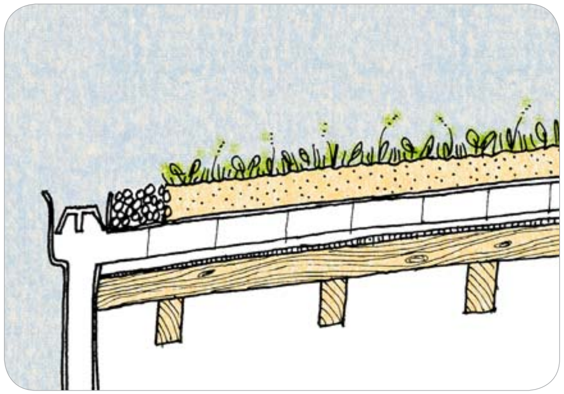

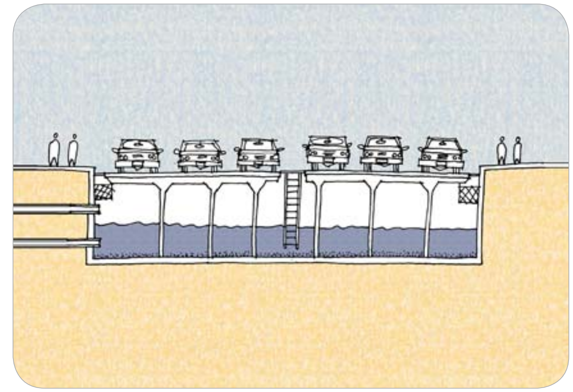
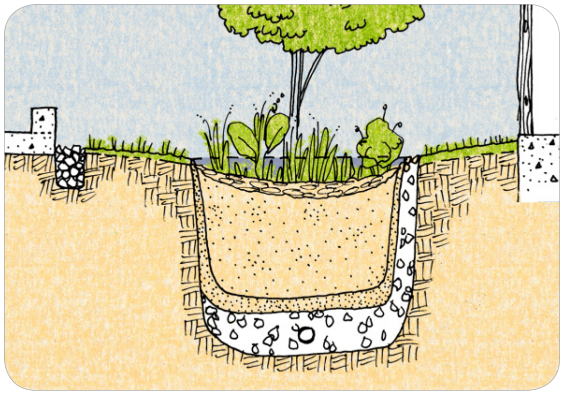
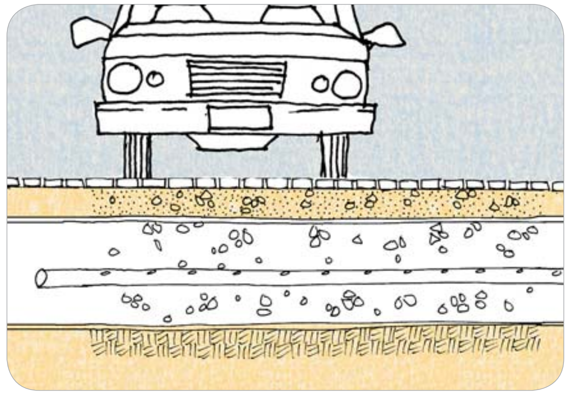
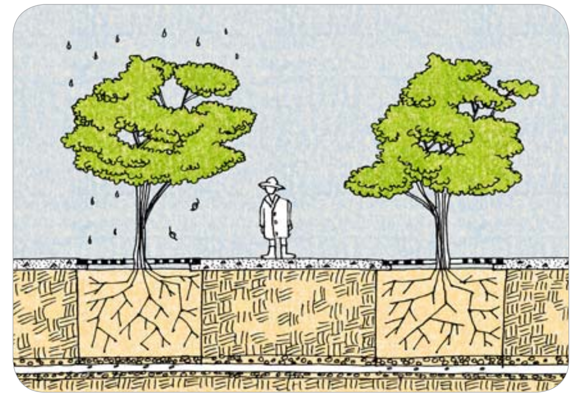
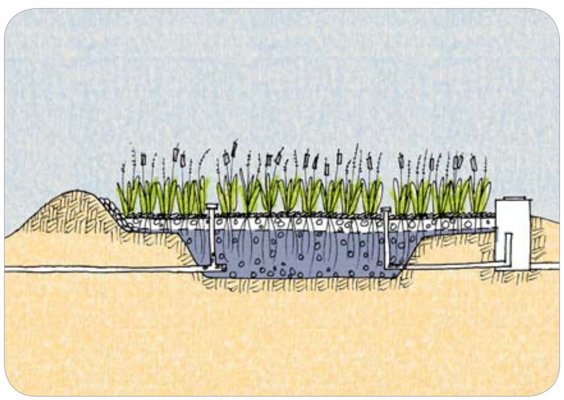
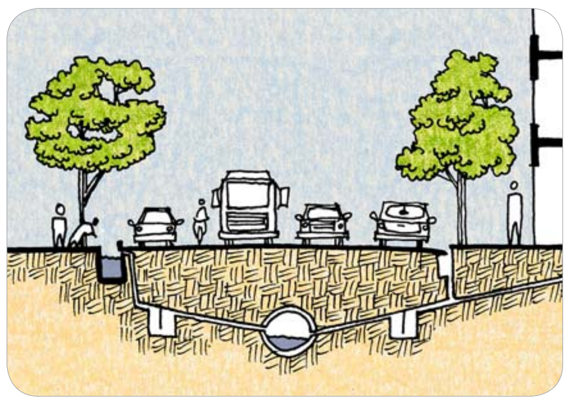
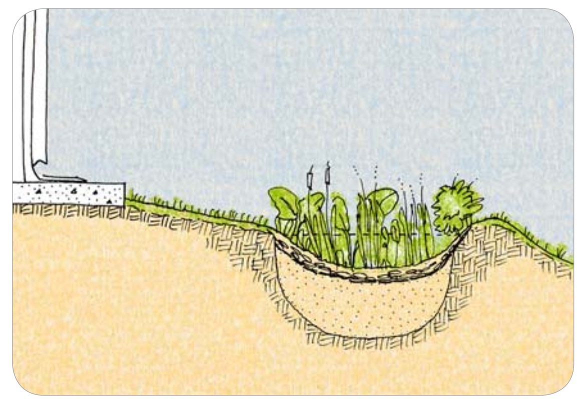

SAN FRANCISCO stormwater design guidelines

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SAN FRANCISCO stormwater design guidelines

City of San Francisco

Gavin Newsom, Mayor
Astrid Haryati, Director of City Greening

San Francisco Public Utilities Commission

Ed Harrington, General Manager
Tommy T. Moala, Assistant General Manager
Jon Loiacano, Principal Engineer

Port of San Francisco

Monique Moyer, Executive Director
Ed Byrne, Chief Harbor Engineer
Byron Rhett, Deputy Director, Planning and Development

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PROJECT TEAM

City of San Francisco

David Beaupre
Rosey Jencks
Sarah Minick
John Mundy
Arleen Navarret

Project Interns

Hayley Diamond
Alicia Omlid
Katie Pilat
Brooke Ray Smith

Hydroconsult Engineers, Inc

Beth Goldstein, PE
Mathew Johnston
Brent Johnson
Leslie Webster

Community Design + Architecture

Timothy Rood AICP, LEED
Greg Pasquali
Jonah Chiarenza

Sustainable Watershed Designs

Scott Durbin

CONTENTS

Executive Summary

Stormwater management is a critical municipal responsibility that has a direct impact on public health and safety, surface water quality, and wildlife habitat.

Like many California municipal agencies, the San Francisco Public Utilities Commission (SFPUC) and the Port of San Francisco administer Stormwater Management Programs developed in accordance with the federal Clean Water Act and a State of California National Pollution Discharge Elimination System (NPDES) Permit.

NPDES permits for stormwater specify a suite of activities that municipalities must undertake to reduce pollution in stormwater runoff. One of these is the development, implementation, and enforcement of a program to reduce pollutants in stormwater runoff from new development and redevelopment projects. This effort is commonly referred to as a *post-construction stormwater control program*.

In February 2007, Port and SFPUC staff initiated a community planning effort to develop a regulatory guidance document that fulfills state and federal requirements for post-construction stormwater runoff control. The San Francisco Stormwater Design Guidelines (*Guidelines*) represent the culmination of this effort. The *Guidelines* describe an engineering, planning, and regulatory framework for designing new infrastructure in

Linked bioretention cells are a central part of the design for the Glashaus development in Emeryville, CA.

a manner that reduces or eliminates pollutants commonly found in urban runoff. The *Guidelines* are designed to work within the context of existing San Francisco regulations and policies, and are consistent with the City's and Port's Building Code and Planning Code requirements.

The *Guidelines* are currently directed primarily to San Francisco's **separate storm sewer areas**, which include the Port of San Francisco, Hunters Point Shipyard, Mission Bay, Treasure Island, Candlestick Point, and areas that discharge to inland receiving waters such as Lake Merced. However, the thresholds presented here and the general strategies described to achieve compliance also apply to **combined sewer areas**. While the thresholds and strategies are the same for both combined and separate sewers, the performance measures are different. For information about requirements in combined sewer areas, see page 62.

Low Impact Design

In keeping with San Francisco's policy goals for promoting sustainable development, the *Guidelines* encourage the use of Low Impact Design (LID) to comply with stormwater management requirements. LID applies decentralized, site strategies to manage the quantity and quality of stormwater runoff. LID integrates stormwater into the urban environment to achieve multiple goals. It reduces stormwater pollution, restores natural hydrologic function to San Francisco's watersheds, provides wildlife habitat, and contributes to the gradual creation of a greener city. LID can be integrated into all development types, from public open spaces and recreational areas to high-density housing and industrial areas.

Master-planned or Multi-Parcel Projects

Many future projects in San Francisco will be located in large redevelopment areas and will include construction of significant horizontal infrastructure and open space in addition to subdivided parcels and individual buildings. Master-planned projects, such as Treasure Island, Hunters Point Shipyard, and the Port's Sea Wall Lot 337, can make use of larger LID strategies that provide superior treatment, wildlife habitat, recreational amenities, and other benefits that may not be possible with smaller projects. Constructed wetlands and large-scale rainwater harvesting are just a few examples of LID strategies presented in these *Guidelines* that are ideally suited to large projects.

Using the Stormwater Design Guidelines

The *Guidelines* are intended to lead developers, engineers, and architects through a planning and design process that incorporates stormwater controls into site design. The *Guidelines* provide a policy overview, describe the regulatory context for post-construction stormwater control requirements, and explain how these requirements will be incorporated into San Francisco's planning and permit review process.

The *Guidelines* introduce the stormwater performance measures that must be achieved for project approval and provide detailed instructions for developing a Stormwater Control Plan (SCP), a document which will allow city staff to assess compliance. A worked example illustrates how to complete each step in the design process, and a template for the SCP is included at the end of the document. The *Guidelines* include compliance strategies, a decision tree to assist in the selection of stormwater controls, and spreadsheets for sizing stormwater controls. The requirements outlined in the *Guidelines* are of a technical nature and most project applicants will require the assistance of a qualified civil engineer, architect, or landscape architect in order to comply.

Every applicant seeking a building permit or every project that requires compliance with California Environmental Quality Act (CEQA) process on or after **January 1, 2010** for a new or redevelopment project over 5,000 square feet must complete a SCP showing that they have incorporated appropriate stormwater controls into their project and have met the stormwater performance measures described in these *Guidelines.* SFPUC and Port permit staffs will review SCP submittals for adequacy.

Native plants in bloom in the swales at the Sunset Circle parking lot, an LID feature that protects the water quality of Lake Merced.

Introduction

San Francisco's location adjacent to the Pacific Coast and San Francisco Bay, the largest estuary on the west coast of the United States, gives the City significant environmental, social, and economic advantages; it also confers unique responsibilities for water quality protection upon the City and its citizens.

The San Francisco Public Utilities Commission (SFPUC) and the Port of San Francisco (Port) have partnered to create the *San Francisco Stormwater Design Guidelines* (*Guidelines*) for San Francisco's developers, designers, engineers, and the general public. The *Guidelines* are designed to help project applicants implement permanent post-construction stormwater controls. Water quality regulations under the federal Clean Water Act require such controls for new and redevelopment projects in areas served by municipal separate storm sewer systems (MS4s).

While water quality protection is the fundamental driver behind stormwater management, well-designed stormwater controls offer many ancillary benefits. These *Guidelines* encourage innovative and multi-purpose design solutions for meeting stormwater requirements in San Francisco's urban setting. In addition to protecting water quality, well-designed multi-purpose solutions will contribute to attractive civic spaces, open spaces, and streetscapes. They will also protect and enhance wildlife habitat and have the potential to effectively integrate stormwater management into the redevelopment of historic sites.

By implementing the stormwater management strategies articulated in this document, each project applicant will contribute to the incremental restoration of the health of the City's watersheds, protect the Bay and Ocean, and build a greener San Francisco. Patrick Condon, Chair in Landscape and Livable Environments at the University of British Columbia, underscores the contribution that each site can make to a region: "What the cell is to the body, the site is to the region. And just as the health of the body is dependent on the health of the individual cells that make it up, so too is the ecological and economic health of the region dependent on the sites that comprise it."

The *Guidelines* function as both policy document and design tool. They explain the environmental and regulatory drivers behind stormwater management, demonstrate the concepts that inform the design of stormwater controls, describe the benefits that green stormwater infrastructure bring to San Francisco, and take project applicants through the process of creating a Stormwater Control Plan (SCP) to comply with stormwater regulations. The *Guidelines* are specific to San Francisco's environment; they reflect the city's density, climate, diversity of land uses, and varying topography.

Regulatory Context

The federal Clean Water Act (CWA) establishes the foundation for stormwater regulation across the country. State, regional, and municipal laws and policies under the CWA help to ensure that San Francisco's stormwater requirements are appropriate to the city's geography, climate, and development patterns.

The Clean Water Act

In 1972, Congress passed the Clean Water Act (CWA) to regulate the discharge of pollutants to receiving waters such as oceans, bays, rivers and lakes. Under the CWA, waste discharges from industrial and municipal sources are regulated through the National Pollutant Discharge Elimination System (NPDES) Permit Program. Approximately 90% of San Francisco is served by a **combined sewer system** (see map on page 10) that conveys both sewage and stormwater for treatment to three sewage treatment plants before being discharged to receiving water. Discharges from the treatment plants are subject to the requirements of NPDES permits.

Stormwater runoff, now recognized by the United States Environmental Protection Agency (EPA) as a leading contributor to water quality degradation in the United States, was unregulated until 1987 when section 402(p) was added to the CWA. Section 402(p) established a two-phase plan to regulate polluted stormwater runoff under NPDES. The Phase I permits, finalized in 1990, regulate **municipal separate storm sewer systems (MS4s)** serving populations of 100,000 or more. Stormwater discharges associated with certain types of industrial facilities and construction sites greater than five acres are also

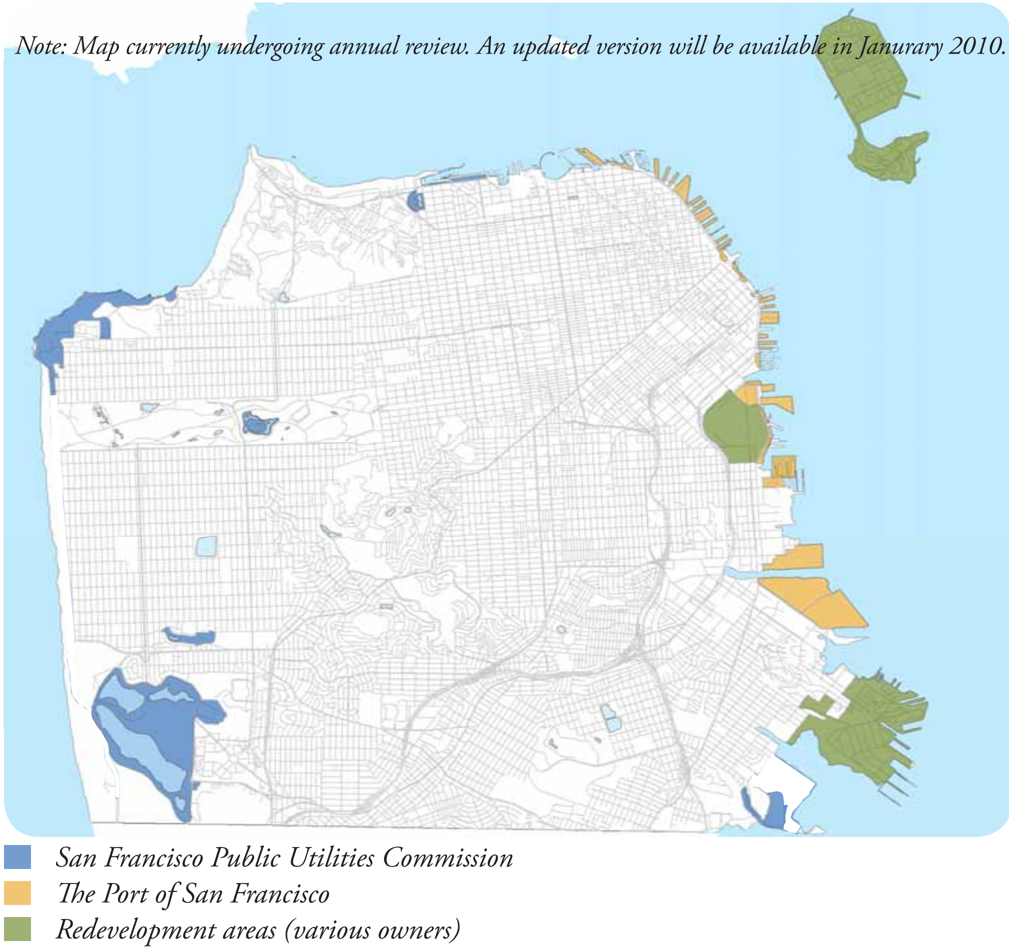

Figure 1. *Separate storm sewer areas and jurisdictions*

Best Management Practices

Stormwater Best Management Practices (BMPs) are measures or programs used to reduce pollution in stormwater runoff. The EPA defines a BMP as a "technique, measure or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner."

regulated under Phase I. Phase II permits, finalized in 2000, regulate MS4s serving populations of 100,000 or less.

The California State Water Resources Control Board (SWRCB) serves as the implementing agency for NPDES regulations. In 2003, the SWRCB issued the *General Permit for Discharges of Stormwater from Small Municipal Storm Sewer Systems* (General Permit) to regulate small MS4s. San Francisco's MS4 areas cover approximately 10% of the City and serve fewer than 100,000 people. They are therefore subject to Phase II requirements in the General Permit.

The General Permit

To comply with NPDES Phase II regulations, the General Permit requires agencies holding the Phase II NPDES Permit (SFPUC and Port) to develop Stormwater Management Plans (SWMPs) describing the measures that will be implemented to reduce pollution in stormwater runoff in the MS4 areas.

The General Permit requires Permittees to implement four measures for post-construction stormwater management in new and redevelopment projects located in areas served by separate sewers:

1. Develop, implement, and enforce a program to address stormwater runoff from new and redevelopment projects to ensure that controls are in place to prevent or minimize water quality impacts;
2. Develop and implement stormwater management strategies, including a combination of structural and/or non-structural best management practices (BMPs) appropriate for the community;

3. Use an ordinance or other regulatory mechanism to control post-construction runoff from new and redevelopment projects to the extent allowable under the law; and,
4. Ensure the adequate long-term operation and maintenance of BMPs.

Under the General Permit, Permittees have two options for adopting the post-construction stormwater management requirements listed above. The first is to use the minimum design standards listed in Attachment 4 of the Phase II General Permit as a framework for administering post-construction control programs (http://www.waterboards.ca.gov/water_issues/programs/stormwater/docs/final_attachment4.pdf).

The second option for compliance is for Permittees to develop a functionally equivalent program that is acceptable to the San Francisco Bay Regional Water Quality Control Board (RWQCB). The Port and the SFPUC have chosen to pursue the latter option by implementing these *Guidelines*, which are largely based on the C.3 Provision of the San Francisco Bay Area Phase I stormwater permits. The C.3 requirements are similar to those in the General Permit, but require more effort on the part of the Permittee to develop a post-construction control program suitable for its climate, geography and development patterns.

Effective January 1, 2010, these *Guidelines* will apply to all projects greater than 5,000 square feet in the City of San Francisco. The *Guidelines* **do not** apply to those projects that have received 1) building permits and/or 2) discretionary approvals by the San Francisco Planning Department, the San Francisco Department of Building

Project Type	***Excluded Projects***
Commercial, industrial or residential development	*Projects with fewer than 5,000 square feet of developed area that are not part of a larger common plan of development.*
Single family residential development	*Construction of one single family home that is not part of a larger common plan of development and is fewer than 5,000 square feet, with the incorporation of appropriate source control measures, and using landscaping to appropriately treat runoff from impervious surfaces.*
Redevelopment and repair projects	*Interior remodels and routine maintenance and repair, such as roof replacement, exterior painting, utility trenching and repair, pier apron repair and pile replacement, pavement resurfacing, repaving and structural section rehabilitation within the existing footprint.*
Parking lots	*Parking lots of fewer than 5,000 square feet.*

Table 1. *Projects excluded from Stormwater Design Guidelines requirements*

Requirement

All project sites with an area greater than 5,000 square feet must incorporate post-construction stormwater controls that meet the performance measures set forth in these *Guidelines*, including minimizing the sources of stormwater pollutants (see Source Controls, beginning on page 75) and treating a specified flow or volume of stormwater (see Treatment BMPs, beginning on page).

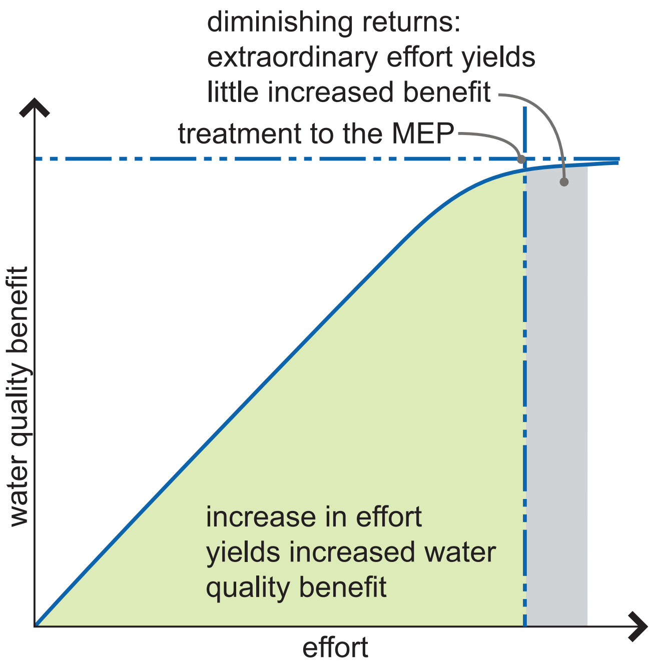

Figure 2. *As the maximum extent practicable (MEP) standard is approached, additional investment in BMPs yields reduced benefit.*

Inspection, the Port of San Francisco Planning Division, or the Port Building Department by January 1, 2010. All new project applications, incomplete project applications, and amendments received thereafter will be subject to these *Guidelines*. Table 1 lists the types of projects that are excluded from the *Guidelines*.

The RWQCB monitors San Francisco's implementation of General Permit requirements. The Port and the SFPUC must submit ongoing reports on their respective development review efforts, the number and type of projects reviewed, and the stormwater control measures included in the projects. To assess the effectiveness of stormwater control measures, the Port and SFPUC must define criteria for compliance. The RWQCB and the EPA require that stormwater control measures be designed to reduce pollution in stormwater runoff to the Maximum Extent Practicable (MEP).

The Maximum Extent Practicable Treatment Standard

MS4 permits require stormwater management strategies to "reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods."

Treatment to the maximum extent practicable (MEP) can be achieved by applying the BMPs that are most effective at treating pollutants in stormwater runoff. The SWRCB has said of the MEP standard that there "must be a serious attempt to comply, and practical solutions may not be lightly rejected." The SWRCB also states that if project applicants implement only a few of the least expensive stormwater BMPs, it is likely that the MEP standard has not been met. If, on the other hand, a project applicant implements all applicable and effective BMPs except those shown to be technically infeasible, or those whose cost would exceed any benefit to be derived, then the project applicant would have achieved treatment to the MEP. As technology and design innovation improve, stormwater BMPs become more effective. The definition of MEP continually evolves with the field to encourage innovation and improved water quality protection. Because of this, some end-of-pipe strategies such as vortex separators, which were considered to meet the MEP standard ten years ago, are no longer accepted as such. Similarly, in cases where just one BMP may have gained project approval in the past, today there are many cases where multiple BMPs will be required in order to achieve treatment to the MEP.

Pollutants of Concern

Because stormwater runs off of diverse sites, it mobilizes many kinds of pollutants. The following list summarizes the main categories of pollutants found in stormwater, their sources, and their environmental consequences.

Gross pollutants mobilized by stormwater include litter, plant debris and floatable materials. Gross pollutants often harbor other pollutants such as heavy metals, pesticides, and bacteria. They also pose their own environmental impacts; they degrade wildlife habitat, water quality, the aesthetic quality of waterways, and are a strangling and choking hazard to wildlife.

Sediment is a common component of stormwater runoff that degrades aquatic habitat and can be detrimental to aquatic life by interfering with photosynthesis, respiration, growth, reproduction, and oxygen exchange. Construction sites, roadways, rooftops, and areas with loose topsoil are major sources of sediment. Sediment is a vehicle for many other pollutants such as trace metals and hydrocarbons. Over half the trace metal load carried in stormwater is associated with sediment. Because of this, sediment removal is a good indicator for reduction of a broader range of pollutants. For the purpose of developing stormwater controls, engineers and designers must consider both coarse and fine ("suspended") sediments.

Oil and grease include a wide range of organic compounds, some of which are derived from animal and vegetable products, others from petroleum products. Sources of oil and grease include leaks and breaks in mechanical systems, spills, restaurant waste, waste oil disposal, and the cleaning and maintenance of vehicles and mechanical equipment.

Nutrients like nitrogen and phosphorous are typically used as fertilizers for parks and golf courses and are often found in stormwater runoff. They can promote excessive and accelerated growth of aquatic vegetation, such as algae, resulting in low dissolved oxygen. Un-ionized ammonia, a form of nitrogen, can be toxic to fish. In San Francisco, nutrients carried in runoff are a significant concern for enclosed freshwater bodies such as Lake Merced, more so than they are for the San Francisco Bay and Pacific Ocean.

Oils and gross pollutants pose a significant threat not only to water quality but also to bay area wildlife.

Stormwater runoff transports trash to local water bodies, where it creates an aesthetic nuisance, harms wildlife, and pollutes receiving waters.

Pesticides (herbicides, fungicides, rodenticides, and insecticides) are often detected in stormwater at toxic levels, even when they have been applied in accordance with label instructions. As pesticide use has increased, so have concerns about their adverse effects on the environment and human health. Accumulation of these compounds in simple aquatic organisms, such as plankton, provides an avenue for biomagnification through the food web, potentially resulting in elevated levels of toxins in organisms that feed on them, such as fish and birds.

