensions can significantly “green” a street with minimal investment as they are inexpensive to build depending on the local land use context. They provide flexibility in both shape and size to conform to site conditions. For steep streets, curb extensions are beneficial because they operate as a “backstop” to capture stormwater runoff from upstream flows. The extension of the curb narrows portions of a street and provide traffic calming benefits additional to pedestrian safety.

Design Considerations

For use in green street applications, curb extensions should have check dams installed for street slopes over 2%. For streets slopes over 5%, the interior of the curb extensions should be terraced with check dams and act more as a series of planters. Stormwater curb extensions can be planted with a variety of trees, shrubs, grasses and groundcovers, depending on site context and conditions. The following design factors should be considered:

- Size of catchment area
- Dimensions of the curb inlet
- Internal Storage Volume
- Overflow Provisions
- Street Slope
- Check Dams
- Street Type
- Existing Subgrade Conditions

Constraints

The most significant constraint when implementing stormwater curb extensions into street design is the potential traffic impact and loss of on street parking space particularly in business districts. Additionally, a conflict with bike travel may arise if adequate space is not allowed between edge of curb extension and a street's travel lane. Geotechnical investigation is also required since infiltration rate depends on site condition. Curb extensions are not suitable on fill sites, where groundwater depth is less than 10 ft below ground surface, where project is located in hillside areas or where areas are subject to slides or unstable soil.

Low-Density Residential Conditions

Existing residential streets offer some of the best opportunities to convert a portion of the street's parking zone into stormwater curb extensions. Residential streets are prime candidates for stormwater curb extension retrofits since utilizing the parking zone to capture stormwater often may have little or no parking impact to residents.

A pair of stormwater curb extensions installed along a low-density neighborhood street.

Stormwater curb extensions in low-density residential areas can often be installed with minimal impact to existing infrastructure. In some cases, the curb extensions can be designed so that the existing street curb and stormwater inlets can be left in place.

High-Density Residential/ Urban Conditions

In areas where on-street parking is fully utilized, smaller stormwater curb extensions, spaced more frequently, can be used to minimize parking loss to any individual property. It is important, though, that they are appropriately sized to handle the amount of stormwater runoff from the catchment area.

Accessible pedestrian ramps can also be integrated into the design of stormwater curb extensions.

In many urban examples, there are streets striped with "no parking" zones that could be converted into stormwater curb extensions without any loss of parking. There are also instances where existing curb extensions that are paved with concrete or have landscaping can be redesigned to manage stormwater.

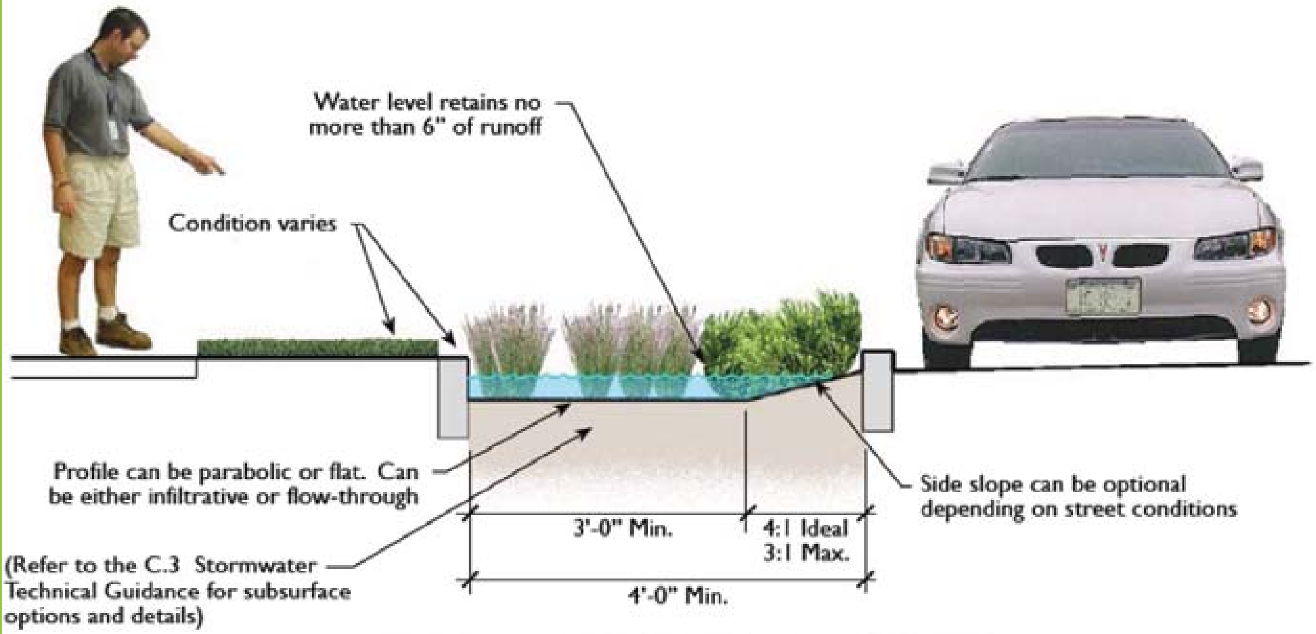
This large stormwater curb extension provides a safer intersection and enhanced bus stop.