Organics can be found in stormwater in low concentrations. They include synthetic compounds associated with adhesives, cleaners, sealants, and solvents that are widely used and are often stored and disposed of improperly.

Bacteria can enter stormwater via sources such as animal excrement, decay of organic materials, and combined sewer discharges. High levels of bacteria in stormwater runoff can lead to beach closures and fishing advisories.

Dissolved metals including lead, zinc, cadmium, copper, chromium, and nickel are mobilized by stormwater when it runs off of surfaces such as galvanized metal, paint, automobiles, and preserved wood, whose surfaces corrode, flake, dissolve, decay, or leach. Metals are toxic to aquatic organisms, can bioaccumulate in fish and other animals, and have the potential to contaminate drinking water supplies.

PCBs and Mercury are legacy contaminants that are found in low concentrations in soils associated with historically industrialized areas. San Francisco Bay is listed by the USEPA as an "impaired water body" for these contaminants. Control of PCBs and mercury will be implemented through design measures that limit the mobilization of these pollutants in contaminated soils.

Synergy with other Regulations and Initiatives

The *Guidelines* are designed to work with San Francisco's existing and emerging regulatory programs and policies. For example, development along the San Francisco waterfront is subject to policies adopted by the Port of San Francisco and the San Francisco Bay Conservation and Development Commission (BCDC); the *Guidelines* are consistent with these policies. Federal, state, and local regulations most relevant to the *Guidelines* are shown in Table 2 at the end of this section.

There are three initiatives underway in San Francisco that directly affect stormwater management in the City and that propose policies parallel to those presented in these *Guidelines*: the *Sewer System Master Plan*, the *Better Streets Plan,* and the Green Building Ordinance. These mutually-supportive efforts are consistent with the stormwater management goals and requirements put forward here.

The SFPUC's *Sewer System Master Plan* (Master Plan) is a comprehensive plan that charts a long-term vision and strategy for the management of the City's wastewater and stormwater. The Master Plan is intended to maximize system reliability and flexibility and to lay a path for capital investment and management of the City's infrastructure for the next 30 years. The Master Plan presents Low Impact Design (LID) as a major tool for addressing the City's drainage management needs. LID is an innovative stormwater management approach that is modeled after nature: it advocates managing runoff at its source using decentralized micro-scale facilities. The Master Plan contains protocols for using LID in ongoing repair and replacement projects as a part of its overhaul of drainage infrastructure.

The *Better Streets Plan* is a collaborative effort between the SFPUC, the Planning Department, the Public Works Department, the City's transit agencies, and other relevant agencies, to create a unified set of standards, guidelines, and implementation strategies that will govern how the City designs, builds, and maintains the public rights-of-way. The goal of the *Better Streets Plan* is to update applicable standards to improve pedestrian safety, enhance landscaping, and identify innovative methods for reducing stormwater runoff from the streets and sidewalks to create a more attractive and sustainable public realm in San Francisco.

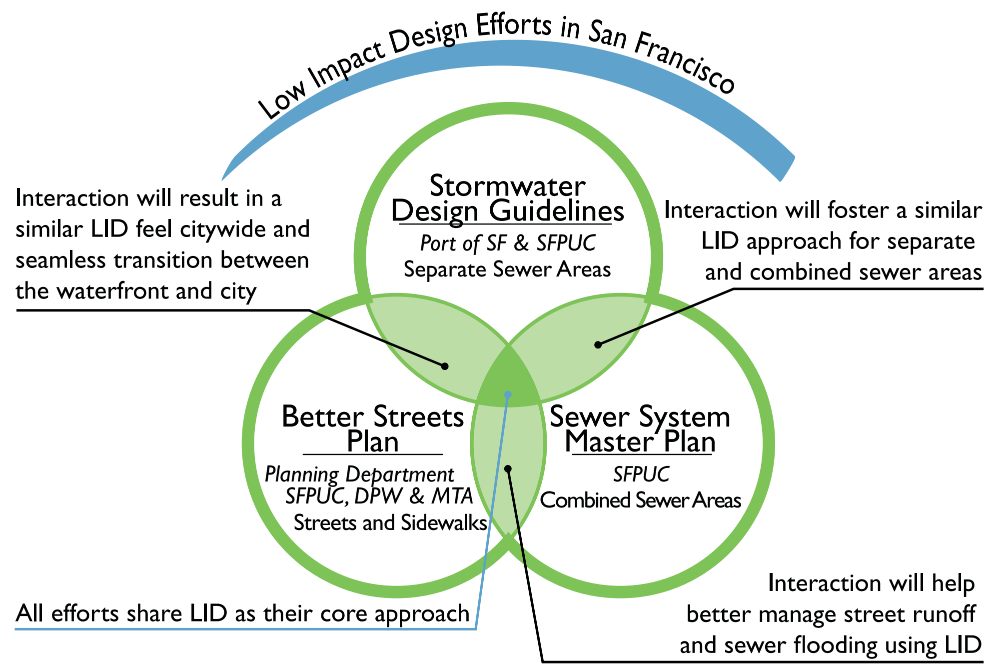

Figure 3. *LID is the common thread linking a number of major planning efforts currently underway in San Francisco.*

A cistern at Mills College in Oakland, CA is a stormwater BMP and a design element. Photo: Ingrid Severson

The Green Building Ordinance is a third initiative that will work in tandem with the *Guidelines*. The ordinance expands the scope of green building standards to apply not only to public buildings but also to private development and redevelopment projects in San Francisco. The task force was charged with creating building requirements that would foster environmentally sensitive design and sustainability in new development projects. As a part of this effort, SFPUC and Port staff developed stormwater management performance standards for new and redevelopment projects over 5,000 square feet. The Ordinance references the *Guidelines* and provides the regulatory authority to implement stormwater management requirements in combined sewer areas.

San Francisco Building Code Requirements

Projects that are implementing the *Guidelines* will also be subject to review by the San Francisco Department of Building Inspection (DBI) or the Port Building Department. Both DBI and the Port administer building codes that include provisions for managing drainage for new construction. Section 306.2 of the San Francisco Plumbing Code and Section 1506.1 of the San Francisco Building Code were amended on June 28, 2005 to allow roofs and other building areas to drain to locations other than the combined sewer. The 2005 amendments anticipated LID strategies such as downspout disconnection and rainwater harvesting, which are described in the *Guidelines*.

They now read as follows:

- **Plumbing Code, Section 306.2:** Roofs, inner courts, vent shafts, light well, or similar areas having rainwater drains shall discharge directly into a building drain or sewer, or to an approved alternate location based on approved geotechnical and engineering designs.
- **Building Code, Section 1506.1:** All storm or casual water from roof areas which total more than 200 square feet shall drain or be conveyed directly to the building drain or storm drain or to an approved alternate location based on approved geo-technical and engineering design. Such drainage shall not be directed to flow onto adjacent property or over public sidewalks. Building projections not exceeding 12 inches in width are exempt from drainage requirements without area limitations.

In the amended codes listed above, “approved alternate location” is the key phrase that allows for downspout disconnection and encompasses all properly designed stormwater management facilities, including rain barrels or cisterns.

In 2008, the SFPUC, DBI, and the Department of Public Health (DPH) signed a Memorandum of Understanding (MOU) for Rainwater Harvesting Systems. The MOU records a technology-based agreement between the three agencies, which concludes that project applicants can safely harvest rainwater and use it for non-potable applications such as toilet flushing, irrigation, and vehicle washing without treating it to potable standards. More detailed specifications and permitting requirements for rainwater harvesting can be found on the “Rainwater Harvesting” fact sheet in Appendix A.

An interior roof drain discharges to a vegetated swale in Emeryville, CA. This properly designed and permitted stormwater facility is an example of an “approved alternate location” for stormwater discharge.

Regulatory Context

Name/Title	Administered By	Summary
FEDERAL REQUIREMENTS		
National Pollutant Discharge Elimination System (NPDES) Phase II General Permit	California Regional Water Quality Control Board (RWQCB)	Requires municipalities to develop programs to control runoff pollution from both new and redevelopment projects. The *Guidelines* provide standards and guidance to implement the requirements of the Phase II Municipal General Permit.
NPDES Industrial Permits	RWQCB	Requires facilities subject to the requirements of the Industrial Permit to implement BMPs to prevent or reduce pollution in stormwater runoff. Newly constructed industrial facilities over 5,000 square feet must implement post-construction controls per requirements of the *Guidelines* .
Federal Clean Water Act 401 Certification	RWQCB	The RWQCB must certify that construction projects taking place in or over federal and state water bodies do not negatively impact water quality. The *Guidelines* will help project proponents comply with post-construction stormwater control requirements often included as conditions of 401 certification.
303(d) Impaired Water Bodies - Clean Water Act - Total Maximum Daily Load (TMDL) Program	RWQCB	San Francisco Bay and other water bodies are impaired by pollutants such as mercury and PCBs. TMDLs require pollutant sources to reduce levels of pollutant loading associated with water quality impairment. Stormwater treatment control selection should consider TMDL pollutant removal.
Secretary of the Interior's Standards for the Treatment of Historic Properties	National Park Service/California State Office of Historic Preservation	In order to qualify for Federal Rehabilitation Tax Credits, construction within designated Historic Districts must avoid or minimize changes that would adversely affect an historic resource's character defining features. Stormwater management measures selected for a given project must comply with these standards as applicable.
Americans with Disabilities Act (ADA) California Code of Regulations Title 24	San Francisco Department of Building Inspection (DBI) San Francisco Department of Public Works (SFDPW)	The ADA establishes requirements for accessibility to places of public accommodation and commercial facilities by individuals with disabilities. Stormwater management measures described in the *Guidelines* must accommodate ADA requirements, including curb ramp standards promulgated through SFDPW Order No. 175,387. Treatment controls located in the public right-of-way must comply with ADA architectural guidelines.
STATE REQUIREMENTS		
California Environmental Quality Act (CEQA)	San Francisco Planning Department	A process to review new and redevelopment projects for potential impacts to the environment and, as necessary, propose mitigation measures to substantially lessen the project's significant environmental effects. The *Guidelines* include measures that will substantially reduce water quality and hydrological impacts associated with new and redevelopment projects.
REGIONAL REQUIREMENTS		
San Francisco Bay Basin Plan	RWQCB	Designates the beneficial uses and water quality objectives designed to protect those beneficial uses for state waters in the San Francisco Bay Region. Stormwater management measures described in the Guidelines promote restoration and maintenance of beneficial uses for waters in and around San Francisco.
San Francisco Bay Sea Port Plan and San Francisco Special Area Plan Maritime Commerce, Land Use and Public Access	San Francisco Bay Conservation and Development Commission (BCDC)	Policies that guide BCDC regulation within 100 feet of the shoreline edge, including most of the Port's piers. Policies are geared to limiting Bay fill, protecting water quality, and encouraging maximum feasible public access that does not impact commercial maritime activities. Wherever practical projects should retain or restore native vegetation buffer zones, rather than hardscape shoreline development. Applicable to waterfront development within 100' of the shoreline. Stormwater management measures described in the *Guidelines* are consistent with BCDC policy goals.

Table 2. *Relevant jurisdictions, codes, and ordinances*

Name/Title	Administered By	Summary
SAN FRANCISCO REQUIREMENTS		
San Francisco Public Works Code	San Francisco Department of Public Works - Bureau of Streets and Mapping (SFDPW-BSM)	SFDPW-BSM permits and approves all work in the public right-of-way, streets and sidewalks (including paper streets). Permits tree-lawns and planting strips. Permits sidewalk, curb and gutter, pavement, or any other facilities in the public right-of-way improvements. Stormwater management measures described in the *Guidelines* must satisfy Public Works Code requirements for design and construction within the public right-of-way.
San Francisco Public Works Code	San Francisco Department of Public Works - Bureau of Hydraulics	San Francisco Department of Public Works - Bureau of Engineering provides technical review on behalf on the San Francisco Public Utilities Commission (SFPUC), and designs and contracts sewer improvements. Stormwater management measures described in the Guidelines must comply with engineering standards administered by San Francisco Department of Public Works - Bureau of Hydraulics.
San Francisco Better Streets Master Plan	Mayor's Office of Greening, San Francisco Planning Department, DPW, Municipal Transportation Agency, and the SFPUC	Guides design and construction within the public right-of -way and streets. Stormwater management measures proposed in the *Guidelines* are consistent with those considered in the *Better Streets Plan* . For design standards applicable to stormwater, the *Guidelines* will take precedence.
Waterfront Land Use Plan - Waterfront Design and Access Element	Port of San Francisco	Guides the physical form of the waterfront revitalization envisioned in the *Port Waterfront Land Use Plan;* provides guidance on public access and waterfront accessibility, planting (both the presence and type of vegetation), protection and preservation of historic resources; and defines distinct geographic areas wherein specific design criteria apply.
Recycled Water Policy	San Francisco Department of Public Health (DPH)	Recycled water must be treated to Title 22 standards, which differ according to the proposed use of the water.
Rainwater Harvesting Policy	Department of Building Inspection (DBI), SFPUC, and the DPH	Rain barrels less than 100 gallons may be installed without a permit if they are used for irrigation and not connected to indoor or outdoor plumbing. Permits must be obtained from DBI for rainwater harvesting systems over 100 gallons that are connected to indoor or outdoor plumbing and are used for irrigation or toilet flushing. Rainwater harvesting systems for indoor uses other than toilet flushing must obtain permits from DBI and DPH.
Greywater Policy	DBI and the DPH	Untreated greywater may be used for subsurface irrigation. For all other uses, greywater must be treated to Title 22 standards, which differ according to the proposed use of the water.
Plumbing and Connections	DBI	The Plumbing Inspection Division (PID) of DBI is responsible for assuring, through permitting and inspection, the proper functioning for installations of drainage, water, gas, and other mechanical systems covered in the Plumbing and Mechanical Codes. These inspections are carried out in buildings that are newly constructed, remodeled, or repaired. Stormwater management measures must be implemented in a manner that satisfies DBI requirements.
San Francisco Planning Code, Article 10	San Francisco Planning Department, Landmarks Preservation Advisory Board and the City Planning Commission	Exterior alterations to San Francisco properties that are designated local landmarks will be reviewed for consistency with requirements set forth in the Secretary of the Interior's Standards for the Treatment of Historic Properties. Stormwater management measures described in the *Guidelines* must comply with Article 10 and the Secretary Standards.
San Francisco Health Code, Article 22A	DPH	The Maher Ordinance regulates construction and post-construction activities for properties constructed on fill materials adjacent to the historic Bay shoreline. Much of the waterfront and other areas in San Francisco are subject to the Maher Ordinance. Soil and groundwater in areas of the San Francisco Waterfront subject to the Maher Ordinance may contain pollutants that preclude the use of stormwater treatment controls using infiltration.

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Boardwalks provide access across waterfront bioretention facilities in Seattle, WA.

San Francisco Context

Before San Francisco developed into the thriving city it is today, it consisted of a diverse range of habitats including oak woodlands, native grasslands, riparian areas, wetlands, and sand dunes. Streams and lakes conveyed and captured rainwater. Wetlands lined the Bay and functioned as natural filtering systems and as buffers from major storms. Rainwater infiltrated into the soil, replenishing groundwater supplies and contributing to stream base flow.

The Urban Watershed

Watershed function

Today, impervious surfaces such as buildings, streets, and parking lots have covered most of the City, preventing rainfall infiltration. Over time, creeks were buried and connected to the sewers, and wetlands were filled. Instead of percolating into soils, runoff now travels over impervious surfaces, mobilizes pollutants like oil and debris, and washes them into the sewer system or receiving water bodies—creeks, lakes, San Francisco Bay, and the Pacific Ocean. During heavy rain events, stormwater runoff can contribute to localized flooding, combined sewer discharges, and the degradation of surface water quality. Moreover, the decrease in infiltration resulting from paved surfaces contributes to groundwater depletion. LID can help to mitigate these adverse effects. With every project contributing incremental improvements, San Francisco can work toward restoring natural hydrologic function in its urban watersheds.

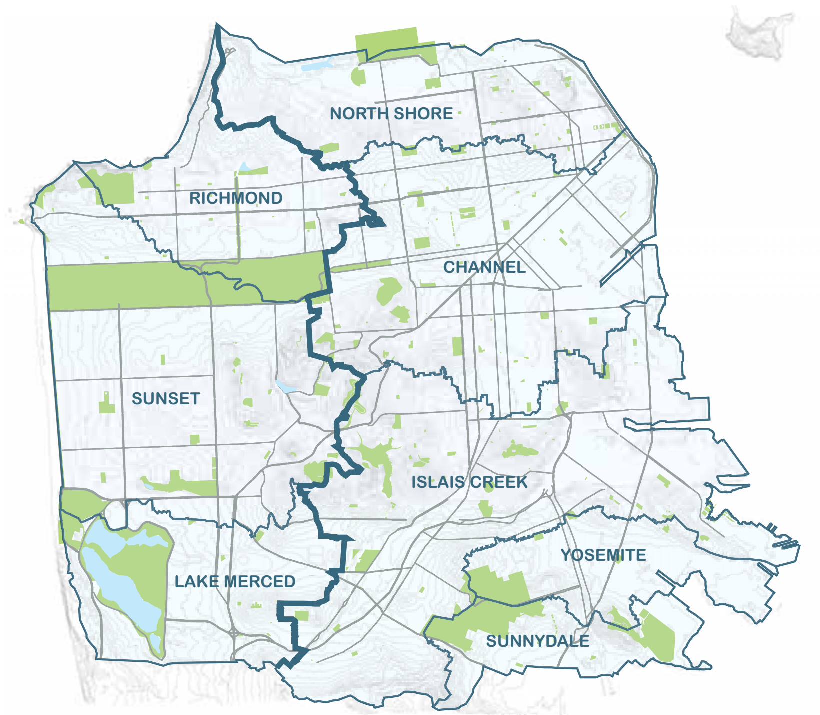


Figure 4. *San Francisco's topography divides the Westside Basins from the Eastside Basins.*

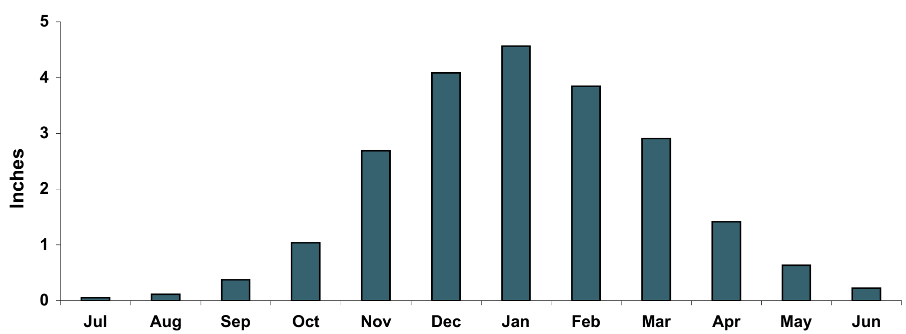


Figure 5. *Average monthly rainfall for San Francisco.*
Source: National Weather Service Gage, Federal Office Building, July 1907 to June 1978

Environment

San Francisco is roughly divided into two major drainages: the eastern and western basins (see Figure 4). These are comprised of eight major sub-basins containing diverse urban neighborhoods with a range of residential, commercial, and industrial land uses, open spaces, and natural areas. Each sub-basin is underlain with unique topography, hydrology, soils, vegetation and water resources that create opportunities and challenges for drainage and stormwater management.

San Francisco has a temperate Mediterranean climate, with dry summers and rainy winters (see Figure 5). In a typical year, San Francisco receives less than an inch total of rain from May through September and an average of 20 inches of rain between November and March. Rainfall is not distributed evenly across the City. It ranges from approximately 22 inches in the south, to 20 inches along the western edge and northeastern quadrant, to 18 inches in the extreme northeast. Like all Mediterranean climates, San Francisco experiences periods of drought punctuated by intense winter rains, often resulting in water scarcity in the summer and flooding in the winters.

The potential for stormwater to infiltrate varies dramatically by location. Infiltration may be limited in areas that have steep slopes, shallow depth to bedrock or to the water table, clay soils, contaminated soils, or are built on bay mud and fill over former creeks and wetlands. However, in many areas of the City, particularly in the western basins, soils are generally sandy and have the potential to provide excellent infiltration rates and pollution removal. Where infiltration is limited, a wide array of stormwater management strategies that do not depend upon infiltration can be implemented.

San Francisco's Stormwater Infrastructure

While the creation of these *Guidelines* is driven primarily by regulatory requirements for the City's separate sewer areas, the majority of San Francisco (90%) is served by a combined sewer system (see Figure 6). The stormwater management goals for areas served by separate storm sewers are different from those for areas served by the combined sewer system. Despite this, many of the fundamental design concepts for stormwater management apply to both areas, and as such, the *Guidelines* can be used as a tool in both the separate and combined sewer areas of San Francisco. Using landscape-based stormwater infrastructure will enhance and diversify the functions of both the separate and combined systems.

Approximately 10% of the City is served by a **separate storm sewer system** or is lacking stormwater infrastructure; in most of these areas stormwater flows directly to receiving waters without treatment. In the separate storm sewer areas, the primary reason for implementing post-construction controls is to improve stormwater quality before it reaches a receiving water body. These controls are aimed at removing specific pollutants of concern and treating what is known as the "first flush". The first flush is the dirtiest runoff, usually generated during the beginning of a rain event; it mobilizes the majority of the pollutants and debris that have accumulated on impervious surfaces since the last rain.

A **combined sewer system** conveys wastewater and stormwater in the same set of pipes. The combined flows receive treatment at wastewater treatment plants before being discharged to the Bay and Ocean. Conventional separate storm sewer systems provide no stormwater treatment, while combined sewer systems treat most urban runoff to secondary standards, including the first flush and most additional stormwater runoff. However, when the capacity of the system is exceeded by large storm events, localized flooding and combined sewer discharges (CSDs) can occur. In the event of a CSD, the system discharges a mixture of partially treated sanitary effluent and stormwater to receiving water bodies. While these discharges are dilute (typically consisting of roughly six percent sewage and 94 percent stormwater), they can cause public health concerns and lead to beach or Bay access closures.

The primary reason for implementing LID measures in a combined sewer system is to reduce and delay the volumes and peak flows of stormwater reaching the sewer system. Volume reductions and peak flow desynchronization can help reduce the number of CSDs, reduce flooding, and protect water quality. Post-construction controls in the combined system can also improve the capacity and efficiency of the City's treatment facilities.

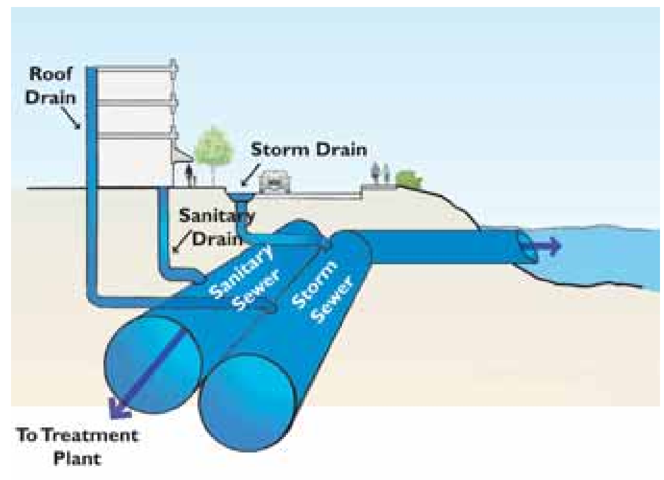


Figure 6. *Combined sewer systems (top) serve 90% of San Francisco. Separate sewer systems (bottom) serve 10%. Image: modified from King County Wastewater Management Division*

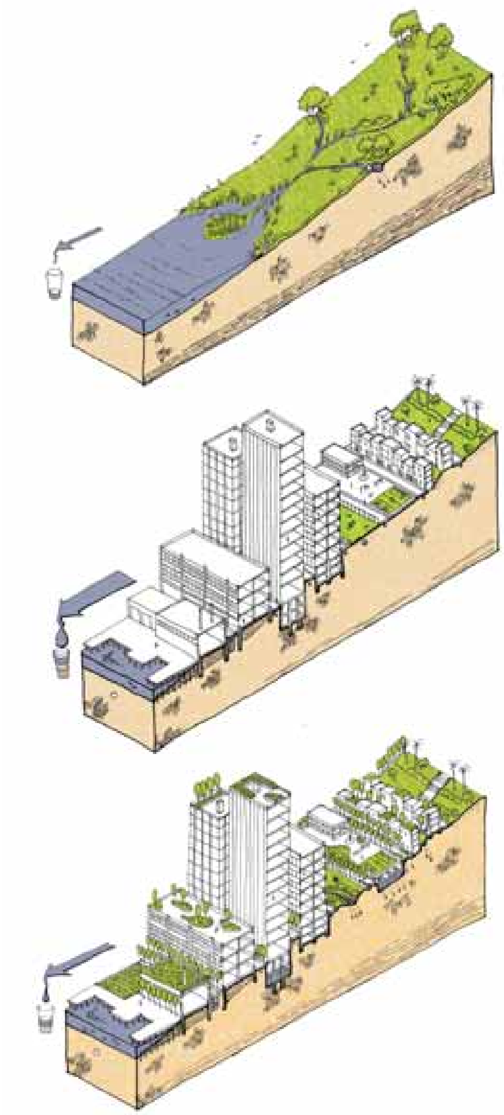


Figure 7. Low Impact Design seeks to reduce runoff and restore hydrologic function through effective site planning, increased permeability, and landscape-based BMPs.

Managing Stormwater in San Francisco

Low Impact Design

To lessen the impacts of urbanization on stormwater quality and peak flows, cities around the world are taking advantage of Low Impact Design (LID), which promotes the use of ecological and landscaped-based systems to manage stormwater. LID aims to mimic pre-development drainage patterns and hydrologic processes by increasing retention, detention, infiltration, and treatment of stormwater runoff at its source. This decentralized approach not only treats stormwater at its source and facilitates the best and highest use of stormwater; it also allows greater adaptability to changing environmental conditions than do centralized conveyance systems.

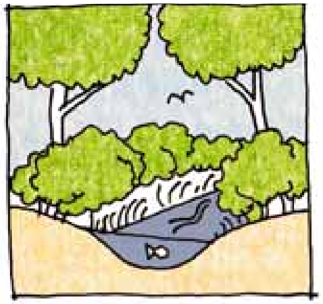
LID strategies direct runoff to BMPs such as flow-through planters, swales and rain gardens. These BMPs capture, filter, and slow stormwater runoff, thereby improving stormwater quality and reducing the quantity of runoff. Strategic placement of BMPs helps to ameliorate the negative water quality and ecosystem impacts of impervious surfaces. LID also emphasizes the integration of stormwater management with urban planning and design and promotes a comprehensive, watershed-based approach to stormwater management.