Stormwater curb extensions can also be designed on streets with an angled parking configuration. Accessible pedestrian ramps can also be integrated into the design of stormwater curb extensions to provide safer pedestrian crossings.

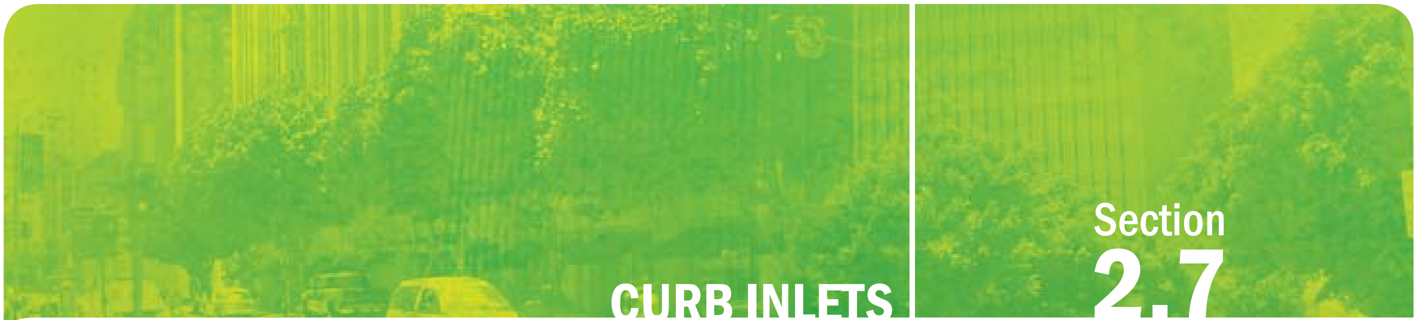
O&M

Stormwater curb extensions typically have an initial cost of 30-50 dollar per square foot. Maintenance includes hand weeding (no chemical applications are allowed), plant trimming, plant replacement, and sediment and debris removal. The curb extension will require maintenance during the 2-year plant establishment period. Long-term maintenance could average 4 times per year. A permanent irrigation system is not required as the curb extension will be vegetated with drought tolerant plants.

Profile w/ description



TYPICAL CURB EXTENSION PROFILE



CURB INLETS

Description

Biotreatment curb inlets are installed upstream of an existing catch basins. It treats runoff via filtration through the engineered soil media before discharging to the downstream existing catch basin. High volumes of stormwater will bypass the biotreatment curb inlet, if full, and flow directly to the inlet. They are well suited for the urban environment and add green space while providing stormwater runoff treatment. Biotreatment curb inlets remove pollutants through the same biological, chemical, and physical mechanisms as bioretention cells .These curb inlets resemble typical urban street tree planters that are installed below grade along a curb line. They consist of a pre-cast concrete container, a mulch layer, bioretention media, observation and cleanout pipes, underdrain pipes, and a single tree or large shrub.

Percolation curb inlets are modified catch basins that allow infiltration of runoff. New catch basins can be designed and constructed with either perforated or no bottom. Existing catch basins can be retrofitted by drilling holes onto the floor.

Design Considerations

Biotreatment curb inlets can receive stormwater runoff from streets and parking lots, as long as a downstream inlet or outfall is present. All land uses are suitable. To treat 90 percent of the annual runoff volume, the surface area of a biotreatment curb inlet should be approximately 0.33 percent of the drainage area. Tree boxes must be regularly spaced along the length of a corridor to meet the annual treatment target. Plants should be selected based on local recommendations for street trees highly tolerant of high stress conditions. Natives are preferred. A curb inlet must be located downstream of the tree fox filter(s) to intercept bypass flow. A decorative grate is typically used to protect the device and the plant, as well as to intercept large debris. Pretreatment under normal conditions is not necessary. Biotreatment curb inlets are off-line devices and should never be placed in a sump position (i.e. at a low point). Instead, runoff should flow across the inlet. Also, biotreatment curb inlets are intended for intermittent flows and must not be used as larger event detention devices.