Figure 7 shows how LID can be incorporated into an urban setting like San Francisco without compromising its character and livability. Vegetated roofs and landscaped areas minimize the amount of stormwater runoff. BMPs are incorporated into the fabric of the city, doubling as recreational areas, wildlife habitat, and landscaping. These measures may increase initial capital costs (approximately 3%), but they bring multiple benefits to the site and the city: not only do they protect water quality and provide open space, they may also decrease downstream stormwater infrastructure costs because they lessen stormwater flows and volumes.

The most effective application of LID is a comprehensive approach that includes *site design*, *source controls*, and *treatment controls*. Careful site design can minimize the impacts of stormwater runoff from the outset. The more that stormwater management is integrated into the design process, the easier it is to create a successful and multi-purpose stormwater management strategy for a given site. The following pages list a set of goals to guide site design.

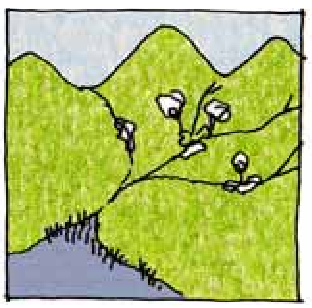
Mint Plaza, San Francisco, CA is an example of how LID can be integrated into an ultra-urban setting. The design includes rain gardens, permeable paving, and a subsurface infiltration gallery.

Figure 8. Site Design Goals



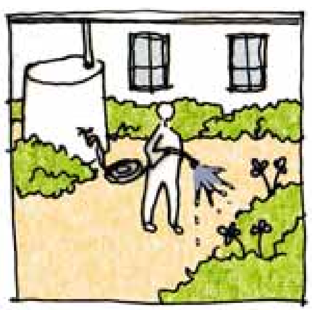
1. Do no harm: preserve and protect existing waterways, wetlands, and vegetation.

Creeks and wetlands are natural drainage features that can define the character and aesthetic value of a site. Moreover, they are already designed to convey and treat stormwater. Trees and ground cover act as natural stormwater management measures. They capture rainwater in their foliage, slow its progress through the landscape, and facilitate its infiltration into the soil.



2. Preserve natural drainage patterns and topography and use them to inform design.

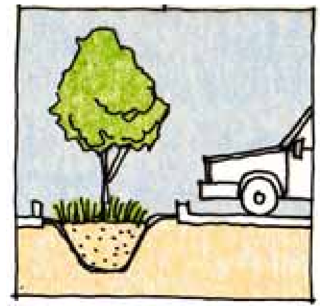
Existing topography and drainage networks can be used as a framework around which to organize development. Changing the topography of a site through grading significantly increases the chances of diminishing water quality by delivering sediment to receiving waters; it also increases project costs.



3. Think of stormwater as a resource, not a waste product.

Stormwater has traditionally been viewed as a nuisance to be eliminated. It is actually an untapped resource that can offset potable water use for irrigation, toilet flushing, cooling towers, and many other applications. It also offers opportunities to create interesting and site-specific designs using water features, rain-irrigated landscapes, and educational elements.

4. Minimize and disconnect impervious surfaces.



Minimizing and disconnecting impervious surfaces allows designers to treat relatively small volumes of runoff from multiple surfaces on a site, rather than treating relatively large volumes of stormwater that have mobilized diverse pollutants from impervious surfaces across an entire site. Disconnecting impervious surfaces and directing runoff to BMPs can be thought of as creating an obstacle course for stormwater; it increases the time needed for runoff to travel from its source to its discharge point, thereby increasing opportunities for treatment, flow reduction, and volume reduction.

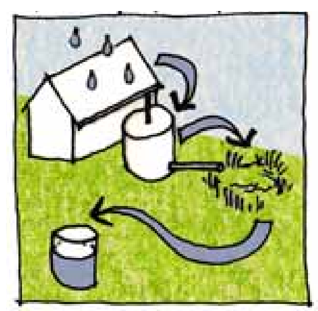
5. Treat stormwater at its source.

Treating stormwater pollutants at their source can reduce the need to treat multiple pollutants or higher pollutant loads further downstream in the drainage area. Treating at the source can result in smaller, less costly and more effective stormwater treatment facilities.

6. Use treatment trains to maximize pollutant removal.

In most scenarios, treatment to the MEP cannot always be achieved with a single BMP. In most cases, a series of linked BMPs called a treatment train must be used to maximize pollutant removal. Like a series of ever-finer sieves, treatment trains clean stormwater by running it through a series of BMPs, each designed to remove specific pollutants, from large pieces of trash, to suspended solids, to dissolved pollutants.

7. Design the flow path of stormwater on a site all the way from first contact to discharge point.



It is important to delineate the path of travel of stormwater from its first surface contact (where it changes from rain to stormwater runoff) to its final discharge point after treatment. All BMPs must have an approved overflow discharge location for storm flows that exceed the design criteria and in case of clogging.

The Ekostaden residential development in Malmo, Sweden, channels all stormwater runoff through BMP treatment features such as bioswales, ponds, and wetlands as shown here.
Photo: Brooke Ray Smith

During the site design process, designers should identify potential sources of stormwater pollution and select appropriate source controls to minimize their impacts. Source controls are stormwater management measures that prevent pollutants from entering stormwater runoff. Source controls can be design measures, such as enclosing trash areas to prevent trash from contacting stormwater; materials choices, such as using non-toxic roofing materials to prevent runoff from entraining pollutants from roof contact; and operational procedures, such as sweeping streets. See page 81 of the *Guidelines* for a description of how to select and locate source controls.

Site design strategies and source control measures minimize the quantity and improve the quality of stormwater runoff from a site. However, it is impossible to eliminate all surfaces that will contribute runoff. Treatment controls must therefore be implemented to accommodate the remaining runoff from the site. Treatment controls are permanent stormwater facilities such as vegetated swales or flow-through planters that are designed to receive and treat runoff from the site. Treatment control BMPs are typically designed to accomplish one or more of the following five stormwater treatment strategies: infiltration, detention, biofiltration, harvesting or retention, or bioretention. Each of these treatment strategies is described in Appendix A. Infiltration is typically the easiest and most cost-effective strategy for managing stormwater but, in areas where this is not feasible, designers can use a combination of the other four strategies. See page 83 of the *Guidelines* for a description of how to select, locate, and size treatment controls.

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Multi-Purpose Design

Low Impact Design can be integrated into the site design process in a way that protects water quality, contributes to the quality of the site design, and meets the stormwater performance measures required by the Port and SFPUC.

LID is the multi-purpose integration of infrastructure, architecture, and landscape and can be a catalyst for design innovation in all three disciplines. LID can integrate water quality protection with improvements to the public realm, create and enhance urban wildlife habitat, promote responsible use of water, and advance environmental education and watershed stewardship.

Traditional urban design goals can also be achieved through the implementation of stormwater BMPs. Stormwater facilities can enhance the aesthetics of the built environment, increase pedestrian safety, calm traffic, make streets and public spaces greener, and provide structure, texture, and identity to the City's streets and other public spaces.

Stormwater BMPs bring designers a diverse palette of paving surfaces, vegetation, and drainage strategies, and also a new purpose that can inform design: to improve water quality and restore ecological function.

Open space is a valuable amenity in San Francisco, now the second densest city in the nation. LID measures can double as **civic spaces**, **open spaces and recreational areas**: a constructed wetland filters stormwater and could be the center of a neighborhood nature

Rain gardens and a creek daylighting project are the centerpieces of open space adjacent to the Headwaters development in Portland, OR.

A community in Germany integrates LID into the parking.

area; a vegetated roof that reduces stormwater discharge can also be a gathering area. At Potsdamer Platz, Berlin, Germany, stormwater management strategies include rainwater harvesting for non-potable uses such as toilet flushing and fire safety, vegetated treatment modules, and water features. Stormwater management forms the centerpiece of this major civic space.

LID can also contribute to San Francisco's **urban ecosystem** by enhancing existing wildlife habitats and creating new ones. San Francisco's trees are concentrated in its parks, not on its streets; the city has roughly 40% fewer street trees per mile than the national average and many of its tree lawns and tree wells have been paved over. Expanding the City's urban forest with careful attention to species selection would simultaneously address stormwater issues, increase wildlife habitat, improve air quality, and create a network of green corridors that would contribute to the aesthetics and health of the City's neighborhoods. Habitat can also be created by implementing stormwater BMPs on the roofs and walls of buildings. In London, England, and Basel, Switzerland, vegetated roofs are being used to provide patches of foraging, breeding, and nesting habitat for endangered wildlife. See Appendix D for a vegetation palette listing climate appropriate plants and their habitat value.

Integrating LID into the **streetscape** yields a more attractive pedestrian realm through the inclusion of vegetated curb extensions, sidewalk planters, street trees, pervious surfaces, and other stormwater BMPs that add attractive, pedestrian-scale details. These elements can simultaneously achieve stormwater management goals and improve streets for pedestrians and local residents by encouraging walking, reducing noise, and calming traffic. They can improve neighborhood aesthetics, safety, quality of life, and even property values. In Vancouver, B.C., Canada, a stormwater management project on Crown Street eliminated curbs, added clustered parking, and designed infiltration areas underneath the parking. The narrow street and clustered parking allows more space to be dedicated to biofiltration areas and plantings, which create a lush and pleasant streetscape.

Stormwater is also a valuable **water resource**. Using stormwater on-site rather than releasing it downstream decreases demand for potable water and can protect receiving waters by reducing runoff rates, volumes, and pollutant loads. Rain barrels and cisterns collect stormwater and store it for later use in irrigation and toilet flushing, uses that unnecessarily burden potable water supplies. Stormwater can even contribute to future potable water supplies, by recharging underground aquifers. In Cambria, California, a two-million gallon cistern beneath an athletic field harvests rainwater from the Cambria

Elementary School site. The water is sufficient for year-round irrigation of the multiple athletic fields.

LID can also be a useful tool for **environmental education** when it is integrated into school curricula, public outreach, or interpretive signs. LID concepts can be presented at many different levels of complexity, from an introduction to watersheds to an explanation of the hydrologic cycle and environmental stewardship. LID concepts touch upon numerous disciplines, including biology, ecology, watershed planning, engineering, design, and resource management. The Eco-Center at Heron's Head Park in the Bayview-Hunters Point neighborhood is an environmental education center for local students of all ages. Educational programs at the Eco-Center focus on habitat conservation and community stewardship. A collaboration between Literacy for Environmental Justice, the Port of San Francisco, and the San Francisco Department of the Environment, the Eco-Center includes a vegetated roof, rainwater harvesting, photovoltaic panels, solar hot water generation, native planting, and other LID features. At the time of writing these *Guidelines*, this project was under construction.

Lastly, LID can help the design and development community achieve **environmental performance measures**, which aim to minimize the environmental impacts of development and provide high quality, healthy environments. In San Francisco, both Leadership in Energy and Environmental Design (LEED®), a green building rating system developed by the U.S. Green Building Council, and the GreenPoint Rated system, a rating system developed by the non-profit Build It Green, are being used to assess the environmental quality of site and building design. In both systems, stormwater management facilities can earn points toward certification.

Environmental Justice

Over the past decade, increased attention has been given to the disproportionate impact of environmental pollution on socio-economically disadvantaged communities. The USEPA defines environmental justice as "the fair treatment of people of all races, cultures and income, regarding the development of environmental laws, regulations and policies." This issue is of concern in many areas of San Francisco, and in particular the Bayview-Hunters Point neighborhood, former home to Hunters Point Shipyard, the only federal Superfund site in San Francisco.

The Bayview-Hunters Point neighborhood contains over 100 brownfield sites. The residents of the primarily African-American neighborhood have borne the environmental and health impacts of these brownfield sites. The *Guidelines* proposes LID measures that can effectively manage stormwater runoff at the Shipyard and other areas of Bayview-Hunters Point, while at the same time improving the quality and safety of neighborhoods by providing attractive landscape features, traffic calming measures, and a safer pedestrian realm.

A vegetated roof and other LID features at the Eco-Center at Heron's Head Park help illustrate sustainable design practices to students in San Francisco's Bayview-Hunters Point neighborhood.

LEED Category	Credits		Points
Sustainable Sites	SS6.1	Stormwater quantity control	1
	SS6.2	Stormwater quality control	1
	SS5.1	Protect or restore habitat	1
	SS5.2	Maximize open space	1
	SS7.1	Urban heat island effect - non-roof	1
	SS7.2	Urban heat island effect – roof	1
Water Efficiency	WE1.1	Water efficient landscaping - reduce by 50%	1
	WE1.2	Water efficient landscaping - no potable water use or no irrigation	1
	WE2	Innovative wastewater technologies	1
	WE3.1	Water use reduction - 20% reduction	1
	WE3.1	Water use reduction - 30% reduction	1
		Total stormwater-related credits	**11**

Table 3. *LEED® credits related to stormwater in LEED-NC® Version 2.2.*

In Southern California, Santa Monica's Main Library used an innovative stormwater management design to help achieve its water-saving goals and receive a LEED Gold rating: a 225,000-gallon cistern under the building stores stormwater for irrigation of both landscaping at the library and adjacent street plantings.

Many of the LEED certification systems include credits that explicitly address stormwater. In LEED for New Construction, these credits are in the Sustainable Sites category (see Table 3). Implementing LID measures such as habitat enhancement, reduction of impervious surfaces,

The Academy of Sciences in Golden Gate Park is targeting LEED Platinum certification and includes a 2.5 acre vegetated roof.
Photo: Rana Creek - Living Architecture

vegetated roofs, and rainwater harvesting can also help project applicants earn credits in other areas.

The GreenPoint Rated system includes many measures that are related to stormwater, although it does not propose any quantitative performance measures for stormwater management (Table 4). Stormwater-related points can be earned in the areas of site design, landscaping, exterior finishing, and innovation in the water category. To be considered GreenPoint Rated, a home must achieve 50 total points, with a minimum number of points in each of the five environmental categories (Community, Energy Efficiency, Indoor Air Quality, Water Conservation and Resource Conservation). Single family projects require at least eight points earned in the water category, while multifamily projects require at least three points earned in the water category. The GreenPoint Rating system specifically encourages rainwater harvesting and water efficient landscaping.

GreenPoint Checklist	Feature		Points (Category)
Multifamily	A.3.a.	Protect soil & existing plants & trees	1 (Community)
	A.7.c.	Specify drought-tolerant California natives, Mediterranean or other appropriate species	1 (Water)
	A.7.d.i.	Mulch all planting beds to a depth of 2 inches or greater as per local ordinance	1 (Water)
	A.7.d.ii.	Amend with 1 inch of compost or as per soil analysis to reach 3.5 % soil organic matter	1 (Water)
	A.7.e.i.	Specify smart (weather-based) irrigation controllers	1 (Water)
	A.7.e.ii.	Specify drip, bubblers, or low-flow sprinklers for all non-turf landscape areas	1 (Water)
	A.7.f.	Group plants by water needs (hydrozones)	1 (Water)
	A.9.	Cool site through permeable paving (minimum of 30% of site)	1 (Community)
	C.12.a.	A portion of the low-slope roof area is covered by a vegetated or "green" roof (25% or greater)	1(Community) 1(Water)
	D.14.b.	Use captured rainwater for landscape irrigation or to flush 5% of toilets and/or urinals	4 (Water)
	F.2.a.	Provide O & M manual to building maintenance staff	1 (Energy)
	F.2.b.	Provide O & M manual to occupants	1 (Energy) 1(Water)
		Total points:	**17**
Single Family	A.1.a.	Protect topsoil from erosion & reuse after construction	1 (Community) 1 (Water)
	A.1.b.	Limit & delineate construction footprint for maximum protection	1 (Water)
	C.1.a.	No invasive species listed by Cal-IPC are planted	1 (Water)
	C.1.c.	75% of plants are California natives or Mediterranean species or other appropriate species	3 (Water)
	C.4.	Plant shade trees	3 (Water)
	C.5.	Group plants by water needs (hydrozoning)	2 (Water)
	C.6.a.	System uses only low-flow drip, bubblers or low-flow sprinklers	2 (Water)
	C.6.b.	System has smart (weather-based) controllers	3 (Water)
	C.7.	Incorporate 2 inches of compost in the top 6-12 inches of soil	3 (Water)
	C.8.	Mulch all planting beds to the greater of 2 inches or local water ordinance requirement	2 (Water)
		Total points:	**22**

Table 4. *GreenPoint Rated credits related to stormwater*

If stormwater is clean enough, it can be used to fill swimming pools.
Photo: Bassin Takis in Paris, KMD Architects

Integrating LID into San Francisco's Urban Landscape

The illustrations on the following pages show how LID can be integrated into San Francisco's diverse land uses to both protect water quality and contribute to the character of a given location. The figures illustrate stormwater management strategies appropriate for each of the following land uses:

- High-density Residential
- Low-density Residential
- Mixed Use
- Industrial
- Open Space and Natural Areas
- Piers over Water
- Former Shipyards

The figures are not meant to provide a comprehensive list of stormwater design solutions that are possible in San Francisco. Rather, they offer ideas and examples of the benefits that result from the implementation of multi-purpose LID.

A creek daylighting project in Zurich, Switzerland protects and improves water quality, by keeping it out of the sewer, and transforms the streetscape.

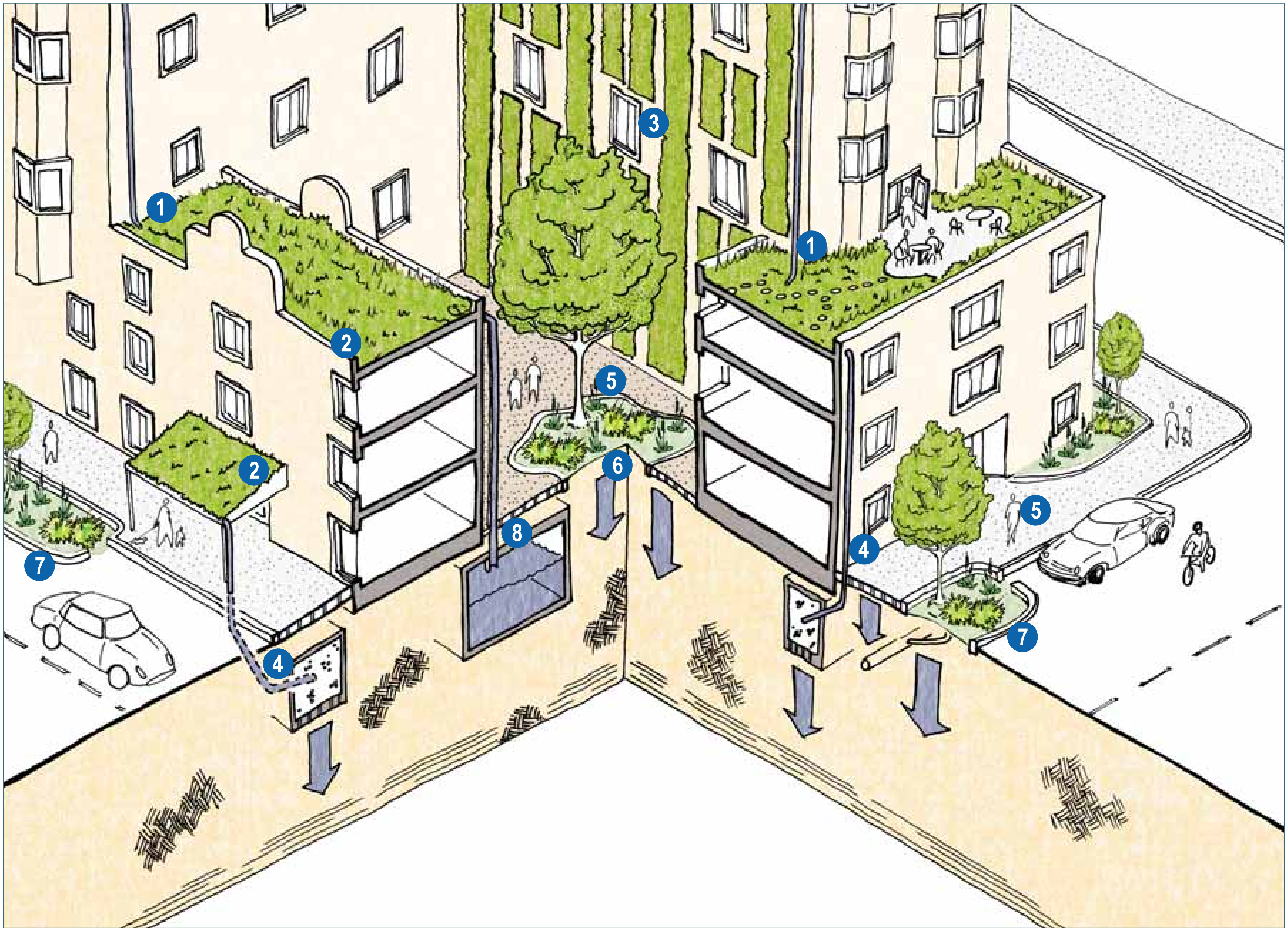
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Figure 9. High-density Residential

In San Francisco, high-density residential development is classified as 40 or more living units per acre. Some defining characteristics of high-density residential are zero-lot line development, reduced, public open space, and high levels of imperviousness. In this context, the greatest opportunities for stormwater management reside in replacing impervious surfaces with pervious surfaces and adding green space to roofs and interior courtyards. Ample roof space with relatively low pollutant loads provides opportunities for eco-roofs and rainwater harvesting. Interior courtyards can accommodate landscape-based BMPs, permeable paving, and subsurface treatment or capture systems. Sidewalks and streets adjacent to high-density residential development are often the nearest public open spaces available to residents. As such, they are ideal places to site stormwater management BMPs that also improve streetscape aesthetics and provide wildlife habitat, such as biofiltration areas, street trees, green walls, and bioretention bulbouts. All of these measures help to manage stormwater runoff; they also reduce the volumes of stormwater generated by the site in the first place.

1. Downspout Discharges to Vegetated Roof to Reduce Runoff
2. Vegetated Roof to Reduce Runoff
3. Green Wall to Slow Runoff
4. Downspout Connected to Dry Well
5. PermeablePaving in Pedestrian Areas
6. Rain Garden for Bio-Infiltration
7. Bio-Retention Planter with Curb Cuts
8. Downspout Connected to Large-Scale Cistern for Rainwater Harvesting

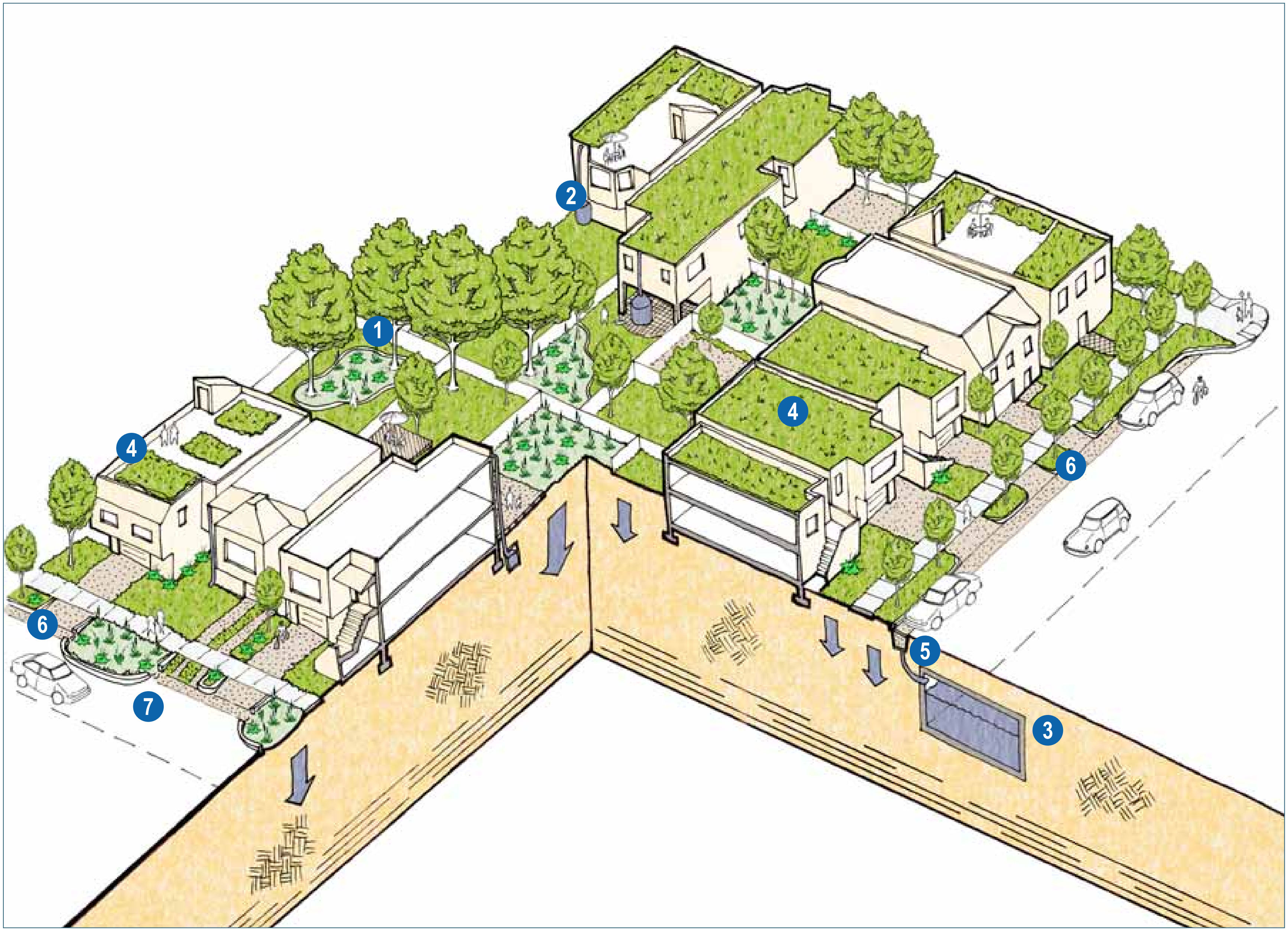
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Figure 10. Low-density Residential

In San Francisco, low-density residential development refers to 24 living units per acre or fewer. Low-density residential parcels typically include open space in the form of yards and setbacks, wider sidewalks than those found in high-density residential, and rooftops that are more likely to be under the control of a single owner. Low-density residential parcels therefore tend to both generate less stormwater and have more space in which to manage stormwater than high-density areas. Diverse parcel sizes and shapes, along with variability in building footprints, provide opportunities for site-specific stormwater management designs.

1. Rain Garden for Bio-Infiltration
2. Downspout Connected to a Rain Barrel
3. Cistern to Store Rainwater for Irrigation
4. Vegetated Roof to Reduce Runoff
5. Infiltration Trench
6. Permeable Paving
7. Bio-Retention Planter with Curb Cuts

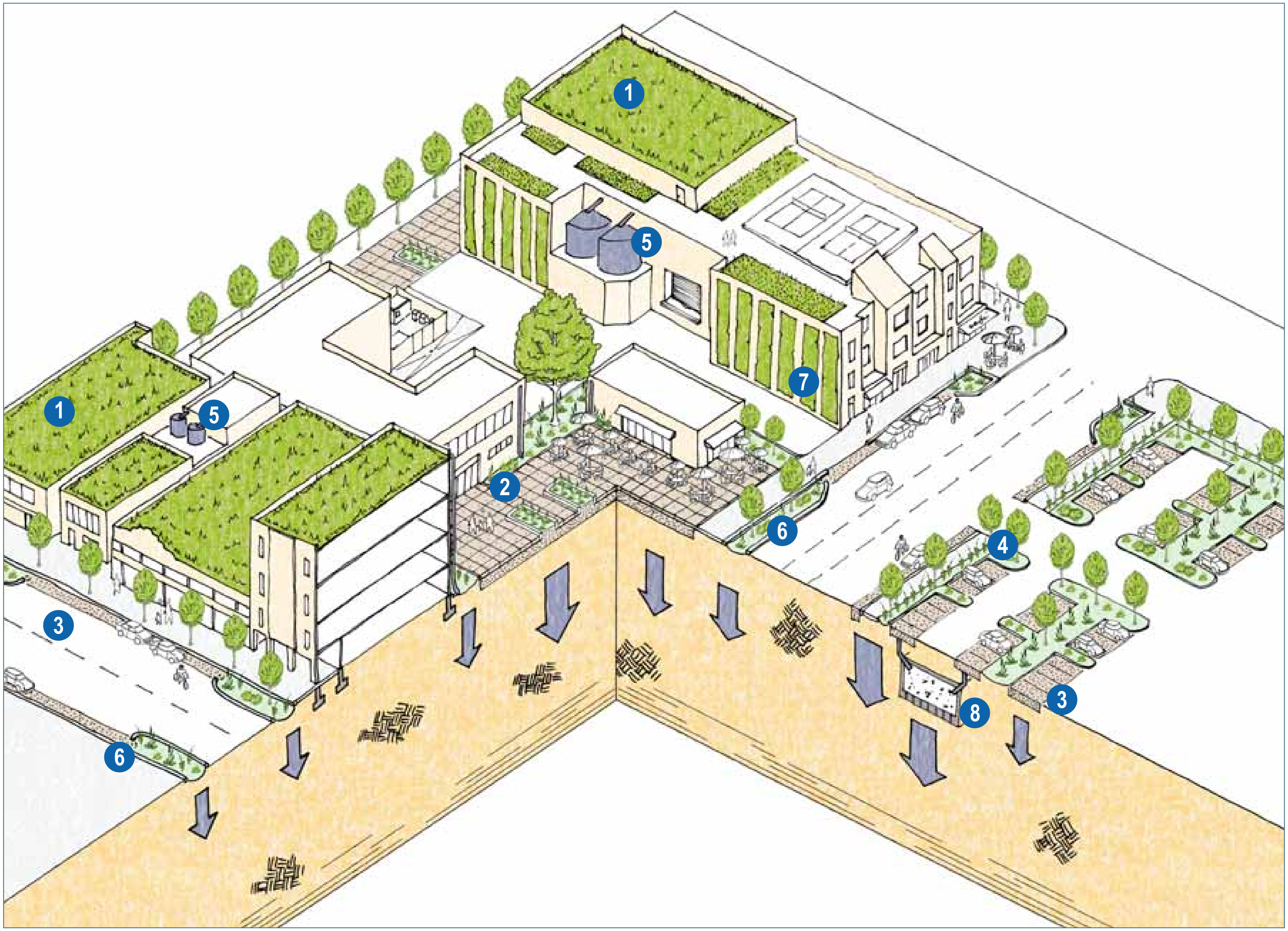
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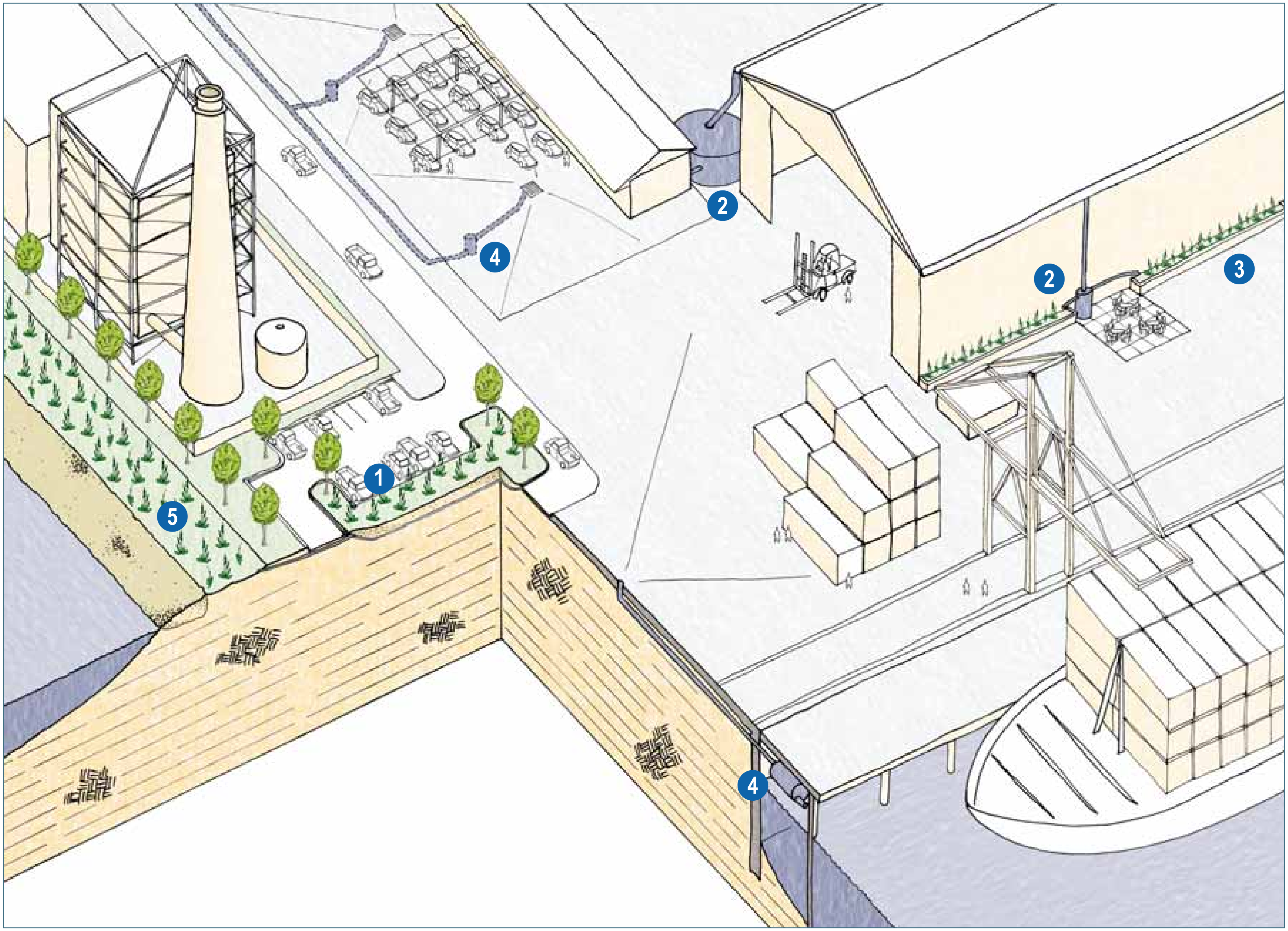
Figure 11. Mixed Use

Many new, redevelopment, and infill projects in San Francisco include mixed-use areas. Mixed use development fosters a high level of activity throughout the day, resulting in an active public realm. Roofs, public plazas, setbacks, parking lots, and the public right-of-way are all spaces that can double as LID measures that improve the quality of the public realm and achieve stormwater management goals. Of these spaces, roofs generally have the lowest pollutant loads while streets have the highest. The commercial elements of mixed use development sometimes require special attention. For example, restaurants and light industrial activities will need to implement source controls targeting grease, litter, and other food wastes.

1. Vegetated Roofs to Reduce Runoff
2. Permeable Paving in Pedestrian Areas
3. Permeable Paving in Parking Areas
4. Swales in Parking Lots
5. Cistern to Store Rainwater for Toilet Flushing
6. Bio-Retention Planter with Curb Cuts
7. Green Wall to Slow Runoff
8. Dry Well



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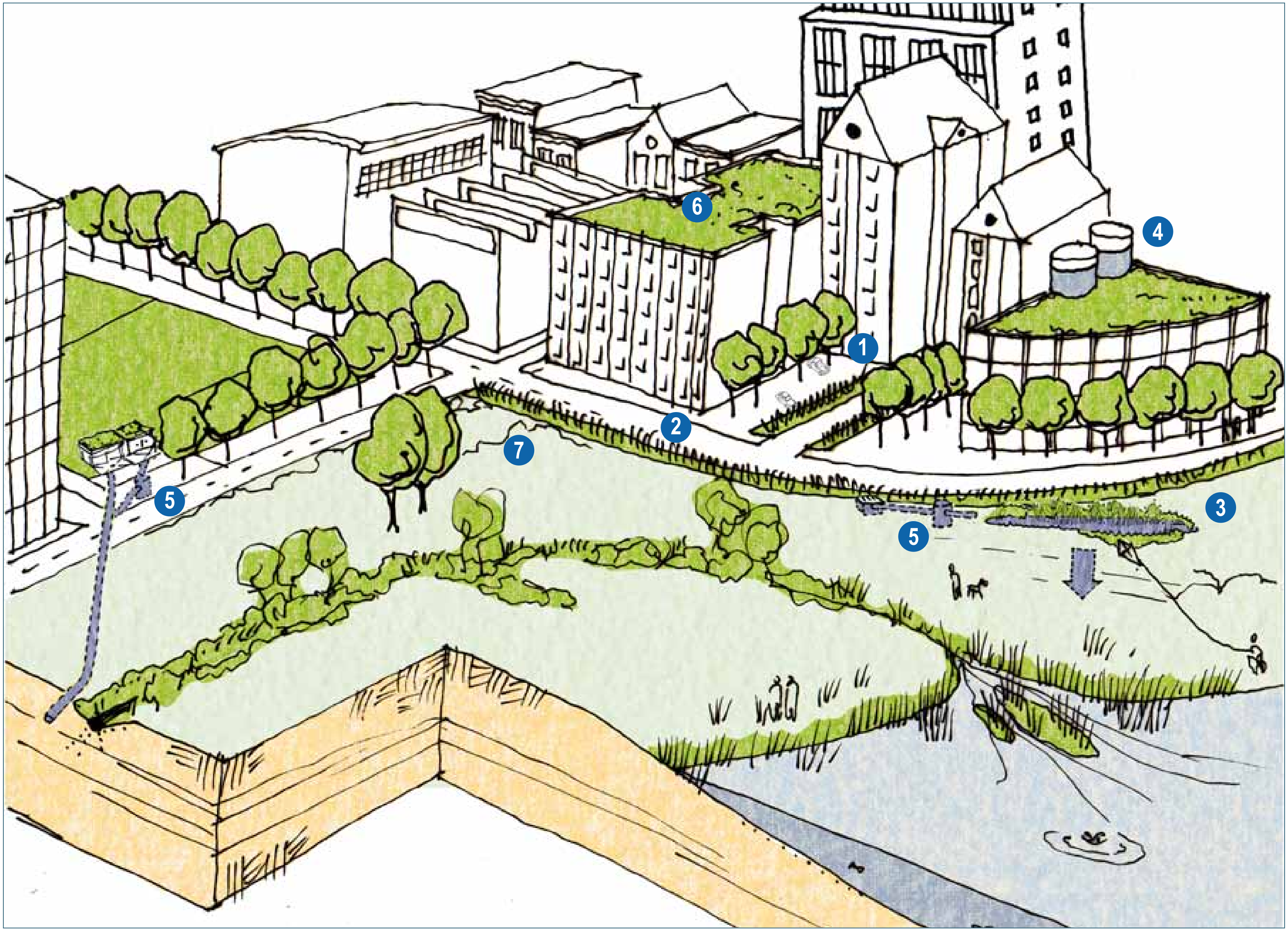
Industrial

Figure 12. Industrial

Industrial land uses in San Francisco are concentrated in the Bayside watersheds. Because industrial areas often contain potentially polluting activities coupled with large impervious areas, treating stormwater on-site in these areas is essential. Industrial land use is generally characterized by large, low-density structures that provide ample space for treatment measures. Stormwater management strategies in industrial areas can serve not only to protect water quality but also to provide high quality rest areas for workers, act as a buffer for adjacent land uses, and maintain public access to waterfront open space where appropriate. Pollutants associated with industrial activities – chemical waste storage, for example – require special source control strategies such as hydraulic isolation and treatment in areas where polluting activities occur.

1. Swales in Parking Lots
2. Cisterns to Store Rainwater for Vehicle Washing
3. Flow-through Planters to Improve Water Quality
4. Vortex/Swirl Separator or Media Filter
5. Vegetated Buffer Strip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Open Space

Figure 13. Open Space

San Francisco's open spaces provide space for passive and active recreation, wildlife habitat, and environmental education. Open space areas also contribute to air and water quality protection. Some open space areas, most notably Lake Merced, include water bodies whose health and function depend upon protection from adjacent polluting activities. To that end, stormwater BMPs can be sited on less sensitive open spaces to protect the more sensitive core areas. Open spaces can often accommodate larger stormwater treatment trains that integrate stormwater management with other ecological functions. Because of this, stormwater management in open spaces can make significant contributions toward restoring natural hydrology and ecosystem health. Open spaces that are opportunity sites for LID include parks, recreational areas, school playfields, and natural areas.

1. Swales in Parking Lots and Roadways
2. Swales to Buffer Open Space from Development
3. Constructed Wetlands to Buffer Open Space from Development
4. Cistern to Store Rainwater for Irrigation
5. Street Drains to Wetland via Swirl Separator; Trash Area Drains to Sewer via Swirl Separator
6. Vegetated Roof to Reduce Runoff
7. Vegetated Slope to Reduce Erosion/Sedimentation

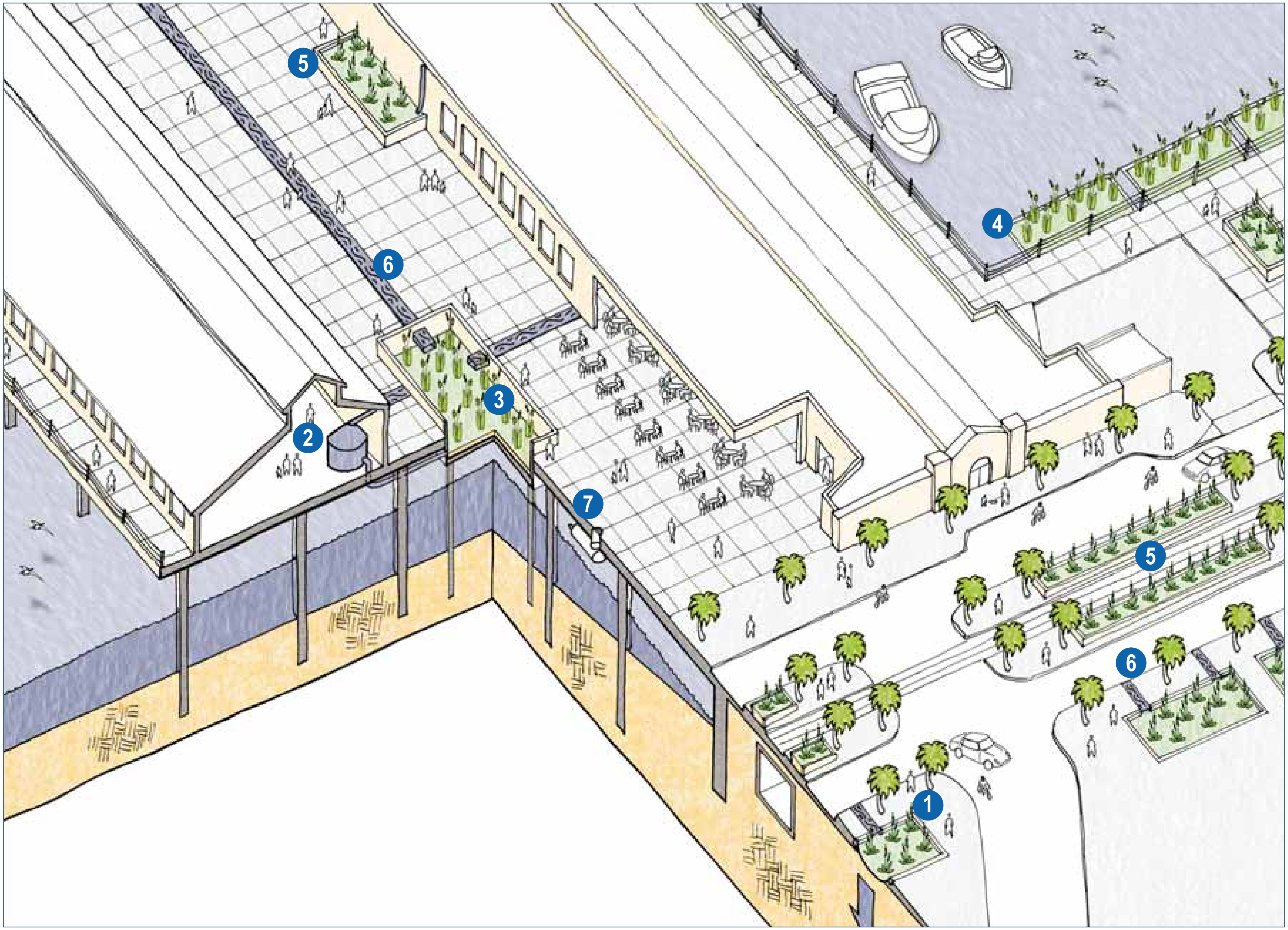
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Figure 14. Piers Over Water

Piers over water are common along San Francisco's waterfront. They are frequently the site of redevelopment projects seeking to adaptively reuse attractive and unique historic properties. Development on piers over water includes a wide variety of land uses, including commercial, recreational, industrial, and maritime uses. Because runoff from piers over water often flows directly to the Bay without the benefit of dedicated conveyance structures, stormwater management on piers over water requires creative infrastructure solutions. Limited space, cultural and historic preservation requirements, and public access goals all impose additional design constraints. The transition between piers and streetscape may provide opportunities for landscape-based stormwater management strategies that may not be feasible on the piers themselves. In some cases, media filtration devices may be the only feasible option for certain aspects of pier redevelopment.

1. Rain Gardens in the Streetscape
2. Cistern for Rainwater Harvesting
3. Detention Pond
4. Vegetated Pontoons for Biofiltration*
5. Above Ground Planter for Biofiltration
6. Trench Drains for Conveyance
7. Vortex/Swirl Separator or Media Filter

* See the Emerging Technologies factsheet in Appendix C for more about vegetated pontoons.

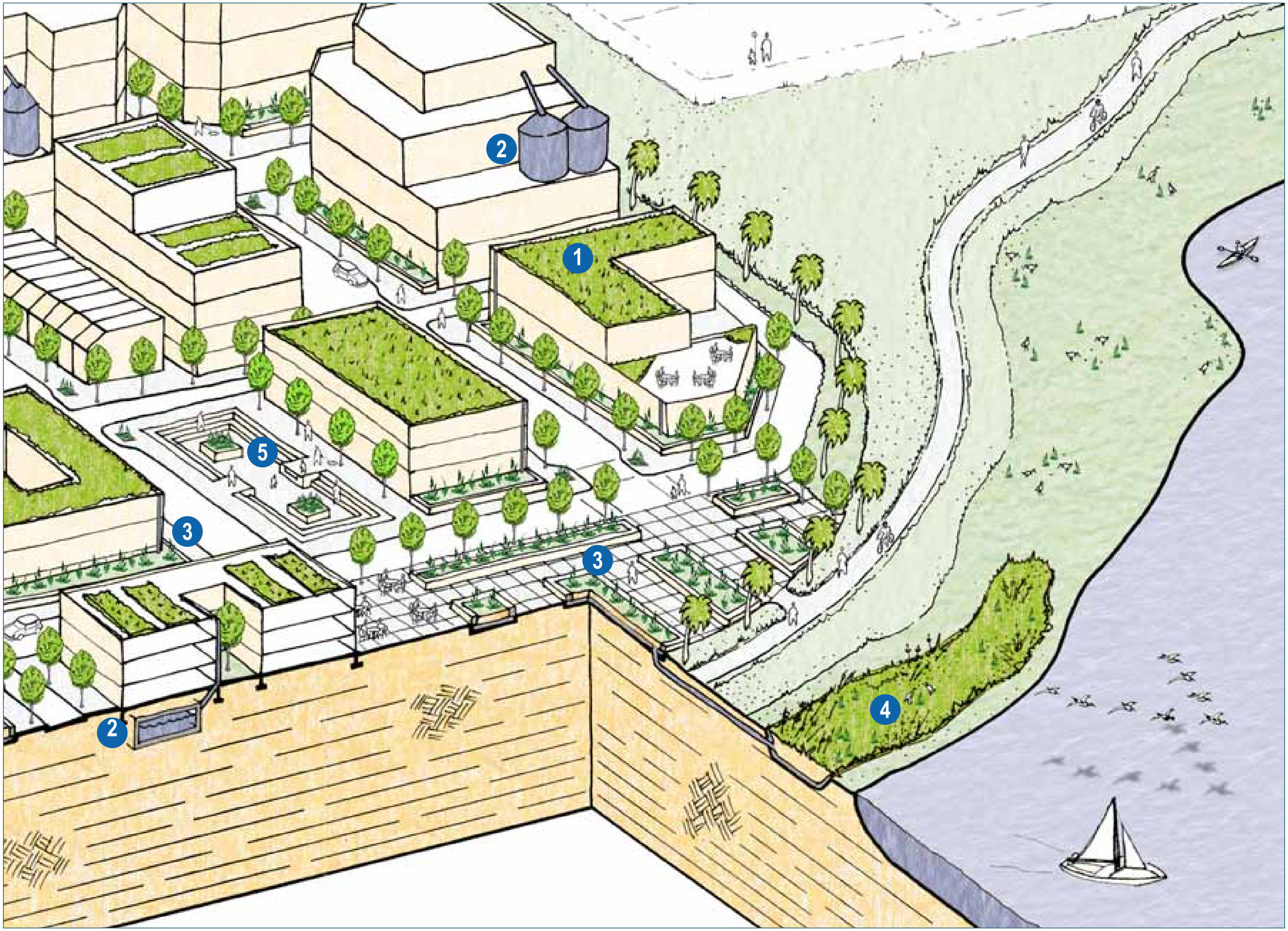
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Figure 15. Former Shipyards

A number of San Francisco's redevelopment areas are former shipyards. Former shipyards have a variety of challenging conditions associated with them, such as a high water table, uncompacted fill, and legacy pollutants from historic shipyard activities. Historic pollution can limit the feasibility of certain LID measures, and those LID measures that are implemented will often require engineered liners to prevent mobilization of subsurface contaminants. Despite these challenges, redevelopment of former shipyards offers significant opportunities for innovative and comprehensive stormwater management because it often requires building new infrastructure systems.

1. Vegetated Roofs to Reduce Runoff
2. Cisterns to Harvest Rainwater for Heating and Cooling
3. Rain Gardens for Biofiltration
4. Constructed Wetland to Buffer Water from Urban Development
5. Urban Stormwater Plaza/Detention Pond

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Port Plan Approval

To ensure consistent implementation of LID in new and redevelopment projects in San Francisco's separate sewer areas, the Port requires all projects disturbing 5,000 square feet or more to comply with stormwater performance measures in order to gain plan approval.

Project applicants subject to these *Guidelines* will be required to complete a Stormwater Control Plan (SCP) to demonstrate that they have met San Francisco's stormwater requirements. The requirements are performance-based and are very similar to those used in other Bay Area Cities. The stormwater performance measures for projects served by separate storm sewer systems under Port jurisdiction require the capture and treatment of:

- The flow of stormwater runoff resulting from a rain event equal to at least 0.2 inch per hour intensity; **or**
- Eighty percent or more of the annual stormwater runoff volume, determined from unit basin storage volume curves for San Francisco.

Project applicants developing or redeveloping properties subject to these performance measures must complete a SCP for project approval. The SCP will allow the Port, the SFPUC, and the Planning Department to certify compliance with these requirements. The contents of the SCP are described in the next section, and a SCP template is provided in Appendix C.

Project applicants must also ensure compliance with other stormwater regulations that may apply to their project. For instance, construction sites greater than 1 acre are generally required to seek coverage under the *California Statewide General Permit for Stormwater Discharges Associated with Construction Activities*. Specific types of commercial and industrial operations must seek coverage under the *California Statewide General Permit for Stormwater Discharges Associated with Industrial Activities.*

Port Requirement

All qualifying projects in the separate storm sewer area that disturb 5,000 square feet or more of the ground plane are required to capture and treat rainfall from a 0.2-inch per hour event **or** eighty percent or more of the annual stormwater runoff volume, determined from unit basin storage volume curves for San Francisco. Disturbed area includes any movement of earth, or a change in the existing soil cover or the existing topography. Land disturbing activities include, but are not limited to, clearing, grading, filling, excavation, or addition or replacement of impervious surface.

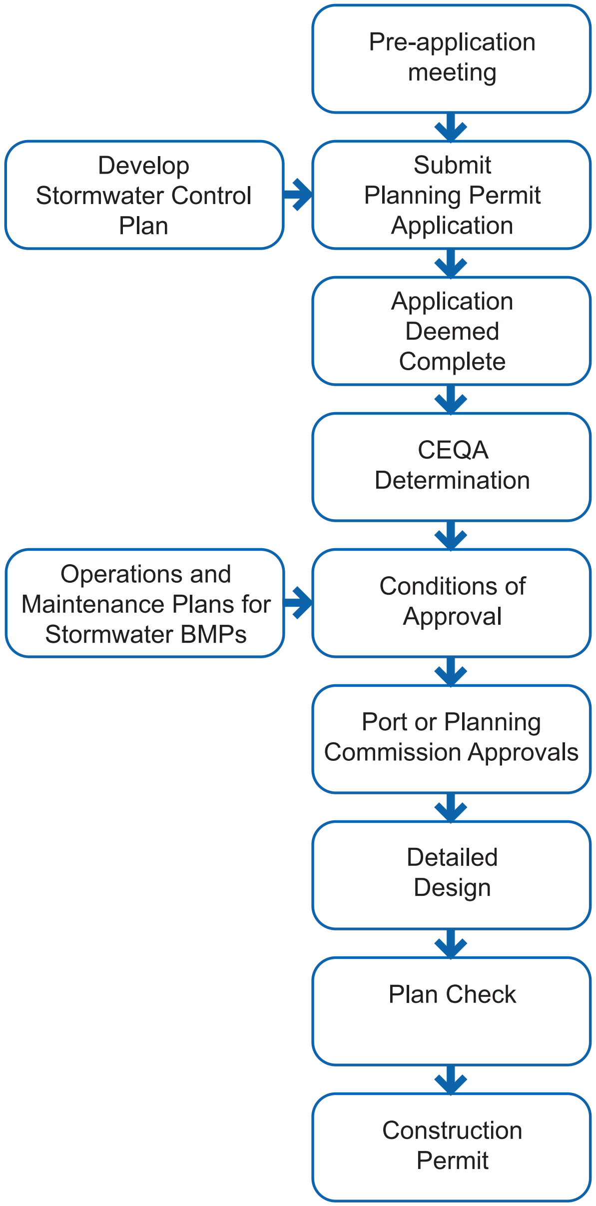

Figure 16. *The SCP submittal and plan approval process.*

The Development Review Process

The Port has integrated SCP review into its existing development review processes. A simplified diagram for a typical development review process is shown in Figure 16.