Constraints

Biotreatment curb inlets require careful selection of plant palette as the majority of these installations do not include irrigation system. Native drought tolerant plants are preferred.

Percolation curb inlets are not suitable on fill sites. Infiltration rate depends on site condition and requires geotechnical investigation. There are not applicable where groundwater depth is less than 10 ft below ground surface, where project is located in hillside areas, or where areas are subject to slides.

Biotreatment curb inlets are installed upstream of an existing catch basins. It treats runoff via filtration through the engineered soil media before discharging to the downstream existing catch basin.

Typical Applications

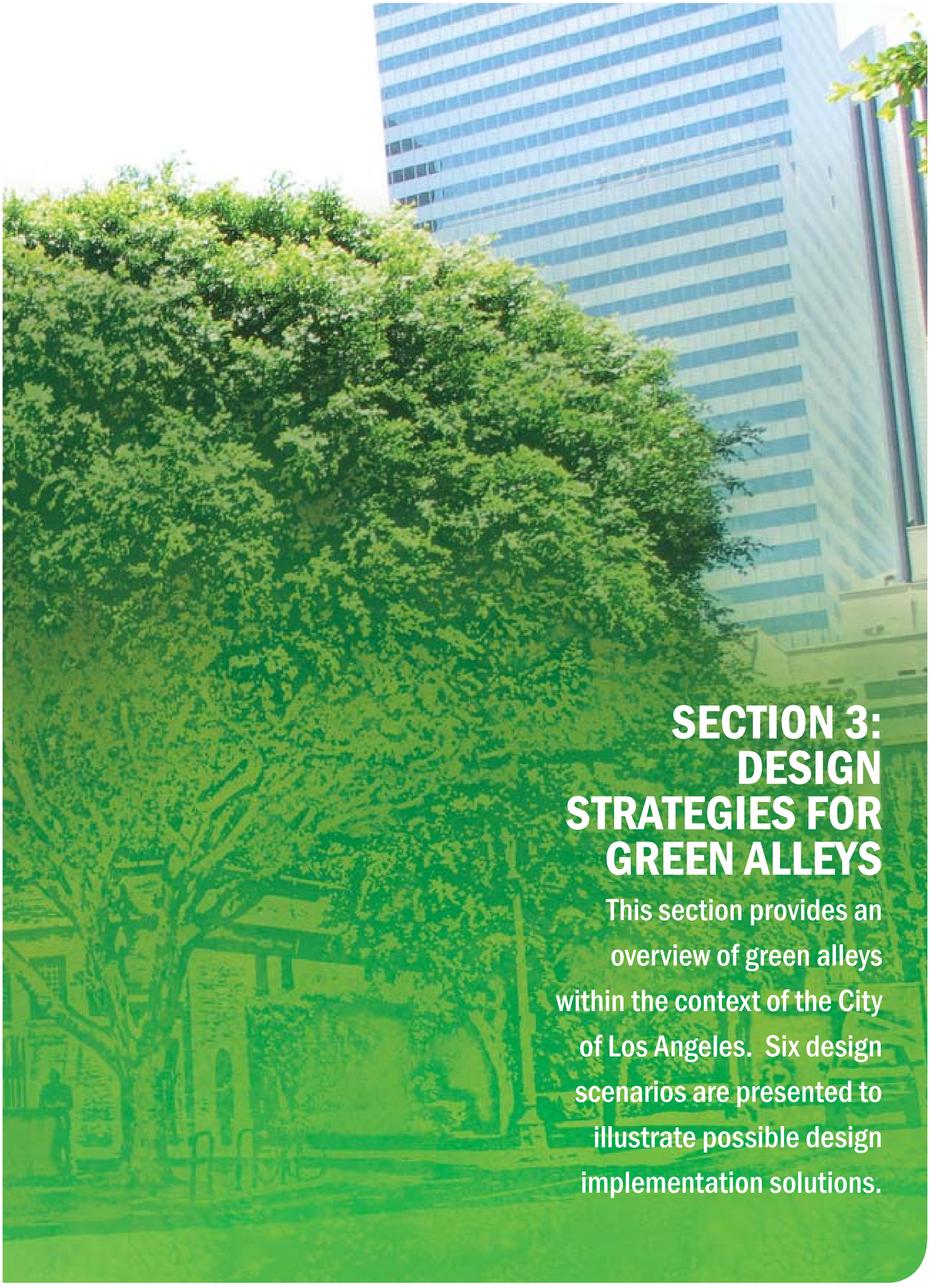
Biotreatment curb inlets are well suited for commercial, industrial, and ultra urban environments. Percolation curb inlets are applicable where native soil exhibit suitable infiltration rate. Biotreatment curb inlets can reduce the runoff volume and peak discharge rate for small, frequently-occurring storms by capturing the water quality volume (WQV). They are not intended to capture volumes larger than the WQV, or to detain the WQV for extended periods of time. Volumes larger than the WQV can be detained in a subsurface storage system downstream such as a gravel bed.

O&M

Biotreatment Curb Inlets typically have an initial cost of $10,000-$30,000 each. Percolation Curb Inlets have an initial cost of $5,000-$10,000 each. For Maintenance, periodic regular removal of trash and debris is required, preferably at least seasonally and after severe storm events. Replenishment of the mulch layer is recommended once or twice annually. Inspect the tree box regularly for clogging and flush via the cleanout, if needed. During extreme droughts, water the tree or shrub just as any other landscape plants.

Profile w/description

Bioretention Curb Inlet



SECTION 3: DESIGN STRATEGIES FOR GREEN ALLEYS

This section provides an overview of green alleys within the context of the City of Los Angeles. Six design scenarios are presented to illustrate possible design implementation solutions.

Section
3.1

GREEN ALLEY OVERVIEW

Chicago alley with impermeable pavement and poor drainage

Chicago alley retrofitted with permeable pavement

There are over 900 linear miles of alleys in Los Angeles, in the form of over 12,000 alley segments. Alleys are widely distributed across the city but especially concentrated in the South (26.9% of the total alleys in Los Angeles), the San Fernando Valley (26.7%), and the Metro (20.8%) subregions of Los Angeles . To put the scope of the alley network in perspective, it is roughly half the size of the largest municipal park in the nation, Griffith Park (4,100 acres)1.

Other cities around the world have recognized the value of alleys and in many great cities they are walkways with storefronts. In Chicago, the Mayor initiated a Green Alleys project, to resurface its alleys with environmentally friendly materials, including permeable asphalt and/or concrete. Chicago launched its program with six pilot projects in 2006, and has since resurfaced 15 to 20 alleys per year, with 30 expected to be completed by 2008.

Alleys are often considered a nuisance but could be an asset, with great potential as open space amenities. Simple infrastructure changes such as using permeable pavement or adding bioswales in alleys will reduce urban runoff, recharge groundwater, and improve water quality in streams, rivers, and coastal waters. Incorporating green infrastructure into traditional urban alleys offers the following benefits[1].

Improving water quality and supply

Creating recreational opportunities

Alleys are a vital land resource in many park-poor neighborhoods. Transforming alleys into walkable, bikeable, playable spaces can supplement scarce park resources by using existing underused infrastructure.

Encouraging neighborhood walkability and connectivity

Active, green alleys can provide connections between parks, schools and neighborhood centers. Converted alleys will encourage people to walk rather than drive when making trips to stores, parks, and other nearby destinations.

Greening the Urban Matrix

Planting drought-tolerant, California-friendly plants in combination with permeable pavement will create shade, retain rainwater, reduce the heat-island effect and provide habitat for native species.

Reducing crime

Many residents perceive alleys as unsafe. Improving lighting and making alleys attractive will help address safety concerns and encourage their use.

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[1] *Transforming Alleys into Green Infrastructure for Los Angeles. USC Center for Sustainable Studies.*

Green Alleys Subcommittee

Alleys, which are concentrated in flood-prone, park-poor communities, constitute a major opportunity to create green infrastructure to support watershed health, community interaction, and physical activity.

The Green Alleys Subcommittee was recently established by the Green Streets Committee to identify alleys in Los Angeles that could become pilot projects for a green retrofit. They are also investigating funding opportunities. The subcommittee is comprised of members from the Board of Public Works; Bureau of Sanitation; Community Redevelopment Agency; Department of Planning; and USC Center for Sustainability. The Community Redevelopment Agency will be piloting Green Alleys for its project areas.