The SCP must be submitted along with the development application for Planning Review. Planning Department staff will often request that applicants provide a preliminary site layout, preliminary landscaping plan, elevation drawings, or other illustrations for review at a pre-submittal meeting. Project applicants will also discuss their preliminary SCP at the pre-submittal meeting. At this stage project applicants should bring a drainage plan with proposed locations for BMPs.

CEQA

Most projects subject to the requirements of these *Guidelines* will also require some level of CEQA review. The California Environmental Quality Act (CEQA) environmental review imposes both procedural and substantive requirements for environmental protection. CEQA requires local jurisdictions to identify and evaluate the environmental impacts of their actions, including zoning decisions and discretionary land-use approvals. The CEQA process provides decision-makers and members of the public with information about potentially adverse environmental impacts and requires implementation of feasible alternatives and mitigation measures in order to reduce those impacts.

CEQA is intended to minimize the environmental impacts of development activities, which is consistent with the objectives of these *Guidelines*. The basic purposes of CEQA are to:

- Inform decision-makers and the public about the potential significant environmental effects of proposed activities.
- Prevent significant, avoidable damage to the environment by requiring changes in projects through the use of alternatives or mitigation measures when the governmental agency finds the changes to be feasible.
- Disclose to the public the reasons why a governmental agency approved the project in the manner the agency chose if significant environmental effects are involved.

The CEQA Initial Study Checklist

The Phase II General Permit requires local municipalities to evaluate water quality effects and identify appropriate mitigation measures when conducting environmental review of proposed projects. This effort can be integrated into the completion of the CEQA Initial Study Checklist. The CEQA Initial Study Checklist is used to determine whether a given project will have significant impacts on the environment.

The San Francisco Planning Department's Initial Study Checklist contains questions that link potentially significant project impacts to requirements under the CWA and the California Water Code:

- Question 14.a: **"Would the project violate any water quality standards or waste discharge requirements?"** This question evaluates a project's compliance with water quality standards and considers the project's potential effect on water bodies on the Section 303(d) list.
- Question 14.d: **"Would the project substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on- or off-site?"** This question investigates the potential effects of increased runoff peak flows and durations.
- Question 14.e: **"Would the project create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial new sources of polluted runoff?"** This question evaluates the potential impacts of pollutants in runoff and increased stormwater flows to the collection system.
- Question 14.f: **"Would the project otherwise substantially degrade water quality?"** This question is the most tightly linked to the *Guidelines*. The intent of these *Guidelines* is to ensure that projects do not degrade water quality.

Port, SFPUC, and City Planning staff will work with project applicants to ensure that the CEQA Initial Study Checklist clearly articulates potential impacts that the project may have on the quantity and quality of stormwater runoff. BMPs required by the *Guidelines* will reduce stormwater impacts by controlling sources of pollution, reducing site imperviousness, and providing for treatment facilities that retain, detain, or treat runoff.

The CEQA process is generally administered in several steps:

1. Review of the CEQA checklist to determine the appropriate level of review.

2. Issuance of a Categorical Exemption for projects exempt from CEQA review.

3. Preparation of an Initial Study to characterize the environmental effects of the project.

4. Preparation of an Environmental Impact Report (EIR) or Negative Declaration.

In cases where a higher level of environmental review is required for project approval, such as a Mitigated Negative Declaration or an EIR, the CEQA process may require the consideration of project alternatives. Because the final project configuration is uncertain, it may not be possible to complete a SCP prior to CEQA approval. In such cases, a preliminary SCP would be required to be completed once the project configuration is finalized. The SCP must be completed and approved before the applicant begins final design drawings for the project.

If CEQA approval for a project includes mitigation measures, project applicants will be required to participate in a mitigation monitoring and reporting program (MMRP). CEQA requires the MMRP to ensure compliance with adopted mitigation measures during project implementation. The MMRP specifies the required actions and monitoring that are required for each mitigation measure recommended in the EIR. The requirements for the construction and maintenance of stormwater BMPs described in the SCP can be used in the MMRP for EIRs and Mitigated Negative Declarations.

The San Francisco Planning Department prepares CEQA documents for proposed City projects. If the CEQA analysis determines that a project would have a significant or potentially significant impact on hydrology and water quality, then the project would be required to administer mitigation measures that would reduce the impact to less than significant, or the City would need to make Findings of Overriding Considerations.

Project applicants must meet the stormwater performance measures described in these *Guidelines* to avoid negative impacts to water quality. By doing so, they may avoid triggering CEQA mitigation requirements. Projects receiving a Categorical Exemption or Negative Declaration under CEQA are still required to submit a complete SCP in order to gain project approval.

Multi-Parcel Projects

While compliance with the *Guidelines* is required for all new and redevelopment projects greater than 5,000 square feet, master-planned and multi-parcel projects offer the greatest opportunity for regional LID elements (i.e., stormwater facilities serving more than one parcel) such as treatment wetlands, water features, and wet ponds. The Port and SFPUC will work with project applicants who are proposing large projects to develop a comprehensive Stormwater Control Plan (SCP) that integrates stormwater management approaches across multiple parcels.

Requirements for a comprehensive SCP and associated Operations and Maintenance Plan will follow the methodology for preparation of an SCP, as discussed in later sections of the *Guidelines*. During CEQA review for large projects, greater emphasis will be placed on the relationship between overall stormwater infrastructure development and the development of specific parcels. Please contact Port staff to initiate this process.

References and Resources

Fulton, William and Paul Shigley. 2005. *Guide to California Planning*. Point Arena: Solano Press Books.

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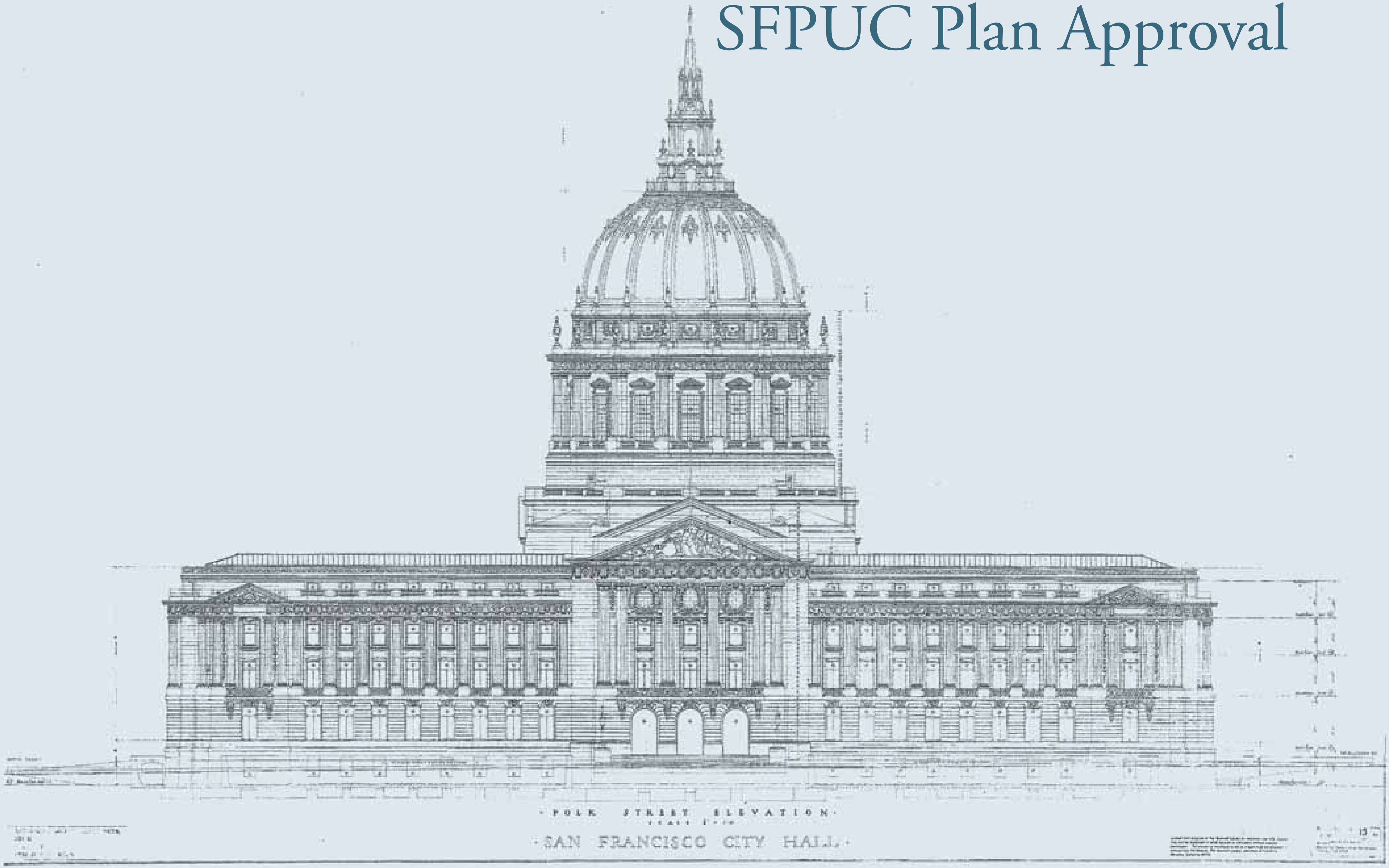
SFPUC Plan Approval



To ensure consistent implementation of LID in new and redevelopment projects in San Francisco, the SFPUC requires all projects disturbing 5,000 square feet or more to comply with stormwater performance measures in order to gain plan approval.

In separate sewer areas under SFPUC jurisdiction, applicants proposing new or redevelopment projects that either a) disturb 5,000 square feet or more of the ground plane, or b) are subject to San Francisco's Green Building Ordinance, are required to:

- Capture and treat the rainfall from a design storm of 0.75 inch using acceptable best management practices (BMPs); and
- Complete a Stormwater Control Plan (SCP) demonstrating how the project will capture and treat rainfall from the 0.75-inch design storm.

This performance measure is equivalent to LEED Sustainable Sites Credit 6.2 titled "Stormwater Design: Quality Control." The rainfall depth of 0.75 inch is the LEED-based performance measure for semi-arid watersheds.

In combined sewer areas under SFPUC jurisdiction, applicants will be required to reduce the flow rate and volume of stormwater going into the combined system by achieving LEED Sustainable Sites Credit 6.1 titled "Stormwater Design: Quantity Control."

The SCP requirement will allow the SFPUC, the Department of Building Inspection (DBI), and the Planning Department to verify compliance with stormwater requirements. The *Guidelines* chapter entitled, "The Stormwater Control Plan," describes the required contents of a SCP and also provides sizing instructions for stormwater treatment BMPs to comply with this requirement. A SCP template is provided in Appendix C.

SFPUC Requirement

Developments or redevelopments disturbing 5,000 square feet or more of the ground surface are required to manage stormwater on-site. Land disturbing activities include, but are not limited to, clearing, grading, filling, excavation, or addition or replacement of impervious surface.

In separate sewer areas, applicants must achieve LEED SS6.2 and demonstrate compliance in a SCP.

In combined sewer areas, applicants must achieve LEED SS6.1 and demonstrate compliance in a SCP.

How does LEED Credit SS6.2 compare to the General Permit requirements?

San Francisco's GBO adopts performance measures drawn from LEED, a nationally-recognized standard. Analysis indicates that the performance measure listed in LEED 6.2 is roughly equivalent to the performance measures listed in the General Permit, with LEED 6.2 being slightly more stringent (by about 2%). The proposal to use LEED-based performance measures was approved by the RWQCB on December 19, 2008.

GBO Project Thresholds

Midsize Residential
(5+ units and < 75 feet
height to highest occupied floor)

High-Rise Residential
(5+ units and > or = 75 feet
height to highest occupied floor)

Mid-Size Commercial Office
Building of a B Occupancy
(>5,000 SF and <25,000 SF)

New Large Commercial Office
Building of a B Occupancy
(>25,000 SF)

***Table 5**. Projects required to achieve stormwater points under the Green Buliding Ordinance*

The Green Building Ordinance

On November 3, 2008, the City of San Francisco's Building Code was amended to include Chapter 13C, "Green Building Requirements," known as the Green Building Ordinance (GBO). The code requires certain types of new and redevelopment projects constructed in San Francisco to meet green building standards developed by San Francisco's Green Building Task Force. Many of the standards are based on LEED, a green building rating system developed by the United States Green Building Council (USGBC). Projects that fall into one of four building categories listed in Table 5 must comply with the GBO by obtaining specified levels of LEED certification. For the full text of the GBO, go to http://www.sfenvironment.org/downloads/library/sf_green_building_ordinance_2008.pdf.

The GBO requires projects to obtain LEED's Sustainable Sites credit entitled "Stormwater Design: Quantity Control" (SS6.1) or "Stormwater Design: Quality Control" (SS6.2), depending on whether the site is in a separate or combined sewer area.

For the full text of Credits SS6.1 and SS6.2, see pages 75-87 of the "LEED for New Construction and Major Renovation Reference Guide, Version 2.2."

The GBO refers to both LEED and these *Guidelines* in Section 1304C.0.3:

Stormwater management shall meet the "Best Management Practices" and "Stormwater Design Guidelines" of the San Francisco Public Utilities Commission, and shall meet or exceed the applicable LEED SS 6.1 and 6.2 guidelines.

The applicable LEED credit for separate sewer areas is SS6.2. while the applicable LEED credit for combined sewer areas is SS6.1. SFPUC staff is currently in the process of modeling the impacts of SS6.1 on the combined sewer area and developing calculators for SS6.1. Until this modeling is completed, applicants with questions about projects in the combined sewer should contact SFPUC staff for direction.

Projects subject to stormwater requirements under the GBO that do not disturb 5,000 square feet of the ground surface must achieve LEED Certification and achieve either LEED SS6.1 or LEED SS6.2, but need not submit a Stormwater Control Plan. Only projects disturbing 5,000 square feet or more need to submit a SCP.

The Development Review Process

The SFPUC has integrated the review of SCPs with the City's development review process. All projects disturbing 5,000 square feet or more must submit a SCP. A diagram showing how the SCP fits into a typical development review process is shown in Figure 17.

Project applicants must also ensure compliance with all stormwater regulations that may apply to their projects. For instance, construction sites greater than 1 acre are generally required to seek coverage under the California Statewide General Permit for Stormwater Discharges Associated with Construction Activities. Specific types of commercial and industrial operations must seek coverage under the California Statewide General Permit for Stormwater Discharges Associated with Industrial Activities.

Permit applicants that are also subject to the GBO will be required to receive third-party verification by the Green Building Certification Institute (GBCI), USGBC's official accreditation and certification body; or by the project's Green Building Compliance Professional of Record. The building permit application must include a complete LEED checklist, as stipulated in Administrative Bulletin for Chapter 13C (AB-093), which outlines administrative procedures for meeting green building requirements (see http://www.sfgov.org/site/dbi_index.asp?id=89703). The LEED Version 2.2 checklist includes Credits SS6.1 and SS6.2, and applicants must indicate their intent to comply in order to receive a building permit.

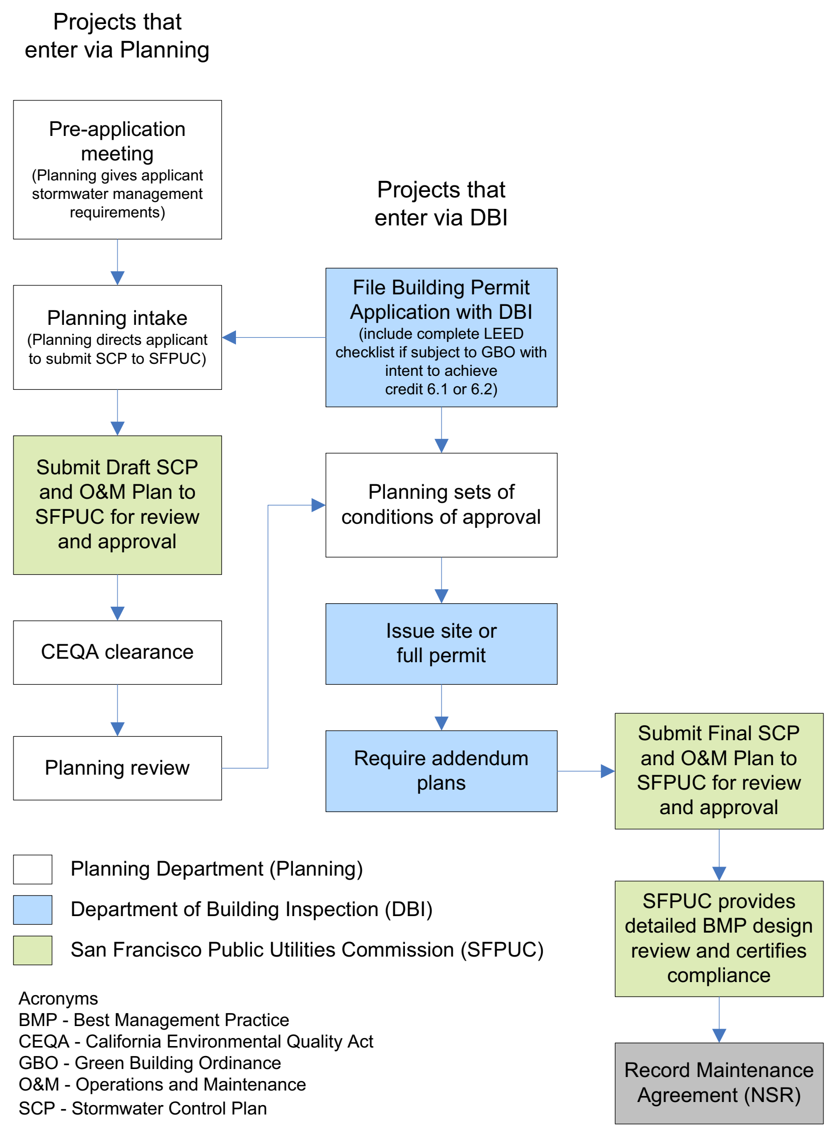


Figure 17. *The Stormwater Control Plan submittal and approval process*

LID measures like the stormwater wetland in Portland's Tanner Springs Park treat polluted street runoff, thereby minimizing negative impacts to water quality.

References and Resources

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The Western Harbor, located in Malmo, Sweden, conveys and treats stormwater by implementing both parcel and block-scale surface systems that direct runoff to vegetation and ponds, which double as amenities throughout the neighborhood. Habitat value is enhanced through the use of various vegetation types.
Photo: Andres Power

Inspection & Enforcement

The SFPUC and the Port require periodic inspections to ensure that BMPs are properly maintained and continue to provide effective stormwater treatment.

Once stormwater management facilities are incorporated into new development and redevelopment projects, the SFPUC and Port require periodic inspections to ensure that they are properly maintained and continue to provide effective stormwater treatment. There are three types of inspections under this operation and maintenance verification program: post-construction building permit inspections, annual self-certification inspections conducted by the property owner, and tri-annual inspections conducted by the Port or the SFPUC, depending on who has jurisdiction on the site. The Port and the SFPUC will also inspect BMPs in response to complaints or emergencies. If maintenance requirements identified through inspections are not completed in accordance with the protocols described in this chapter, the SFPUC or the Port will enact enforcement procedures.

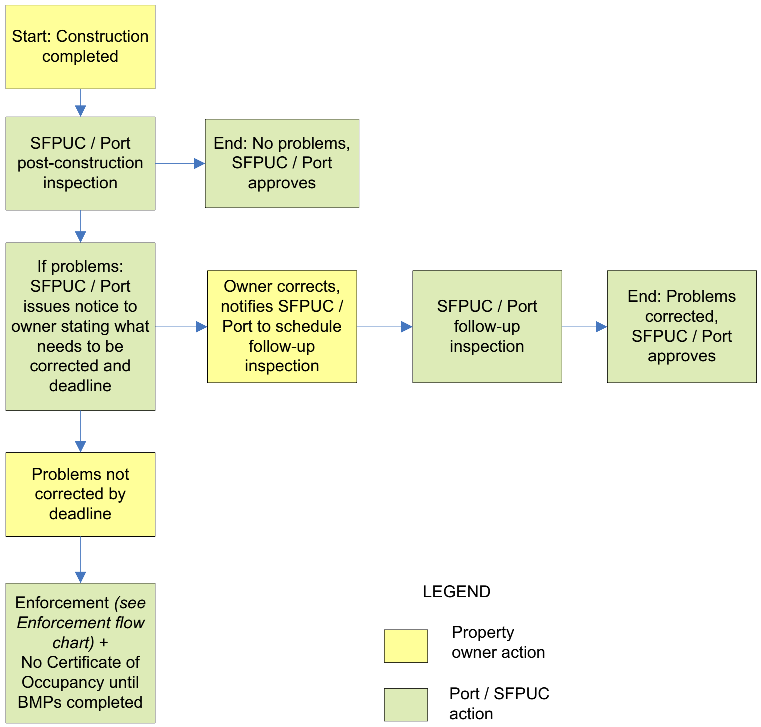


Figure 18. *Post-construction inspections.*

Inspections

Post-construction inspections

The Port or the SFPUC will inspect stormwater BMPs upon completion of construction. These inspections will be based on a standardized inspection checklist. Inspection staff will confirm that stormwater facilities are built in conformance with approved plans.

If there are issues that require follow-up, the Port or the SFPUC will send the property owner a notice stating what corrective action needs to be taken and the timeframe for corrective action. The deadline will be between 24 hours and 30 days from the date of the notice, depending on the severity of the problem. The property owner is responsible for correcting these issues and scheduling a follow-up inspection by the Port or the SFPUC. If the issues are rectified by the time of the follow-up inspection, the Certificate of Occupancy will be issued. A diagram showing the post-construction inspection process is shown in Figure 18.

Annual self-certification

Once BMPs are successfully built, the Port or the SFPUC will send self-certification inspection reminders to property owners at all sites with stormwater BMPs. The reminder will include a submittal deadline and a blank self-certification checklist. The property owner will perform the self-certification inspection and digitally submit the completed checklist and maintenance logs from that year to the SFPUC Collection System Division or to the Port. With this submittal, the property owner will propose either approval or maintenance they will perform if there are outstanding issues that have not been resolved by the submittal date. The Port or the SFPUC will either approve the submittal and renew the certificate of compliance or contact the property owner to schedule an inspection.

If a Port or SFPUC inspection is necessary, the property owner must be present and provide annual maintenance logs. If the issues are rectified by the time of the inspection, the certificate of compliance will be renewed.

For sites at which the property owner does not submit self-certification documents, the Port or the SFPUC will send a notice stating that the deadline has passed and will contact the property owner to schedule an inspection. The notice will include a fee to cover the cost of the inspection plus a penalty. If the inspection indicates that there no maintenance issues requiring follow-up action, the certificate of compliance will be renewed. A diagram showing the annual self-certification process is shown in Figure 19.

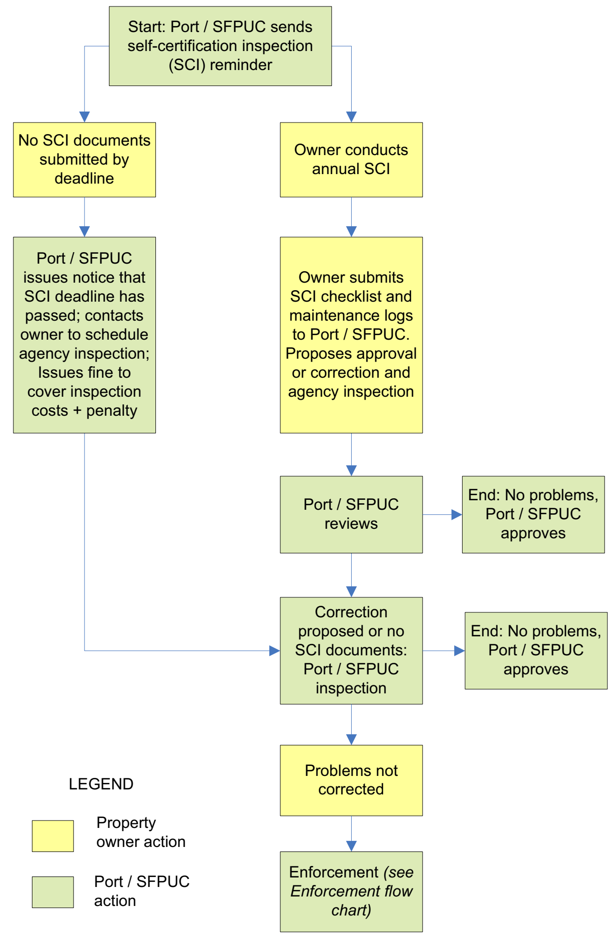


Figure 19. *Annual self-certification inspections.*

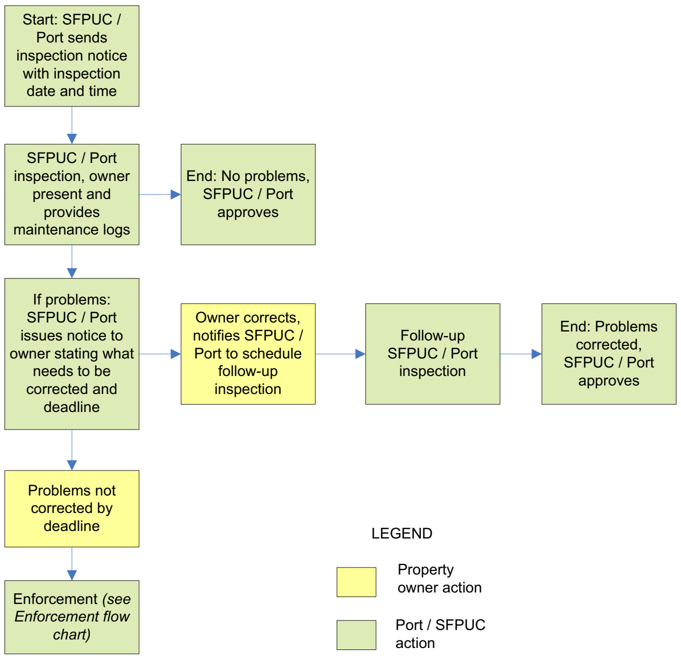


Figure 20. *Tri-annual Port / SFPUC inspections.*

Tri-annual Port / SFPUC inspections

Every third year, the Port or the SFPUC will inspect stormwater BMPs. The agency with jurisdiction on the project site will send inspection notices to property owners at sites due for inspection. The notice will include a proposed inspection date and time and a phone number to call should the proposed date not work for the property owner. The property owner must be present and provide annual maintenance logs. If the inspection indicates that there no maintenance issues requiring follow-up action, the certificate of compliance will be renewed.

If there are issues that require follow-up, the Port or the SFPUC will send the property owner a notice stating what corrective action needs to be taken and the deadline. The deadline will be between 24 hours and 30 days from the date of the notice, depending on the severity of the problem. The property owner is responsible for rectifying the issues and scheduling a follow-up inspection by the Port or the SFPUC within the time allotted. If the inspection indicates that the issues are rectified, the certificate of compliance will be renewed. A diagram showing the tri-annual Port or SFPUC inspection process is shown in Figure 20.

Enforcement

For all three types of inspections, if the property owner is unresponsive or if maintenance issues are not rectified by prescribed deadlines, the Port or the SFPUC will carry out an enforcement action. If an enforcement action becomes necessary, the Port or the SFPUC will issue a warning with a 15-day deadline for the property owner to take corrective action and schedule a follow-up inspection. The warning will include a fee to cover the cost of the inspection plus a penalty. If the inspection indicates that maintenance issues requiring follow-up action have been rectified, the annual certificate of compliance will be renewed. If there are outstanding issues requiring maintenance action or if the owner is unresponsive, the Port or the SFPUC will issue a notice of violation stating that the property owner will be fined. Fines will be levied based upon Article 4.1 of the San Francisco Public Works Code.

If the issues have not been rectified by the end of 25 days, the Port or the SFPUC will perform the required maintenance and will bill the owner for the fine plus the cost of the work. If the owner does not pay the fine and the bill within 30 days, the Port or the SFPUC have the option to initiate lien proceedings against the property. A diagram showing the enforcement process is shown in Figure 21.

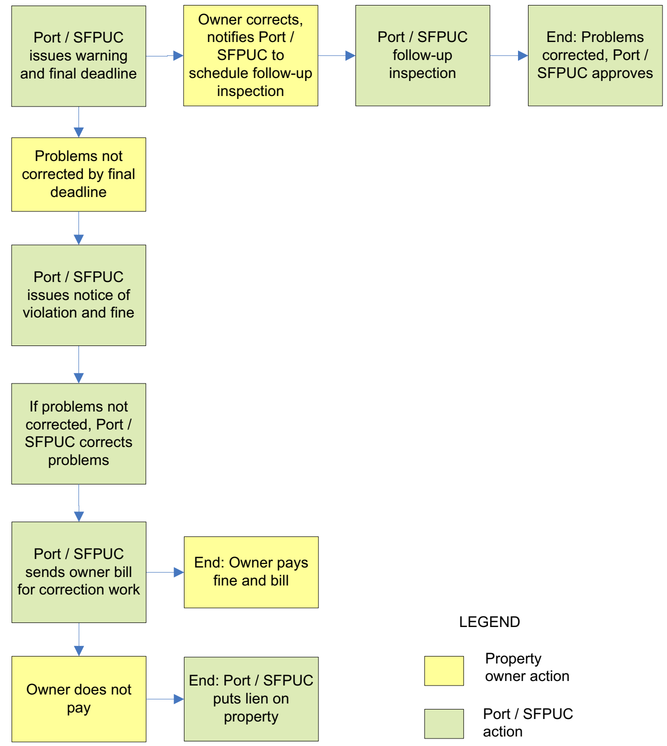
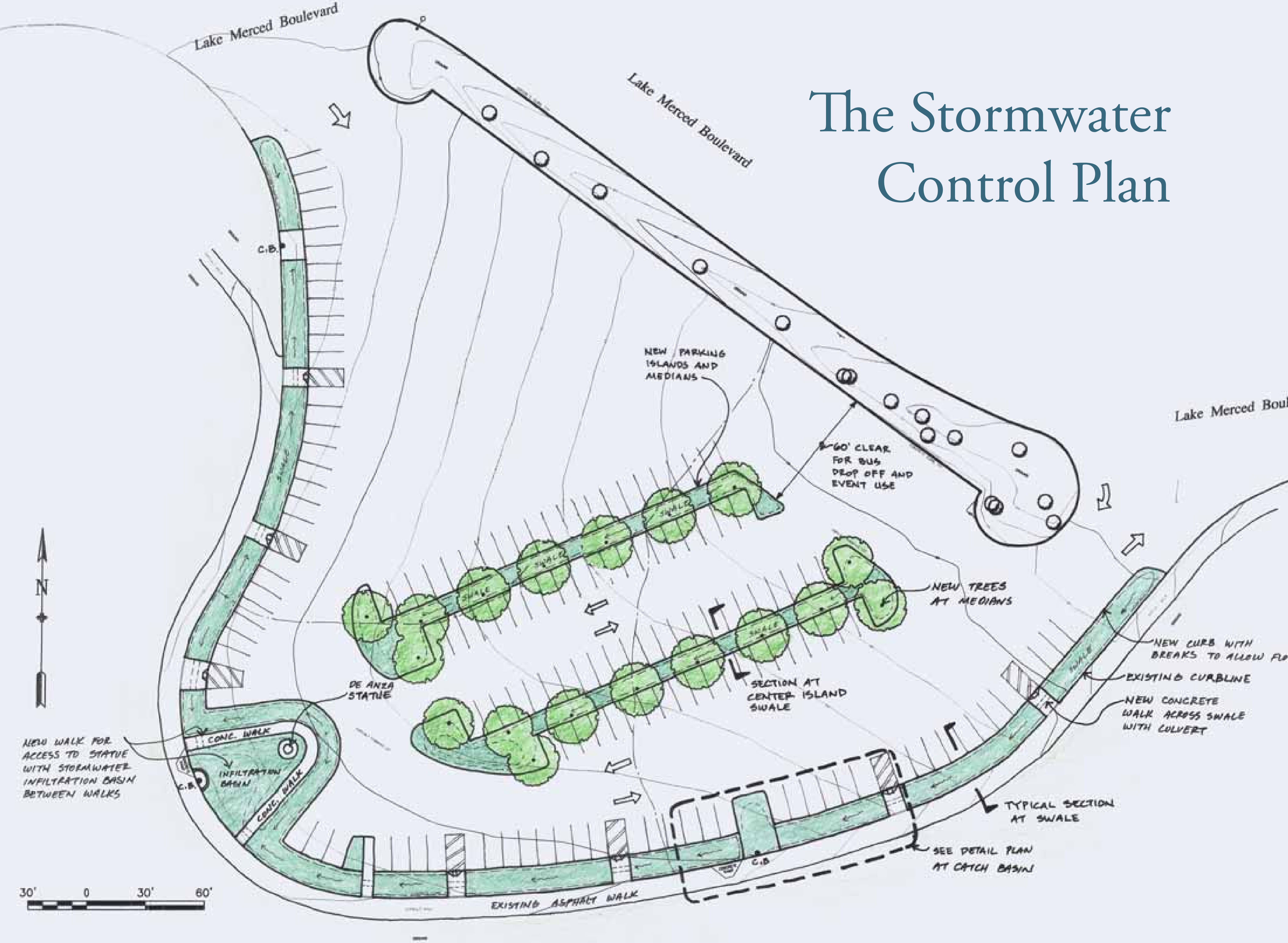


Figure 21. *Enforcement.*

The Stormwater Control Plan



The Port and SFPUC require submittal of a Stormwater Control Plan (SCP) with every development application for discretionary planning approval in San Francisco for all projects disturbing 5,000 square feet or more of the ground plane.

The Port and SFPUC require the submission of a Stormwater Control Plan (SCP). The SCP will allow the Port, the SFPUC, and the Planning Department to review projects that are subject to the *Guidelines* and ensure compliance with them. SCPs must be reviewed and stamped by a California licensed landscape architect, architect, or engineer.

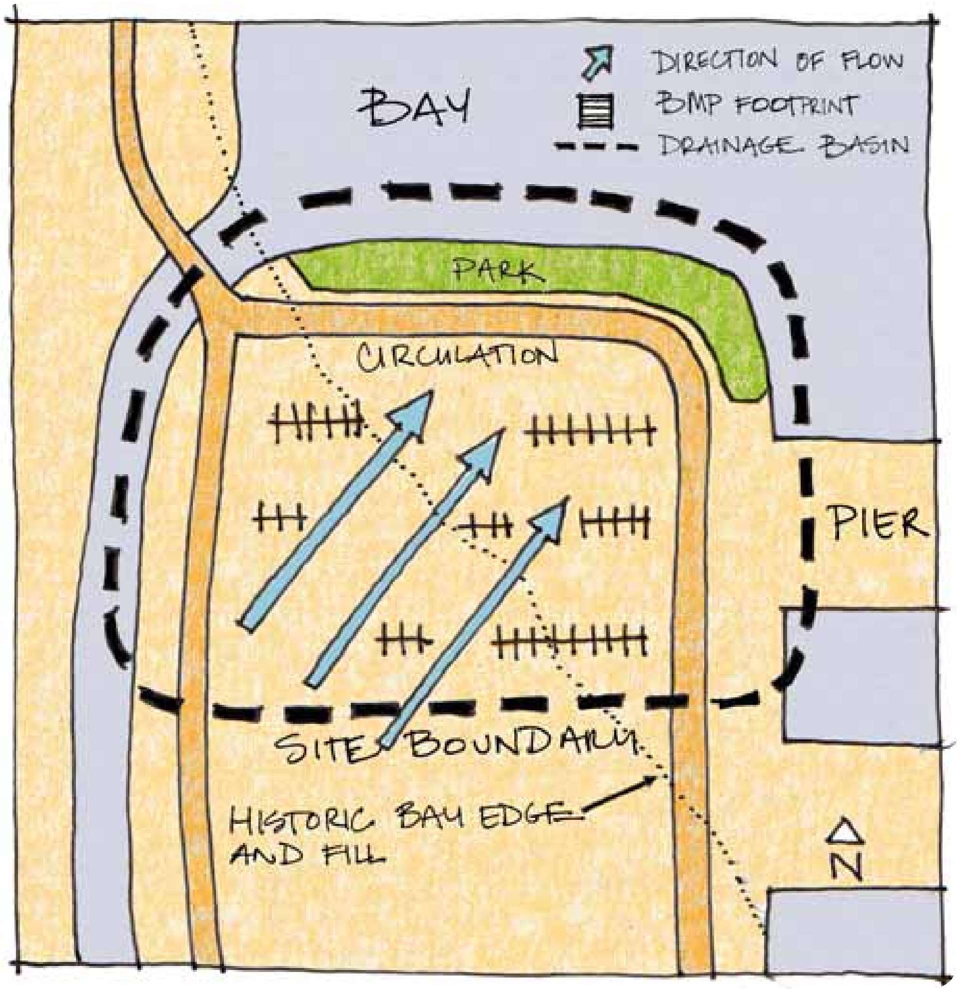
Project applicants must complete each of the following elements in their SCPs to be eligible for project approval:

1. Characterize existing site conditions
2. Identify design and development goals
3. Develop a site plan
4. Develop a site design
5. Select and locate source controls
6. Select and locate treatment BMPs
7. Size treatment BMPs
8. Check against design goals and modify as necessary
9. Develop an operations and maintenance plan
10. Compile the Stormwater Control Plan

Although the elements of the SCP are presented as a series of steps, in practice they should be iterative. For example, although site design comes before BMP sizing in the SCP checklist, BMP sizing results may require designers to make changes to the original site design. The following section provides an overview of each element of the SCP, illustrated by a conceptual drawing. An example of a completed SCP is included in Appendix C.

Requirement

The Stormwater Control Plan (SCP) must be reviewed and stamped by a licensed landscape architect, architect, or engineer.



Step 1

Characterize existing conditions

The stormwater management approach available to a given site is largely dictated by existing site conditions. Soil types, topography and drainage, vegetation types, wildlife habitat, proximity to receiving waters, existing structures, adjacent land uses, and historical and cultural features are all factors that project proponents should consider prior to initiating design of stormwater BMPs. A comprehensive checklist of site conditions that should be evaluated during the site analysis phase can be found in the SCP (Appendix C).

Jurisdictional concerns can influence a site as much as physical conditions. For example, parcels within 100 feet of the San Francisco Bay shoreline are subject to San Francisco Bay Conservation and Development Commission (BCDC) policies governing public access, circulation, and landscaping. Alterations to structures along most of the San Francisco Northern Waterfront are subject to the requirements of a National Historic Register District. Some properties may have deed restrictions establishing requirements for the management of residual soil and groundwater pollution. Port, SFPUC, and City Planning staff will work with project applicants to identify jurisdictional issues that are relevant to the site.

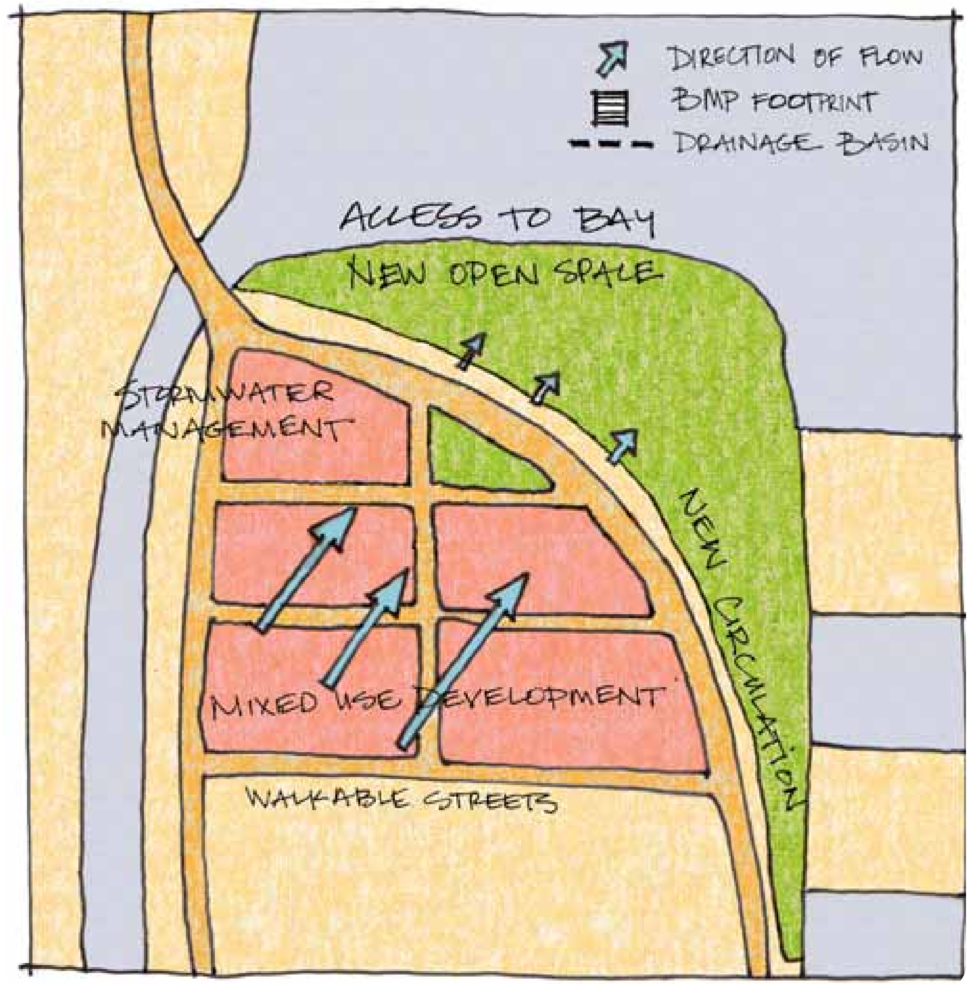
Characterizing existing conditions helps to define the opportunities and constraints that will shape the site design. Opportunities include existing drainage patterns and vegetation, oddly configured or otherwise unbuildable parcels, easements, and landscape amenities, including open spaces that can serve as locations for BMPs. Differences in elevation across the site and existing low-lying areas present opportunities to implement BMPs that reduce or eliminate the need for pumping or other mechanical conveyance, a savings in both installation and long-term operation costs.

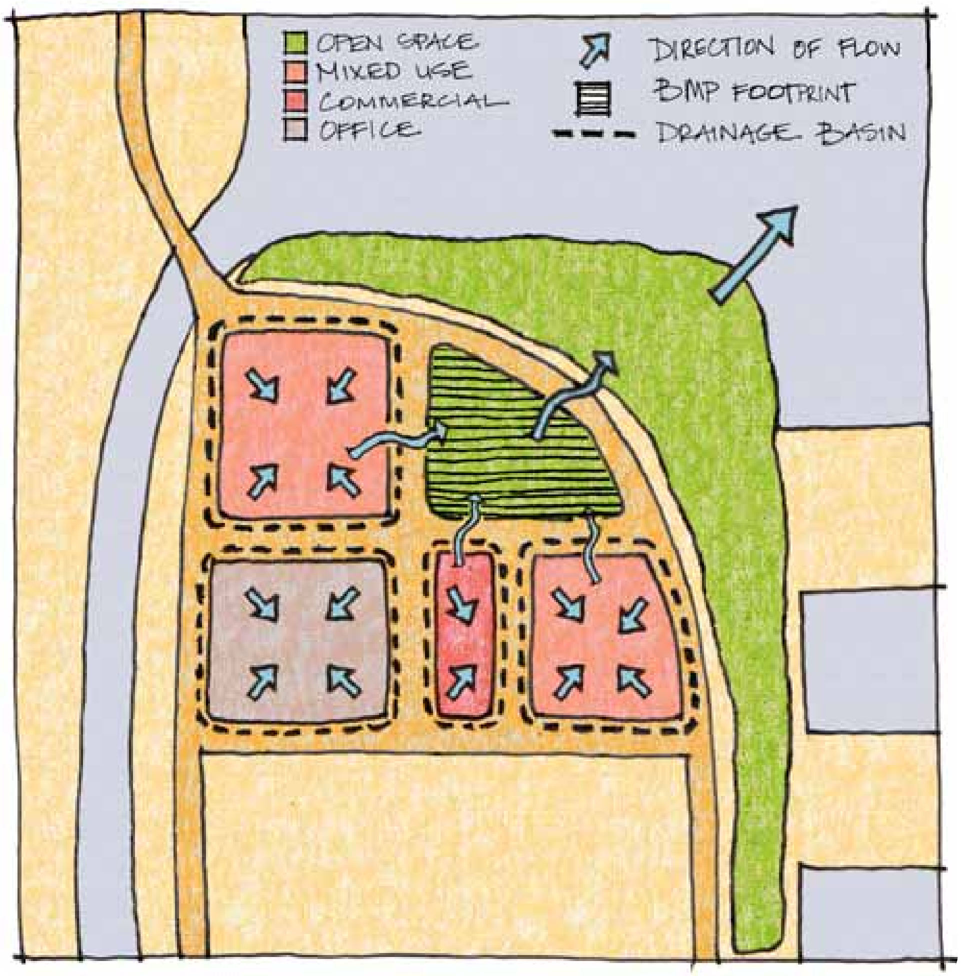
Constraints might include impermeable soils, a high water table, contaminated soils, geotechnical instability, existing utilities, and historic and cultural resources. Site-specific percolation tests and other geotechnical investigations by a certified engineer will be needed to ensure the most effective design solutions.

Step 2

Identify design and development goals

Every project applicant will begin the design process with a set of goals that will impact stormwater management requirements for the site. The program, density, and intensity of land use on a site present both opportunities and constraints for stormwater management. A project applicant intending to build a mixed-use development with high-density housing in the Bayview-Hunters Point neighborhood will approach the design process differently from a project applicant seeking to develop an industrial facility on a waterfront pier. The former might use stormwater to define the character of the public realm and create water features in community open spaces. The latter might use stormwater in cooling towers and wash-down areas to offset potable water use.





Step 3

Develop a site plan

Using the evaluation of existing conditions, along with the design and development goals, project applicants can begin to see how their project will integrate with or alter the hydrology of the site. The site plan should delineate the proposed land uses and major post-development drainage basins and should show, at the conceptual level, how water will move across the site.

Step 4

Develop a site design

Page 28 of this document introduced seven goals to guide the integration of stormwater management into site design. This section identifies strategies to achieve each goal.

Goal 1: Preserve and protect creeks, wetlands, and existing vegetation and other wildlife habitat.

- Incorporate creeks, wetlands, and existing vegetation into the site design (See Appendix D for appropriate vegetation).
- Develop setbacks that protect creeks, wetlands, and sensitive wildlife habitats and also provide usable open space for the public.
- Concentrate development in already developed areas.

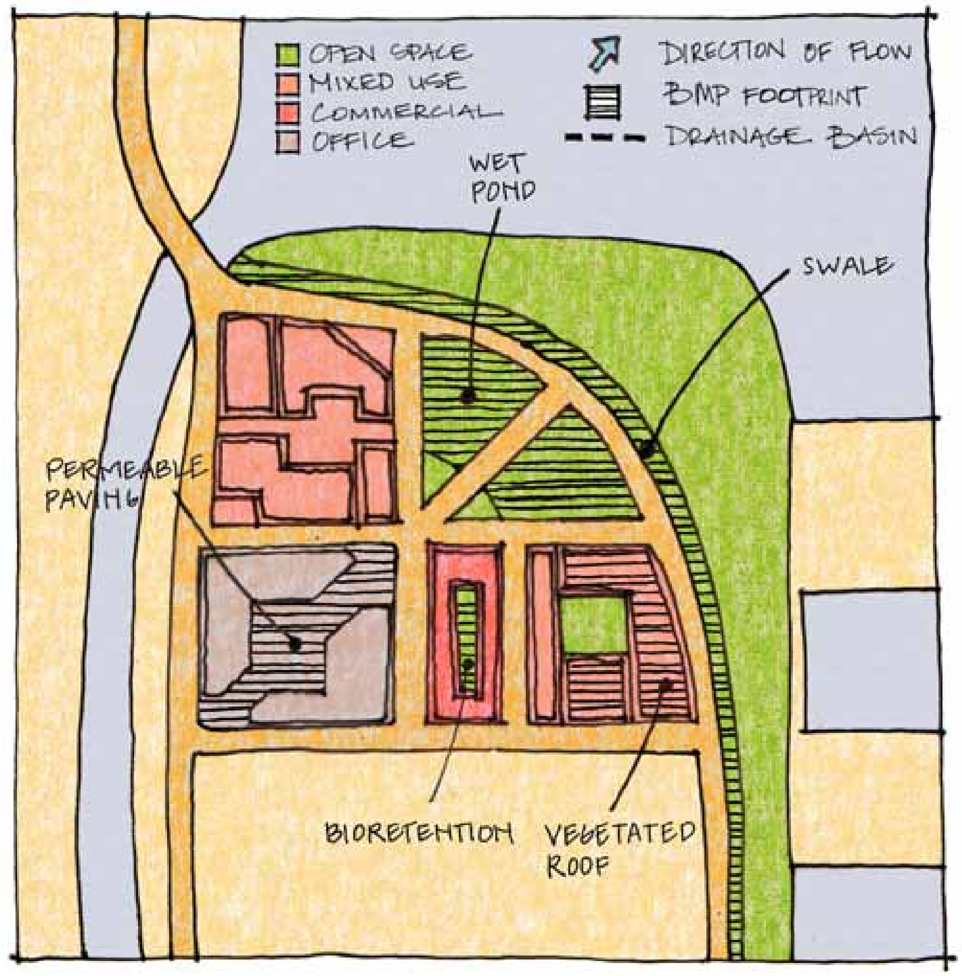
- Encourage high-density, transit-accessible development.
- Encourage clean-up and reuse of brownfield sites.
- Look at each site as an opportunity to protect, enhance, or create wildlife habitat.

Goal 2: Preserve natural drainage patterns and topography and incorporate them into site design.

- Daylight historic watercourses and make them a central element of site design.
- Design stormwater BMPs to take advantage of existing slopes and drainage paths.
- Minimize re-grading and soil impacts.
- Prioritize the use of infiltration-based BMPs where soils, groundwater, and geology allow.

Goal 3: Minimize and disconnect impervious surfaces.

- Design compact, multi-story structures, as allowed by applicable zoning regulations.
- Cluster buildings to reduce the length of streets and driveways, minimize land disturbance, and protect natural areas.
- Design narrow streets and driveways, as allowed by the local jurisdiction.
- Use landscape and permeable paving materials rather than traditional hardscape. Plazas, sidewalks, driveways, streets, parking areas, and patios can be constructed from materials such as crushed aggregate, decomposed granite, turf block, unit pavers, porous asphalt, or pervious concrete.
- Install vegetated roofs to reduce runoff from buildings.
- Minimize parking lot footprints and impacts by building structured parking with alternative roof uses and designing compact parking spaces and space-efficient circulation patterns.



Stormwater treatment facilities enhance public spaces in Portland's South Waterfront redevelopment area.

From the Site to the City

LID is implemented site by site, but each site should be considered in the context of its watershed-wide goals. Over time, incremental improvements will add up to long-term water quality protection for the Bay and Ocean, the restoration of hydrologic function in San Francisco's watersheds, and city-wide greening.

- Drain runoff from impervious areas to pervious areas. In cases where infiltration is not appropriate, landscape features can serve as treatment and conveyance structures and can be fitted with an underdrain to allow for discharge to the municipal storm sewer system or receiving waters.

Goal 4: Design the flow path of stormwater on a site all the way from the first contact to the discharge point.

- Identify the location where stormwater will first enter a site. For example, the first point of contact is often a roof. How will the water travel from the roof to a BMP? In the event that the BMP overflows, where will it discharge?
- Identify an approved discharge location (downstream conveyance system, another BMP or receiving water body) to accommodate flows beyond the capacity of each BMP.
- Design and clearly identify an overflow conveyance system to accommodate flows beyond the BMP's treatment capacity and up to a 100-year storm. All BMPs must have an approved discharge location.

Goal 5: Treat stormwater as a resource, not a waste product.

- Capture stormwater for irrigation, toilet flushing, cooling towers, vehicle wash-down areas, and other non-potable applications.
- Design multi-purpose BMPs that not only manage stormwater but also improve streetscape and public space design.
- Use stormwater for design inspiration.
- Incorporate environmental education and interpretation into LID where appropriate.

Goal 6: Treat stormwater at its source.

- Identify pollutants of concern and their sources early in the design process and install source control measures where appropriate.
- Aim for ubiquitous infiltration of stormwater on site.
- Place treatment BMPs as close to the source of runoff as possible.

Goal 7: Use treatment trains to address a broad array of pollutants.

- Combine stormwater BMPs that target different pollutants to create a treatment train. This strategy ensures higher levels of treatment and reduces the required size of each BMP in the treatment train.
- Pretreatment BMPs, such as sediment forebays, help reduce maintenance costs and improve the overall performance of stormwater BMPs.