USC is a participant in this Subcommittee due to their ongoing initiatives in this area. The USC Center for Sustainable Cities undertook a major research project on alleys in the City of Los Angeles. They conducted physical audits of 300 alleys across the city, studied behavioral activity patterns in alleys, analyzed soil pollution levels in alleys, and held focus groups with residents to better understand attitudes and concerns about alleys. Their findings suggested that alleys, which are concentrated in flood-prone, park-poor communities, constitute a major opportunity to create green infrastructure to support watershed health, community interaction, and physical activity. On the basis of these findings, the Center is collaborating with the Departments of Public Works, Planning, Recreation and Parks, and CRA to develop policy and program ideas, and potential demonstration projects, for alley greening.

Section

3.2

GREEN ALLEY PROGRAM

In order to have a baseline measurement to compare the costs of different green alley solutions against the one another and the standard alley treatment, a standard base template was used.

The following scenarios were developed by Ah'be landscape architects in coordination with the Department of Public Works, as possible design implementations solutions for the developing green alley program. In order to have a baseline measurement to compare the costs of different green alley solutions against the one another and the standard alley treatment a standard base template was used, shown in figure 3.1, that represents a 75' long section of a 20' wide alley. The alley must maintain vehicular access, including heavy truck loads such as garbage trucks. The alley also has two driveway entries that must also be preserved. For each scenario a basic cost estimate is provided. Each alley is assumed to be new construction unless otherwise indicated.

Cost Estimate

Material	Unit	Unit Cost	Quantity	Total
8" Asphalt paving (includes 12" CMB)	SF	$9.75	1350	$13,162.50
Concrete Swale	SF	$22.00	150	$ 3,300.00
			Total	$16,462.50
			Avg. cost per SF	$ 10.98

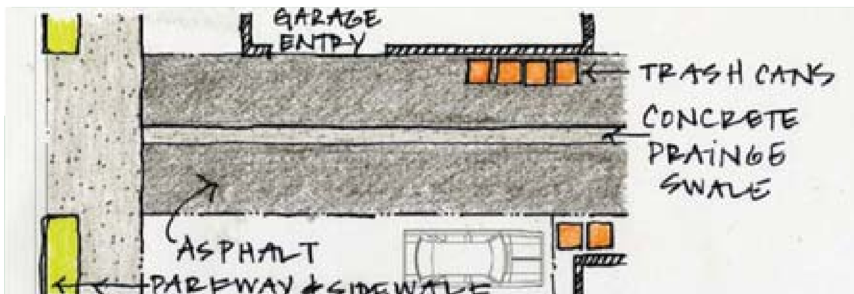


Figure 3.1: Standard Alley designed with a black top asphalt surface and a concrete drainage swale running down its center.

Green Alley Scenario 1

For alleys where storm water BMP's cannot be integrated, other 'sustainable goals' can be addressed, such as reducing the urban heat island by including materials with a high albedo rate (limited solar heat gain) and using recycled and/or locally manufactured paving surfaces that replace asphalt with “green paving alternatives”.

These methods should be implemented while also maintaining existing drainage.

Possible Materials

Regular Concrete: The light grey color of standard Portland concrete cement has a high albedo rate.

White Concrete Cement: With an even higher albedo rate, white concrete cement is made up of materials that are naturally low in iron and manganese. White Photocatalytic Cement: A hydraulic binder that's made with Titanium dioxide, is added to the mix that has photocatalystic properties allowing the concrete to respond to UV rays in sunlight and causing accelerated oxidation, ultimately speeding up the rate the concrete will decompose pollutants it comes into contact with. This means that it not only will stay white, but by self cleaning itself it digests pollution.

Green Mix Foamed Asphalt: This asphalt mix is produced with 100% recycled asphalt pavement and involves a cold mixing process. The energy used in making it is significantly less than the standard hot mix process and has no greenhouse gas emissions.

Rubber Asphalt: Rubber asphalt has a porous top layer that cools down quicker than concrete, which cools our roads and diminishes the heat island effects. It significantly decreases noise levels while reducing maintenance cost and increasing pavement life. The material also improves resistance to cracks and skids.

NaturalPAVE XL Resin Pavement: This paver is a non-petroleum, versatile material that is mixed with aggregate materials to produce compacted pavement surfaces that retain natural coloration and texture. It can also be used to cover up existing asphalt and has a high albedo rate.

Cost Estimate

Material	Unit	Unit Cost	Quantity	Total
Natural Grey Concrete	SF	$5.00	1500	$ 7,500.00
Standard Alley cost	1	$16,462.50	1	$16,462.50
			Total	$23,962.50
			Avg. cost per SF	$ 15.98

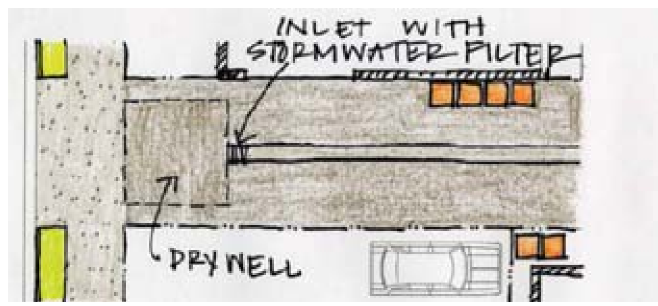
Standard Alley with 2" white top treatment options added to surface

Material	Unit	Unit Cost	Quantity	Total
Natural Concrete Cement	SF	$11.00	1500	$16,500.00
Standard Alley cost	1	$16,462.50	1	16,462.50
			Total	32,962.50
			Avg. cost per SF	$ 21.98

Cost estimate for white top alley constructed new

Material	Unit	Unit Cost	Quantity	Total
Natural Grey Concrete Cement	SF	$12.00	1500	$18,000.00
Concrete Drainage Swale	LF	$22.00	150	$ 3,300.00
			Total	$21,300.00
			Avg. cost per SF	$ 14.20

Green Alley Scenario 2



This scenario maintains the existing central drainage swale while adding a dry well with a grease interceptor downstream at the end of the alley.

Cost estimate for standard alley with drywell

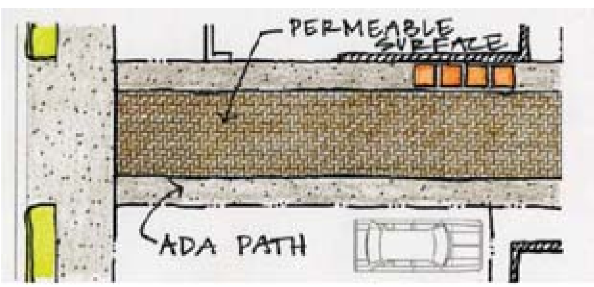
Material	Unit	Unit Cost	Quantity	Total
8" Asphalt paving on 12" CMB	SF	$9.75	1370	$13,357.50
Concrete Swale	SF	$20.00	130	$ 2,600.00
Drywell* (includes excavation, debris removal and all new construction material (graded drain rock and geotextile fabric)	EA	$22,000.00*	1	$22,000.00*
Stormcepter filtration system	EA	$20,000.00	1	$20,000.00
			Total	$57,957.50
			Avg. cost per SF	$ 38.64

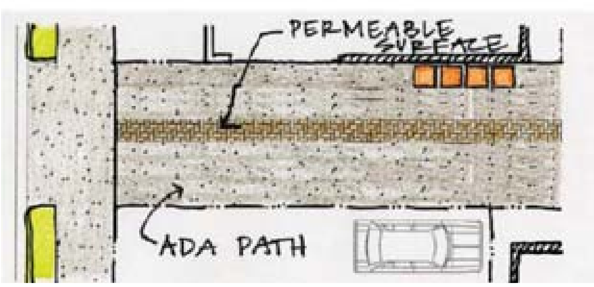
Cost of adding a dry well to an existing alley

Material	Unit	Unit Cost	Quantity	Total
Demolition of existing alley	SF	$3.00	1500	$4,500.00
Drywell* includes excavation, debris removal and all new construction material (graded drain rock and geotextile fabric)	EA	$22,000.00*	1	$22,000.00*
Stormwater filtration system	EA	$20,000.00	1	$20,000.00
			Total	$46,500.00
			Avg. cost per SF	$31.00

**Note: The cost of the dry well will be dependant of its size. Size of drywell is based on water shed area and the desired volume of water to be stored. The above cost was estimated conservatively.*

Green Alley Scenario 3





In scenario 3, permeable paving surfaces are implemented to reduce storm water runoff and increase infiltration rates. Maintaining an ADA compliant path of travel is vital when designing green alleys. Layout configuration and percentage of coverage can be adjusted for multiple configurations.

For example:

- On alleys with a central swale limit permeable surface to central area.
- On alley with a crowned surface limit permeable surfaces to outside perimeters.
- Permeable surfaces could also run perpendicular to intersect sheet flow runoff.

Permeable Paver options:

- SF-Rima provides a sturdy pavement that is suitable for heavy loads while reducing stormwater runoff and decreasing flooding.
- Permeable Holland pavement provides a variety of patterns and is ADA compliant.
- Both pavers are available from Angelus Block Company. www.angelusblock.com
- Permapave Permeable Pavers are natural stone pavers, which contain an underlying stone reservoir that stores surface pollution or runoff before infiltrating into the soil. Pavers have a flow through rate of up to 30 liters per second, removing 100% of gross pollutants from stormwater as it passes through the substrate. This paver is not currently suitable for heavy load traffic or available in southern California, but their products appear excellent and should be followed up with in the future. More information of this product can be found on www.permapave.com.