Step 5

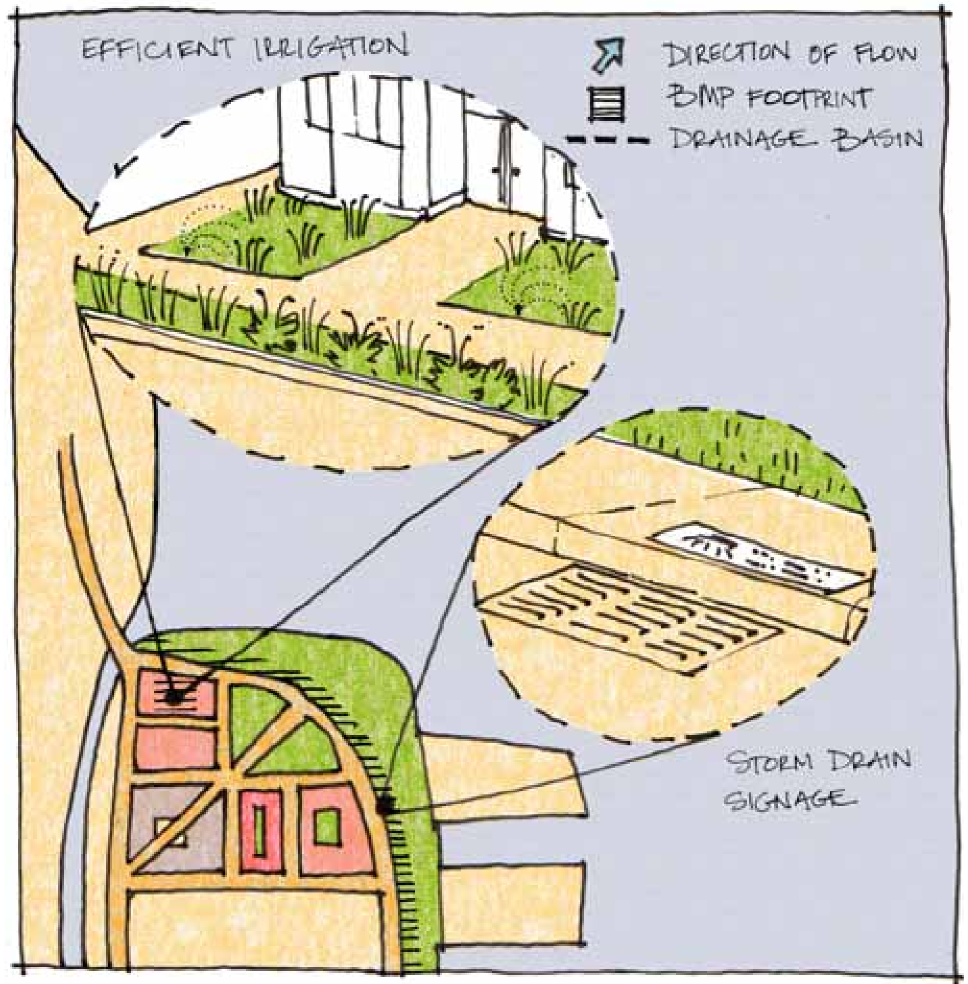
Select and locate source controls

Everyday activities such as recycling, trash disposal, and vehicle and equipment washing generate pollutants such as trash, sediments, oil and grease, nutrients, pesticides, and metals that can be mobilized by stormwater runoff and carried to receiving waters. These pollutants can be minimized by applying source control BMPs. Source control BMPs prevent pollutant generation and discharge by controlling pollution at its source, or, at a minimum, limiting pollutant exposure to stormwater.

Source control BMPs include both structural features and operational practices. Typical structural source control BMPs involve covering, berming, or hydraulically isolating a potential pollutant source area.

Operational source control measures include routine pavement sweeping and substituting traditional materials with those that are less toxic; for example, replacing traditional anodized chain link fencing with vinyl coated fencing.

Specific requirements for land uses and activities that will need to implement source control measures are found in Attachment 4 of the Phase II General Permit (http://www.waterboards.ca.gov/water_issues/programs/stormwater/docs/final_attachment4.pdf). The Fact Sheets (Appendix A) include a list of resources for source control measures. Form A of the SCP (Appendix C) guides the project proponent through the source control BMP selection process.



Source Control Requirement

The following uses and activities are required to implement specific source control measures as specified in Attachment 4 of the Phase II General Permit (http://www.waterboards.ca.gov/water_issues/programs/stormwater/docs/final_attachment4.pdf):

- 100,000 sq. ft. commercial developments
- Restaurants
- Retail gasoline outlets
- Automotive repair shops
- Parking lots

A drain adjacent to a trash compactor is connected to the sanitary sewer system. A concrete berm surrounding the trash storage area hydraulically isolates stormwater runoff in this area from the rest of the site.

Hydraulic Isolation

Hydraulic isolation is the practice of separating one drainage area from surrounding areas such that fluids cannot pass between them. This can be done using grading or constructed barriers. Hydraulic isolation allows designers to treat runoff and waste from the isolated area according to the specific pollutants found there. In some cases, hydraulically isolated areas can be connected to the sanitary sewer system rather than the storm sewer system.

Vehicle wash racks and trash compactor areas are examples of areas that can be hydraulically isolated to protect surrounding areas from the soap, grease, oil, sediments, trash and other pollutants associated with those activities.

Integrated Pest Management

Integrated Pest Management (IPM) is an ecological approach to suppressing pests. IPM uses information on the life cycle of pests, along with multiple pest control techniques, to keep pests at acceptable levels in an economical and environmentally safe way. IPM focuses on monitoring and preventing pests and using low-risk pest control techniques. Because pest problems are often symptomatic of ecological imbalances, the goal is to plan and manage ecosystems to prevent organisms from becoming pests in the first place. This means developing landscape plans that focus on the use of native or Mediterranean plant species suited to San Francisco's climate and soil conditions (Appendix D). IPM principles help to reduce or eliminate the use of pesticides; thereby reducing the risk that stormwater runoff will mobilize pesticides and carry them to collection systems or receiving water bodies.

Step 6

Select and Locate Treatment BMPs

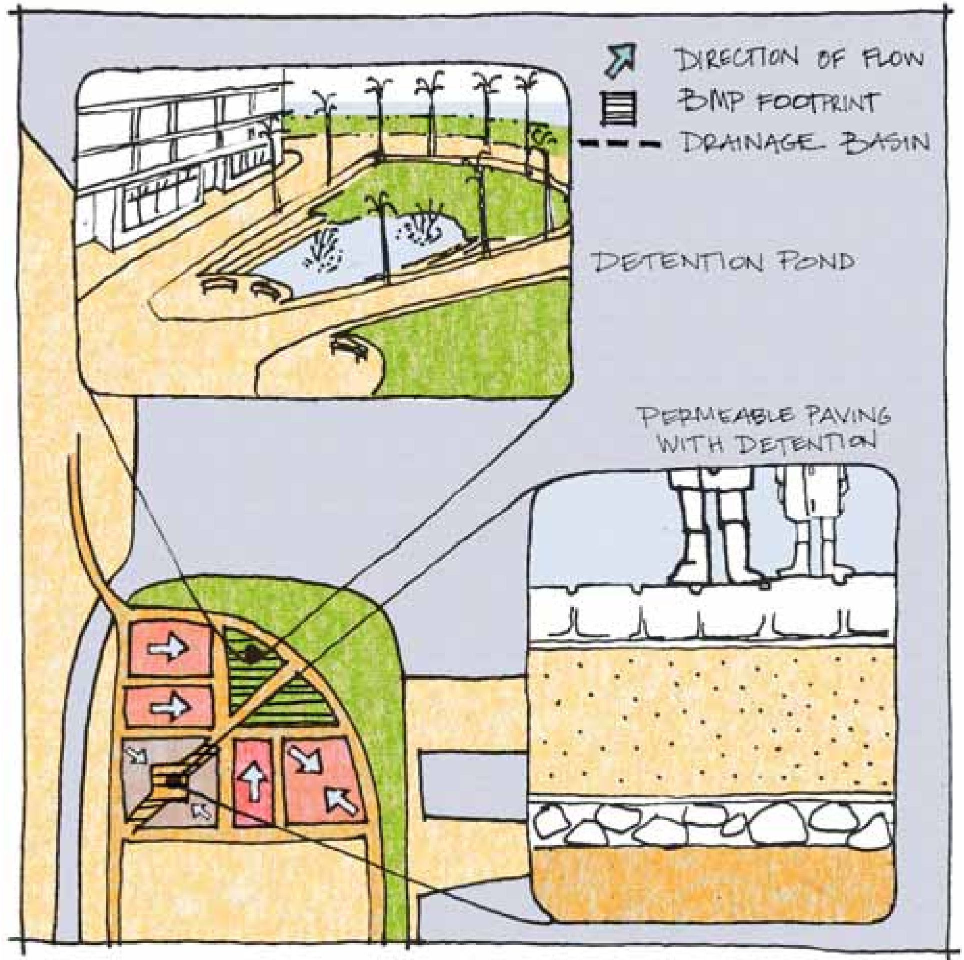
Site design and source control make significant contributions to effective stormwater management. But achieving treatment to the MEP also requires the implementation of treatment control BMPs. The selection of stormwater treatment BMPs is guided by existing site conditions, design and development goals, and the pollutants of concern for the site.

The two-step BMP selection process outlined here will help project applicants to identify a suite of site-specific treatment BMPs. The first step is to use the BMP Decision Tree (see Figure 22), to identify BMPs that are suitable for a given site. The second step is to narrow the list of suitable BMPs to the ones that target the pollutants of concern that have been identified for a given site.

The BMP Decision Tree

The BMP Decision Tree will help project applicants use site-specific information to select the BMPs that are most appropriate given the conditions at their site. BMPs that are not suitable will be eliminated from consideration.

The BMP Decision Tree prompts the project applicant to consider specific site characteristics that affect BMP design. The answers narrow the field of appropriate BMPs. On-site percolation tests and geotechnical investigations must be done during the site analysis to determine whether infiltration-based BMPs are feasible for the site (for instance, is there adequate depth to groundwater, which for most sites will be 10 feet). However, infiltration-



El Monte Sagrado Spa in Taos, New Mexico uses wetlands to treat stormwater so that it can be used to fill spa pools.

Permeable pavement can be integrated into a variety of hardscapes such as roads and sidewalks, plazas, terraces and patios.

based BMPs need not always be eliminated based upon this information. Rather, a modified design solution can make a BMP feasible. Vegetated swales can be used for stormwater treatment in areas with poor infiltration or contaminated soils provided that they are lined with an impermeable liner, underdrained, and constructed with clean import soil. See the BMP Fact Sheets in Appendix A for information on liners and underdrains.

Steep slopes can limit the range of appropriate BMPs for a given site because they can cause high flow rates and instability. Terracing the site is one design solution that could allow the implementation of slope-dependent BMPs on a steep site. Check dams can also be used to mitigate problems caused by steep slopes.

After all of the information has been evaluated, the BMP Decision Tree will indicate one of three outcomes for a given site:

- All BMPs are feasible;
- A subset of BMPs is feasible for unconditional implementation; or
- A subset of BMPs is feasible with conditions.

The resulting list of BMPs can then be evaluated for their effectiveness in treating the pollutants of concern for the project. Project applicants should include the results of the Decision Tree process in their SCP.

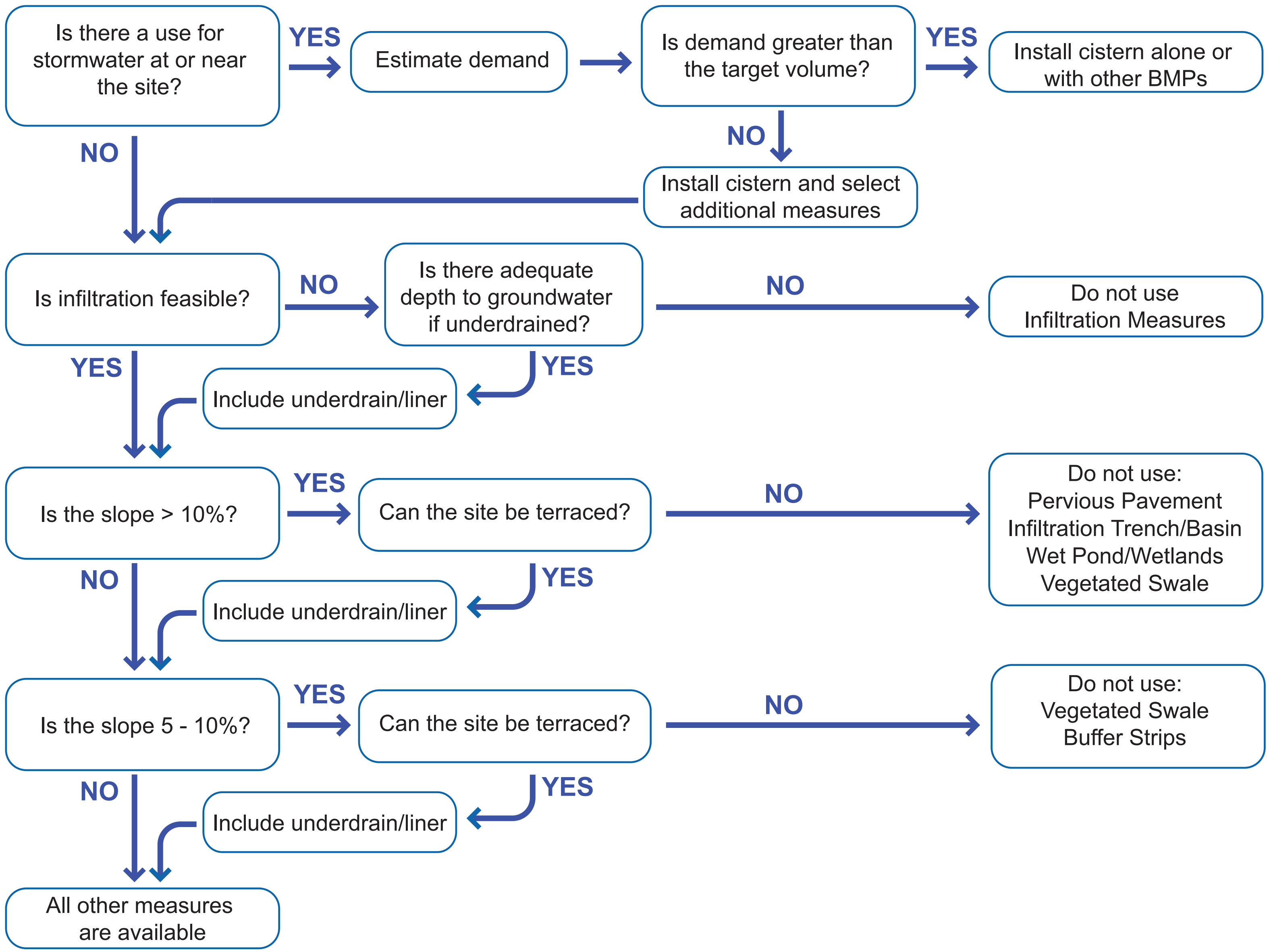


Figure 22. *Stormwater BMP Decision Tree*

Weirs (top) and cascades (bottom) make street-side bioretention possible on steep slopes in Seattle, WA.

Match BMPs with Pollutants of Concern

Table 6 includes a list of pollutants typically found in stormwater runoff and their association with common San Francisco land uses. Project applicants can use the table to screen for likely pollutants of concern, but identifying the specific commercial and industrial activities proposed for a site provides a better indication of which pollutants to target. For example, a restaurant would need to include BMPs to prevent oil and grease from contacting stormwater, and roadways in any project bring up concerns about metals, oil and grease, and sediments.

After project applicants consult Table 6 to anticipate the pollutants of concern for their proposed land uses, they can use Table 7 to identify BMPs that both treat pollutants of concern and are deemed appropriate for the physical site conditions by the BMP Decision Tree. To learn more about each BMP listed in the table, see the BMP Fact Sheets in Appendix A.

Land Use Type	Metals	Sediments	Trash	Oil and Grease	Organics	Nutrients
High Density Residential	•	•	•	•		•
Low Density Residential	•	•	•	•		•
Mixed Use	•	•	•	•	•	•
Light Industrial	•	•	•	•		
Heavy Industrial	•	•	•	•	•	
Open Space		•	•		•	•
Piers Over Water	•	•	•			
Former Shipyards	•	•	•	•	•	•

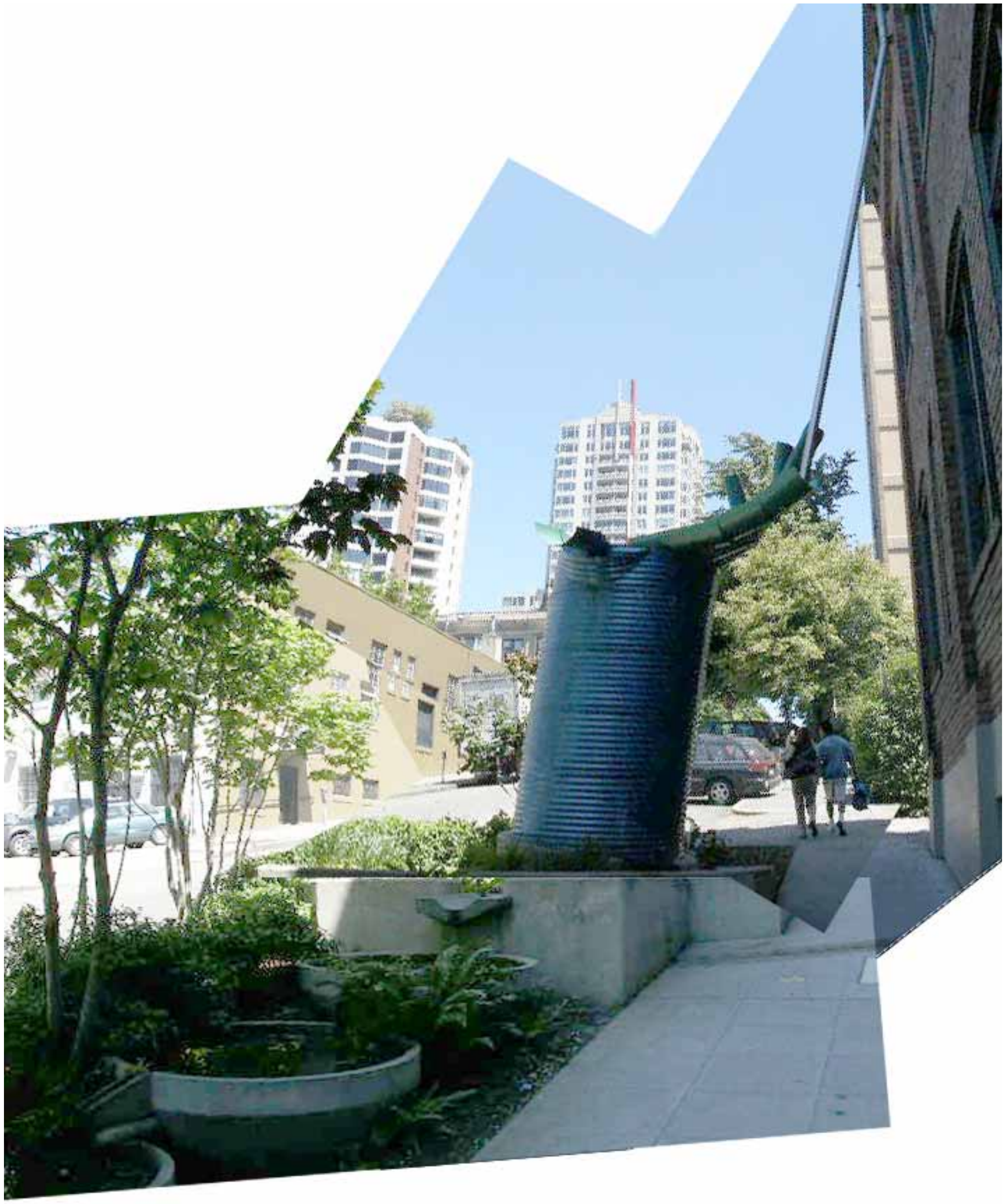
Table 6. *Typical pollutants associated with common San Francisco land uses*

Treatment Control		Metals	Sediments	Trash	Oil and Grease	Bacteria	Organics	Nutrients
Infiltration								
	Dry Well	●			●	●	●	●
	Infiltration Basin	●	○ p	○ p	●	●	●	●
	Infiltration Trench	●	○ p	○ p	●	●	●	●
	Permeable Pavement	◒	● p	○ p	○	◒	◒	●
Detention								
	Constructed Wetland	●	● p	○ p	●	●	●	◒
	Detention Pond	◒	◒ p	○ p	◒	◒	◒	○
	Detention Vault	○	◒	○	◒	○	○	○
	Wet Pond	●	● p	○ p	●	●	●	◒
Bioretention								
	Flow-through Planter	●	● p	○ p	●	●	●	◒
	Rain Garden	●	● p	● p	●	●	●	●
Biofiltration								
	Vegetated Buffer Strip	●	● p	◒ p	◒	○	◒	○
	Vegetated Swale	◒	◒	○	◒	○	◒	○
	Media Filter	●	● p	● p	●	●	●	●
	Sand Filter	●	●	●	●	●	◒	◒
	Vegetated Rock Filter	◒	● p	○ p	●	◒	●	●
	Swirl Separator	○	●	●	◒	○	○	○
	Water Quality Inlet	○	◒	◒	◒	○	○	○
	Drain Insert	◒	◒	●	◒	○	○	○
Retention								
	Rainwater Harvesting*							

○ Low ◒ Moderate ● High p Requires Pre-treatment

*Rainwater Harvesting does not provide stormwater treatment. However, it prevents polluted stormwater from reaching receiving water bodies.

Table 7. *BMPs that capture or treat pollutants typically found in stormwater runoff.*



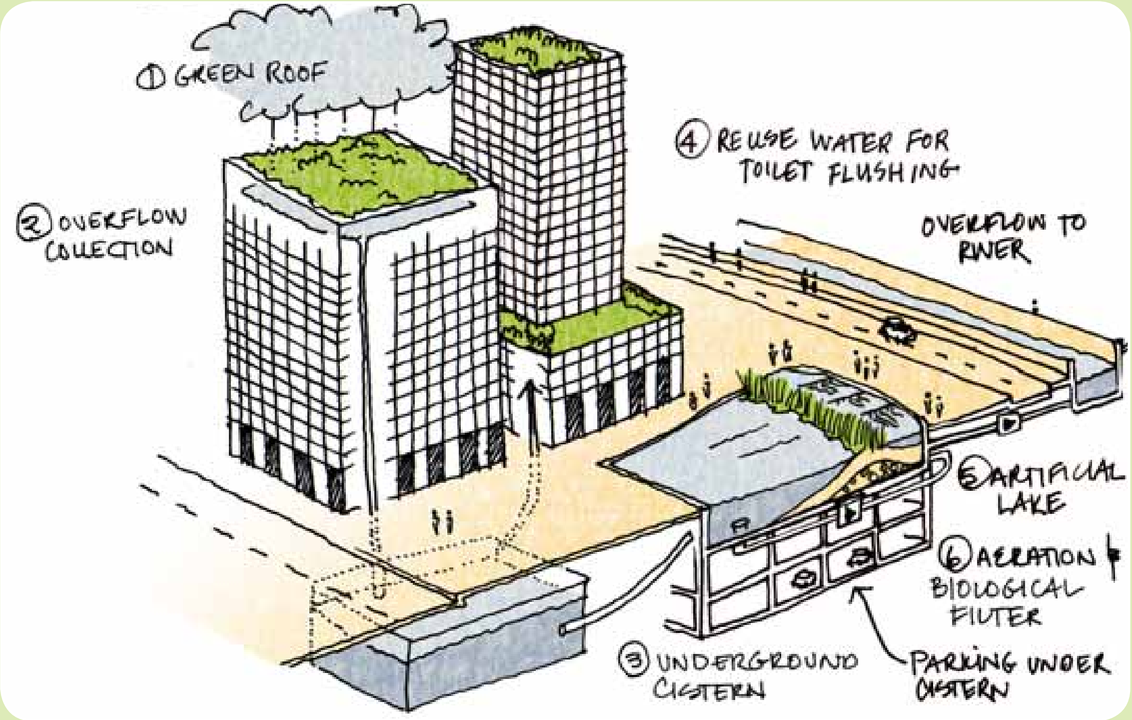
Treatment Trains

A single treatment BMP may not adequately treat the entire range of pollutants from its contributing watershed, especially in large developments involving diverse activities. For example, some treatment BMPs are designed to remove fine suspended sediment but may not be able to remove dissolved metals. Because of this, a combination of several BMPs in succession may be needed to treat all of the pollutants on a given site.

A combination of BMPs, constructed in a series to target specific pollutants, is called a treatment train. Treatment trains not only improve water quality, they also improve the long-term efficiency and reduce the maintenance requirements for each treatment BMP involved in the train. Heavy sediments and trash can negatively impact BMP performance, thus silt traps and sediment forebays are commonly used as a first step in the treatment process. In the same way that pre-rinsing dirty dishes increases the efficacy and efficiency of a dishwasher, removing sediment prior to infiltration of stormwater will improve the long-term capacity of the underlying soils to infiltrate water by preventing sediment from clogging pore spaces that allow the movement of water through the soil.