Cost estimate for permeable alley with two 4' wide concrete walks on either side

Material	Unit	Unit Cost	Quantity	Total
Permeable Paver (includes bedding material and geotextile fabric)	SF	$15.00	900	$13,500.00
Concrete Paving	SF	$12.00	600	$7,200.00
			Subtotal	$20,700.00
			Avg. cost per SF	$13.80

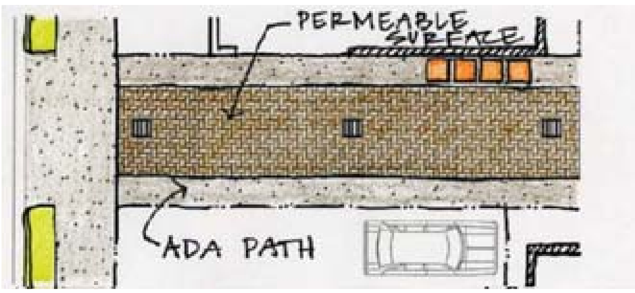
Cost estimate for concrete alley with 4' wide permeable band along the center of the alley

Material	Unit	Unit Cost	Quantity	Total
Permeable Paver Swale (inc ludes bedding material and geotextile fabric)	SF	$15.00	300	$4,500.00
Concrete Paving	SF	$12.00	1200	$14,400.00
			Subtotal	$18,900.00
			Avg. cost per SF	$12.60

Cost estimate for standard asphalt alley with 4' wide permeable band along the center of the alley

Material	Unit	Unit Cost	Quantity	Total
Permeable Paver Swale (ivncludes bedding material and geotextile fabric)	SF	$10.00	300	$3,000.00
8" Asphalt Paving (includes 12" CMB)	SF	$9.75	1200	$11,700.00
			Subtotal	$14,700.00
			Avg. cost per SF	$9.80

Green Alley Scenario 4



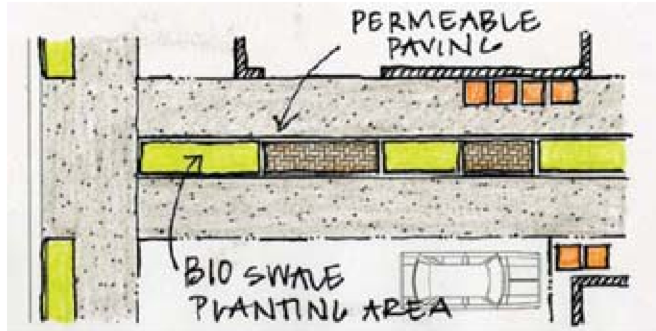
Scenario 4 combines scenario 2 and 3 with smaller drywells. At minimum, there should be a dry well located at each end of the alley and 1 every 75-100 LF of drainage area.

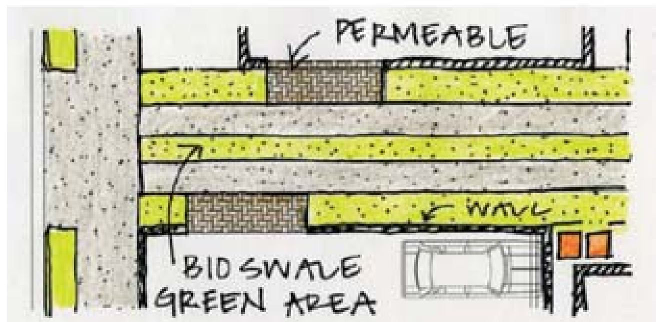
Cost estimate for permeable alley with two 4' wide concrete walks on either side

Material	Unit	Unit Cost	Quantity	Total
Permeable Paver (includes bedding material and geotextile fabric)	SF	$15.00	900	$13,500.00
4' wide 6" concrete walkway	SF	$12.00	600	$7,200.00
Drywell*	EA	$22,000.00*	1	$22,000.00*
			Subtotal	$42,700.00
			Avg. cost per SF	$28.47

**Note: The cost of the dry well will be dependant of its size. Size of drywell is based on water shed area and the desired volume of water to be stored. The above cost was estimated conservatively.*

Green Alley Scenario 5





In Scenario 5, a biofiltration system is adopted to treat storm water and create a "greenscape". Biofiltration is the removal and oxidation of organic gases by method of beds made of compost or soil. Variations of the percent of surface to be permeable based on desired infiltration area could fluctuate but will impact cost and design appearance.

Any bio-areas (with planting suitable for infiltration) will need watering for an establishment period. Irrigation could be provided from a variety of sources and is considered optional but highly recommended for plant survival.

Cost estimate for a 5' wide central bio-swale (Access is provided across bio-swale at key locations)

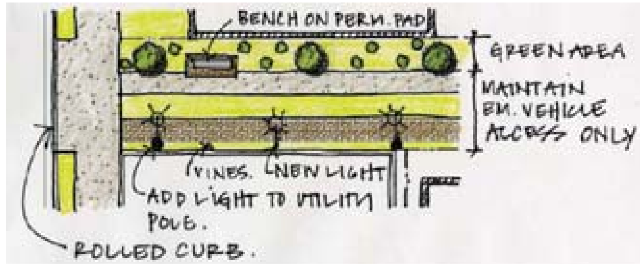
Material	Unit	Unit Cost	Quantity	Total
Permeable Paver (includes bedding material and geotextile fabric)	SF	$15.00	1000	$15,000.00
Concrete header (6" x 6" w/rebar)	SF	$12.00	80	$960.00
Bio-swale* (excavation, graded drain rock subgrade, top soil,				
Plant material, groundcover)	SF	$18.00*	500	$9,000.00*
Irrigation	SF	$1.50	500	$750.00
			Subtotal	$15,960.00
			Avg. cost per SF	$17.14

Cost estimate for permeable strips of bio-planters, permeable pavers at driveway entries, and concrete bands for vehicular travel. (Access is provided across bio-swale at key location).

Material	Unit	Unit Cost	Quantity	Total
Permeable Paver (includes bedding material and geotextile fabric)	SF	$15.00	160	$2,400.00
Concrete Paving	SF	$12.00	500	$6,000.00
Bio-swale* (excavation, graded drain rock subgrade, top soil, Plant material, groundcover)	SF	$18.00*	1000	$18,000.00*
Irrigation	SF	$1.50	1000	$1,500.00
			Subtotal	$27,900.00
			Avg. cost per SF	$18.60

**Note: The unit cost for Bio-swale is estimated on a conservative scale.*

Green Alley Scenario 6



Scenario 6 consists of the addition of elements to increase walk-ability along the alleys. This includes closing alleys off to all vehicles except for emergency access. All asphalt should be replaced with a mix of greener options described in previous options. Other elements that could be added to the alley include a variety of lighting options. Spotlights can be added to existing utility poles and new fixtures could be added between the utility pole, planting areas and seating. Additional planting might be possible on perimeter edges particularly if drive lane can be narrowed. All added planting areas would need irrigation.

Material	Unit	Unit Cost	Quantity	Total
Permeable Paver (includes bedding material and geotextile fabric)	SF	$15.00	515	$7,725.00
Concrete Paving	SF	$12.00	250	$3,000.00
Bio-swale* (excavation, graded drain rock subgrade, top soil,				
Plant material, groundcover)	SF	$18.00*	735	$13,230.00*
Additional Planting				$0.00
24" box small tree	EA	$350.00		$0.00
5 gallon shrubs	EA	$28.00		$0.00
Irrigation	SF	$3.00	735	$2,205.00
Pedetrian light fixtures	EA	$2,500.00	3	$7,500.00
Bench	EA	$1,200.00	1	$1,200.00
Rolled curb*	EA	$17.00*	1	$17.00*
			Subtotal	$34,877.00
			Avg. cost per SF	$23.25

**Note: Costs for Bio-swale and rolled curb are conservative estimates.*

Additional options for lights could include fixtures powered by alternative energy could sources including solar and wind. A small wind turbine such as the GUS 1 Tangarie wind turbine can be attached to several City of Los Angeles approved fixtures. These can be either off or attached to the electrical grid. The advantage to accessing the electrical grid is to sell-back to the utility when there is excess energy stored, and conversely, access to power when there is not enough power generated to power the light fully for night operations. Light fixture costs[2] are provided below.

Matched Battery:

$551.50 x 2 units per system = $1,083.00

Hardware:

(connectors/mountings/wiring) = $200.00

Optional Inverter:

(for hook-up to the grid, separate stand alone boxes engineered per application/for entire project) = approx. $1,200.00 per pole

TOTAL SYSTEM COST:

(INVERTER) = $6,461.00 PER POLE LIGHT