Common treatment train configurations include:

- Silt trap → Swale → Wetland
- Cistern → Rain garden
- Retention basin → Sand filter
- Vegetated strip → Infiltration trench



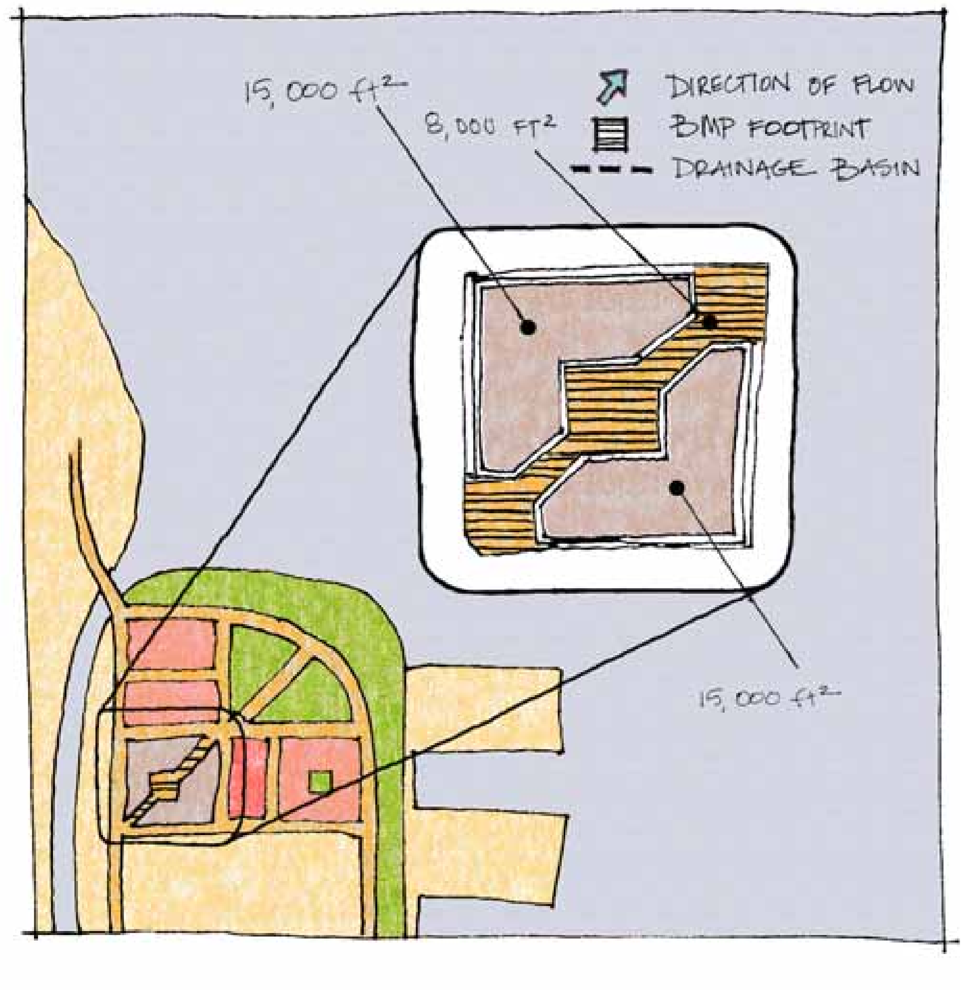



Case Study: Berlin Treatment Train

The design for Potsdamer Platz, one of Berlin's most important public squares, includes a stormwater treatment train that uses multiple stormwater management strategies (indoor use, storage, biofiltration, and outdoor use) to control both the quality and the volume of stormwater on-site. The roofs of the development, some of which are vegetated roofs and some of which are traditional, harvest rainwater to be used in the buildings for toilet flushing and irrigation. During large storm events, five underground cisterns store rainwater and then release it slowly into a series of pools and planted 'biotopes' for filtration. In the summer months, additional filters can be added to remove algae. Treated rainwater then flows through a very popular outdoor waterscape where employees and visitors gather. Like San Francisco, Berlin has an average annual rainfall of 21 inches.

Treatment Train Principles

- Think of each element in a treatment train as a separate functional unit.
- Before adding additional elements to a treatment train, analyze their performance relative to previous BMPs in the train. If the expected water quality benefits are limited, the increase in cost may outweigh the benefits.
- Do not alter or remove design measures used to reduce the size of stormwater treatment measures without a corresponding resizing of associated stormwater treatment BMPs, otherwise the capacity of the BMPs will be exceeded.



Step 7

Size Treatment BMPs

After selecting a suite of treatment BMPs that are appropriate for the site conditions and target the pollutants of concern, project applicants will need to size these BMPs to achieve the required stormwater performance standards. This section explains how to size treatment BMPs, but project applicants can also use the automated electronic sizing spreadsheets provided in Appendix B, which can also be found on the SFPUC and Port websites at www.sfwater.org and www.sfport.com. While the Port and SFPUC do not require the use of the sizing spreadsheets for BMP design, project applicants must complete Table 1 of the electronic sizing spreadsheet in Appendix B to document drainage parcels and design flow rates and volumes. This information is required in the SCP.

The performance measures discussed in this section aim to protect the water quality of receiving water bodies. They meet all regulatory requirements and are the foundation of the BMP sizing spreadsheet. For information about how the performance measures were developed, please see the resources at the end of this section.

A rain garden at Glencoe Elementary in Portland, Oregon reduces stormwater flows to Portland's collection system.

Treatment Control		Sizing Design Criteria	
		Flow-based	Volume-based
Infiltration	Dry Well		•
	Infiltration Basin		•
	Infiltration Trench		•
	Permeable Pavement		•
Detention	Constructed Wetland		•
	Detention Pond		•
	Detention Vault		•
	Wet Pond		•
Bioretention	Flow-through Planter	•	
	Rain Garden	•	• (if infiltrating)
Biofiltration	Vegetated Buffer Strip	•	
	Vegetated Swale	•	
	Media Filter	•	
	Sand Filter	•	
	Vegetated Rock Filter	•	
	Swirl Separator	•	
	Water Quality Inlet	•	
	Drain Insert	•	
Retention	Rainwater Harvesting		•

Table 8. *Treatment control measures and sizing methods*

Port Requirements

Stormwater performance measures for areas in the separate sewers operated by the Port require the capture and treatment of:

(a) The flow of stormwater runoff resulting from a rain event equal to at least 0.2 inch per hour intensity; or

(b) Eighty percent or more of the annual stormwater runoff volume, determined from unit basin storage volume capture curves for San Francisco (see Figure 23).

Performance measure (a) should be used for sizing flow-based BMPs, such as vegetated swales or flow-through planters. These are BMPs whose primary mode of pollutant removal depends on the flow rate of runoff through the BMP. Performance measure (b) should be used for sizing volume-based BMPs, such as infiltration basins or detention basins. These are BMPs whose primary mode of

Requirement

The Port's stormwater performance measures for areas served by separate storm sewers require the capture and treatment of:

(a) The **flow** of stormwater runoff resulting from a rain event equal to at least 0.2 inch per hour intensity; **or**

(b) Eighty percent or more of the annual stormwater runoff **volume** determined from design rainfall capture curves for San Francisco. The maximum drawn-down time for stormwater captured during a rain event is 48 hours.

pollutant removal depends on the volumetric capacity of the BMP. These performance measures are adapted from the General Permit.

Project applicants should determine which sizing criteria apply to each BMP and size the facility accordingly. Many BMPs can be designed to attain both flow-based and volume-based stormwater management goals, but they are most often categorized as one or the other (see Table 8).

Flow-based Sizing

The recommended method for hydraulically sizing flow-based treatment BMPs is the Uniform Intensity Approach and is used in conjunction with the Rational Method for estimating stormwater flows. It is also described in the CASQA 2003 Stormwater Best Management Practice Handbook New Development and Redevelopment. Automated electronic sizing spreadsheets can be found at www.sfwater.org and www.sfport.com, and are described in Appendix B. The Rational Method is used as follows:

1. **Identify each drainage management area on the site.** A drainage management area is a discrete area or subwatershed. The runoff from each drainage management area will drain its own treatment control BMP(s). The steps below should be applied to each drainage management area.

2. **Determine the area in acres (A)** of the drainage management area that drains to the proposed BMP(s).

3. **Assign a Runoff Coefficient**, or C-factor, to each land surface in the drainage management area. The C-factor describes the percentage of runoff generated by different types of surfaces during rain events. Surfaces that produce higher volumes of runoff, such as concrete, have relatively higher C-factors, while surfaces that produce lower volumes of runoff, such as landscaped areas, have relatively lower C-factors. Table 9 lists established C-factor values for each land surface.

4. **Calculate the Composite C-factor (C)**, a weighted average of all the C-factors for all the surfaces in the drainage management area. Multiply each C-factor by the area of the surface it applies to. Add the results and divide by the total site area.

Flow-Based Sizing

The Rational Method: Q=CiA

Where:

Q = flow in ft^3/second

C = composite runoff coefficient (composite C-factor)

i = rainfall intensity in inch/hour (0.2 inch/hr recommended)

A = drainage area in acres

Type of Surface	*Typical Range*	*Recommended Value*
Asphalt	*0.7 - 0.95*	*0.8*
Concrete	*0.8 - 0.95*	*0.9*
Brick	*0.7 - 0.85*	*0.8*
Roofs	*0.75 - 0.9*	*0.85*
Pervious Concrete	*0.1 - 0.3*	*0.2*
Pervious Asphalt	*0.1 - 0.3*	*0.2*
Paving Stones	*0.1 - 0.7*	*0.4*
Grass Pavers/Turf Blocks	*0.15 - 0.6*	*0.35*
Lawns and Grass:		
sandy soil, slope <2%	*0.05 - 0.1*	*0.08*
sandy soil, slope >7%	*0.15 - 0.2*	*0.17*
heavy soil, slope <2%	*0.13 - 0.17*	*0.15*
heavy soil, slope >7%	*0.25 - 0.35*	*0.3*
Landscaping	*0.15 - 0.3*	*0.2*
Crushed Aggregate	*0.15 - 0.3*	*0.25*

Table 9. *Typical runoff coefficients*

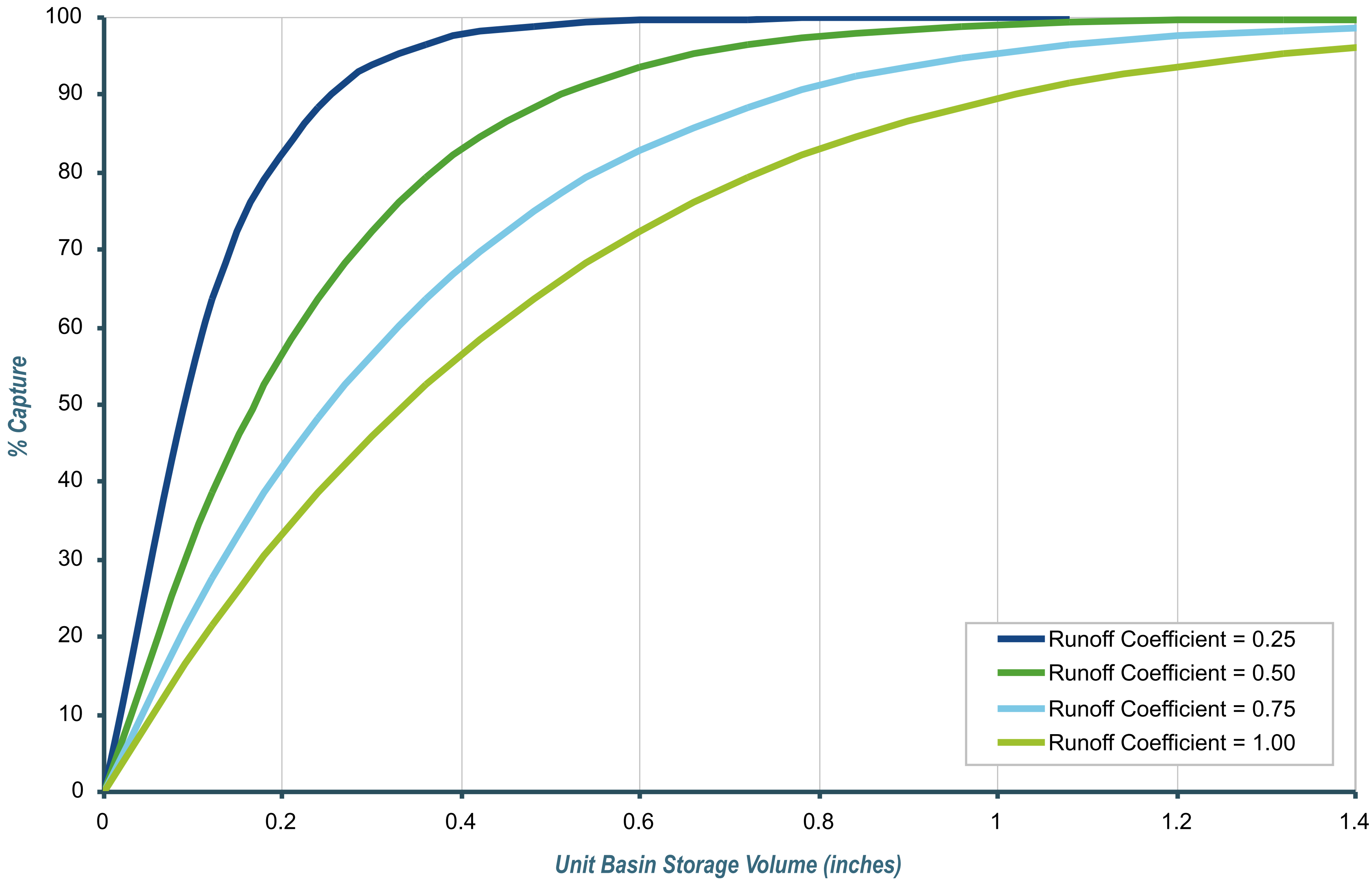


Figure 23. *Composite runoff coefficients and unit basin storage volume for 80 percent capture with 48-hour drawdown*

5. **Use a design rainfall intensity (i) of 0.2 inch per hour**. This intensity represents twice the 85th percentile hourly depth, which can be derived by ranking the hourly depth of rainfall from storms over the period of record. The General Permit specifies that, for water quality protection, the design rainfall intensity be equal to or greater than twice the 85th percentile hourly depth.

Q = CiA yields the design flow rate **(Q)**, in cubic feet per second, that a BMP must accommodate to meet the performance measures. For more information on sizing flow-based treatment BMPs, see the Fact Sheets in Appendix A and the sizing spreadsheets in Appendix B.

Volume-based Sizing

The recommended method for hydraulically sizing volume-based stormwater treatment BMPs is based upon a goal of 80% annual stormwater volume capture within a 48-hour draw-down period. This method is further described in CASQA's 2003 Stormwater Best Management Practice Handbook New Development and Redevelopment, which is available at www.cabmphandbooks.com.

The following steps explain how to calculate each variable.

1. **Identify each drainage management area on the site.** A drainage management area is a discrete area or subwatershed. The runoff from each drainage management area will drain its own treatment control BMP(s). The steps below should be applied to each drainage management area.

2. **Determine the area in acres (A)** of the drainage management area that drains to the proposed BMP.

3. **Calculate the Composite C-factor** for the drainage management area using the method described in steps 3 and 4 of the flow-based sizing section.

4. **Use the composite C-factor** to interpolate a Unit Basin Storage Volume value (in inches) from the unit basin storage volume curves in Figure 23. Interpolate between the reference C values as necessary to determine a Unit Basin Storage value. A 48-hour draw-down time is recommended, unless soils at the site are coarse.

Volume-Based Sizing

BMP Capture Volume =

BMP Drainage Area x **Unit Basin Storage Volume**

Where:

BMP Capture Volume = the volume of water that the BMP must capture to achieve compliance with the volume-based performance measures.

BMP Drainage Area = the contributing drainage area for the BMP.

Unit Basin Storage Volume = the depth of rainfall, in inches, that is related to a percentage of annual runoff capture. It is determined for various runoff coefficients from historical rainfall records.

Rainwater harvesting is a volume-based BMP that can be used to collect water for various types of industrial operations, resulting in reduced utility costs.

5. **Calculate the BMP Capture Volume** by multiplying the **BMP Drainage Management Area** by the **Unit Basin Storage Volume**. Convert to cubic feet for easy interpretation.

The BMP Capture Volume is the volume needed to meet regulatory standards for stormwater treatment. This or a larger volume must be used for BMP design. The BMP Capture Volume must be recorded and submitted in the SCP. The BMP Fact Sheets in Appendix A and sizing spreadsheets in Appendix B also contain information pertinent to sizing volume-based treatment BMPs.

SFPUC Requirements

Stormwater performance measures for areas in the separate sewers under the jurisdiction of the SFPUC require the capture and treatment of rainfall from a 0.75-inch design storm, which is equivalent to LEED Sustainable Sites Credit 6.2.

To meet the SFPUC performance measure and earn LEED Credit SS6.2, use the following calculation:

V = CAd, where **V** = Volume of water in cubic feet, **A** = size of the drainage management area in square feet, **C** = runoff coefficient, and **d** = rainfall depth in inches.

1. **Determine the area in square feet (A)** of the drainage management area, also known as a subwatershed, that drains to the proposed BMP.

2. **Calculate the Composite C-factor (C)** for the drainage management area using the method described in steps 3 and 4 of the flow-based sizing section.

3. **Use 0.75 inch as the design rainfall depth (d)** for the facility. This design rainfall depth corresponds to LEED Credit SS6.2 for semi-arid watersheds.

5. **Calculate the Volume** by multiplying **C**, **A**, and **d**. Divide by 12 to convert to cubic feet. The maximum allowable draw-down time is 48 hours.

The BMP must capture a volume of water equal to or greater than the volume calculated using the equation above to meet regulatory standards for stormwater treatment. The volume that the BMP will capture must be recorded and submitted in the SCP. The

BMP Sizing

V=CAd

Where:

V = volume in ft^3

C = composite runoff coefficient (composite C-factor)

A = drainage area in square feet

d = design rainfall depth in inches

(use 0.75 inch)

"BMP Fact Sheets" in Appendix A and the sizing spreadsheets in Appendix B also contain information pertinent to sizing volume-based treatment BMPs.

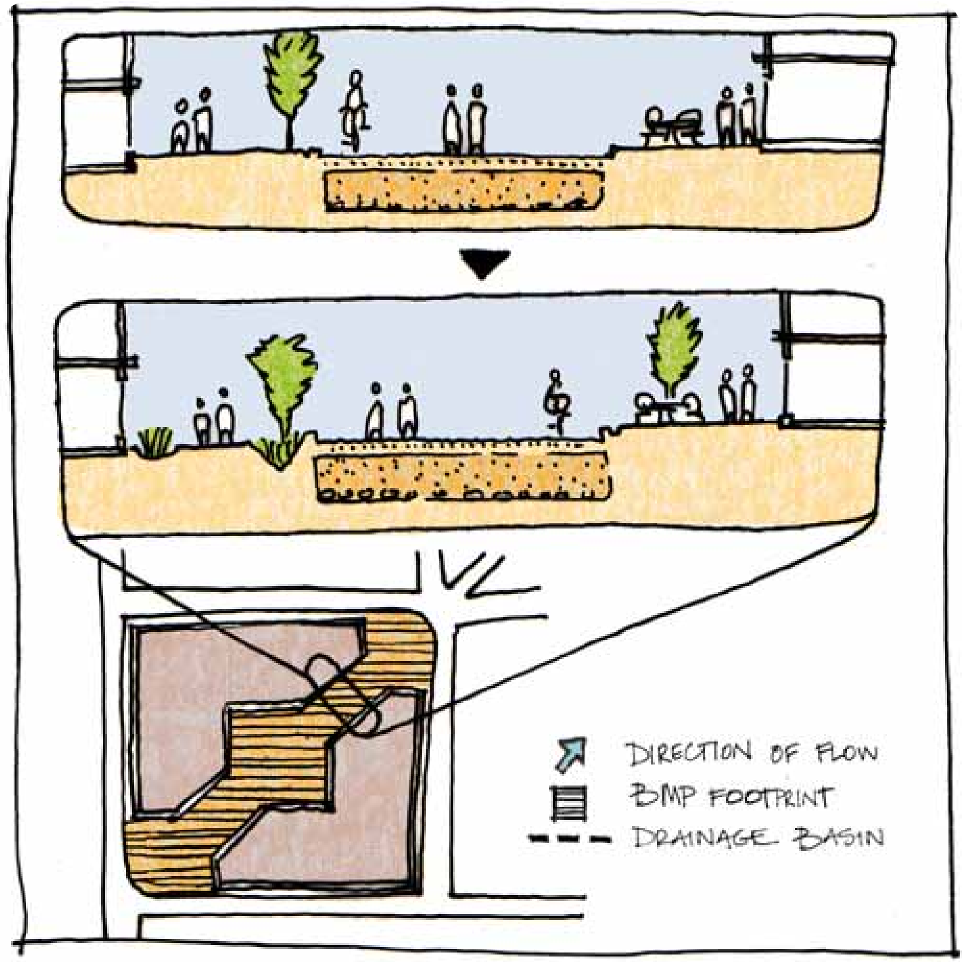
Project applicants in combined sewer areas under SFPUC jurisdiction must achieve LEED SS6.1 to reduce the flow and volume of stormwater into the collection system. SFPUC staff is in the process of creating additional guidance for achieving SS6.1. In the meantime project applicants are encouraged to consult *LEED for New Construction Version 2.2* and contact Urban Watershed Management Program staff if necessary.

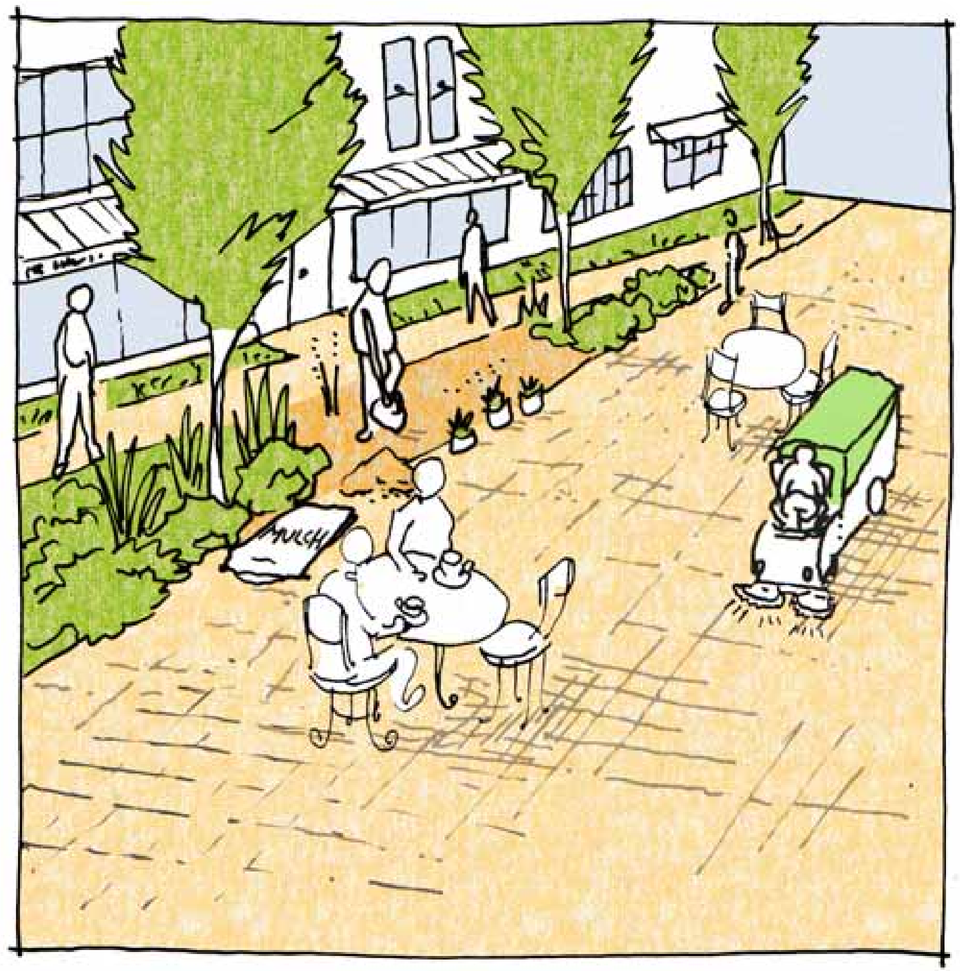
Step 8

Check against Design Goals and Modify if Necessary

After site design, source control, BMP selection, and BMP sizing are completed, project applicants should review the original design goals and evaluate whether they have been achieved. If not, an iterative design process that may include BMP relocation or resizing can ensure that the project achieves its design and development goals and complies with stormwater treatment requirements.

At this stage in the design process, there is a general understanding of how the runoff will move across the site, source control measures have been identified and located, treatment controls have been selected based on site conditions and pollutants of concern, and target water quality volumes and flow rates have been calculated. The next task is to locate and size the actual treatment controls. Sizing tools for each treatment control are





included with the Fact Sheets in Appendix B, and are available electronically at www.sfwater.org and www.sfport.com.

Step 9

Develop an Operations and Maintenance Plan

Treatment and control facilities must be regularly maintained to ensure that they continue to provide effective treatment and do not harbor mosquitoes, cause flooding, or otherwise create a nuisance. Improper maintenance is one of the most common reasons for BMP underperformance and failure.

The General Permit requires that project applicants provide verification of maintenance provisions "through such means as may be appropriate, including, but not limited to legal agreements, covenants, CEQA mitigation requirements and/or Conditional Use Permits." Stormwater facilities installed as part of new development or redevelopment projects will be incorporated into both the Port's and SFPUC's operation and maintenance verification program. An operations and maintenance plan is a required element of the SCP. To develop an operations and maintenance program for new facilities, follow these steps:

1. **Identify who will own or have operational responsibility** for the facility. In the case of Port facilities, operational responsibility will be assigned through lease and development agreements. In the case of privately owned facilities regulated by the SFPUC the property owner will be responsible for operations and maintenance.

2. **Identify applicable maintenance requirements** for each stormwater control at the facility and list the requirements into the SCP. The SCP must identify any title transfers, lease provisions, or maintenance agreements that will be executed before construction is complete.
3. **Develop an Operations and Maintenance Plan** (O&M Plan) for the site incorporating detailed requirements for each treatment and control BMP at the facility. The O&M Plan must be submitted before the building permit is finalized and a certificate of occupancy is issued. Any necessary agreements must be executed concurrent with submittal of the O&M Plan.
4. **Maintain the facilities** from the time of construction until ownership or lease is formally transferred.
5. **Formally transfer** operation and maintenance responsibilities to any new owner, occupant or lessee. **The transfer will require the new owner, occupant, or lessee to maintain facilities in perpetuity and comply with Port and SFPUC self-inspection, reporting, and verification requirements.**

Mulching is an important part of BMP maintenance.

Designing to Minimize Maintenance

Streamlined maintenance and maximized performance can be achieved by considering the following design features:

- Use pretreatment systems to remove coarse sediment and litter, particularly for infiltration systems. Pretreatment systems can also reduce the velocity of flows entering the treatment BMP, reducing wear on the BMP and extending its useful life.
- Use deeper rooted vegetation in conjunction with infiltration BMPs. Good root structure helps to maintain soil porosity and reduces the maintenance needs of the BMP. For a list of recommended vegetation species, see Appendix D.
- Whenever possible, select BMPs that do not require slow-release control structures. Such structures can clog and require periodic inspection and maintenance.
- Stormwater facilities that are above-ground are more likely to be visible and therefore receive maintenance.

Regular inspections are required in order to maintain the effectiveness of treatment control BMPs. Inspection and maintenance activities can be divided into two functions:

1. Scheduled routine inspection and maintenance, and
2. Non-routine repair and maintenance.

Routine inspection can reveal potential problems with BMP operations and help to ensure the highest level of pollutant removal. Routine maintenance refers to activities performed on a regular basis to keep the BMP in good working order. These activities are generally not complicated (sediment removal, landscape work, etc.) and can be performed by most facility maintenance staff. Typical maintenance activities are described in each of the BMP Fact Sheets included in Appendix A.

Step 10

Compile the Stormwater Control Plan

A Stormwater Control Plan (SCP) with exhibits – as described in the SCP template (Appendix C) – must be submitted to the Port or SFPUC as part of the planning approval process. The completed SCP must include the following information:

- Information on Project Owner/Developer and Design Team
- Project location
- Project description
- A site plan showing proposed project
- Any soils or geotechnical reports necessary to complete stormwater design
- Site analysis for locating and sizing BMPs
- A site drainage plan showing direction of stormwater flow to the point where it enters the storm sewer system or receiving waters
- Stormwater sizing calculations
- A post-construction O&M Plan
- Refer to Appendix C for a template of an SCP.

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"Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land."

- Luna Leopold

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