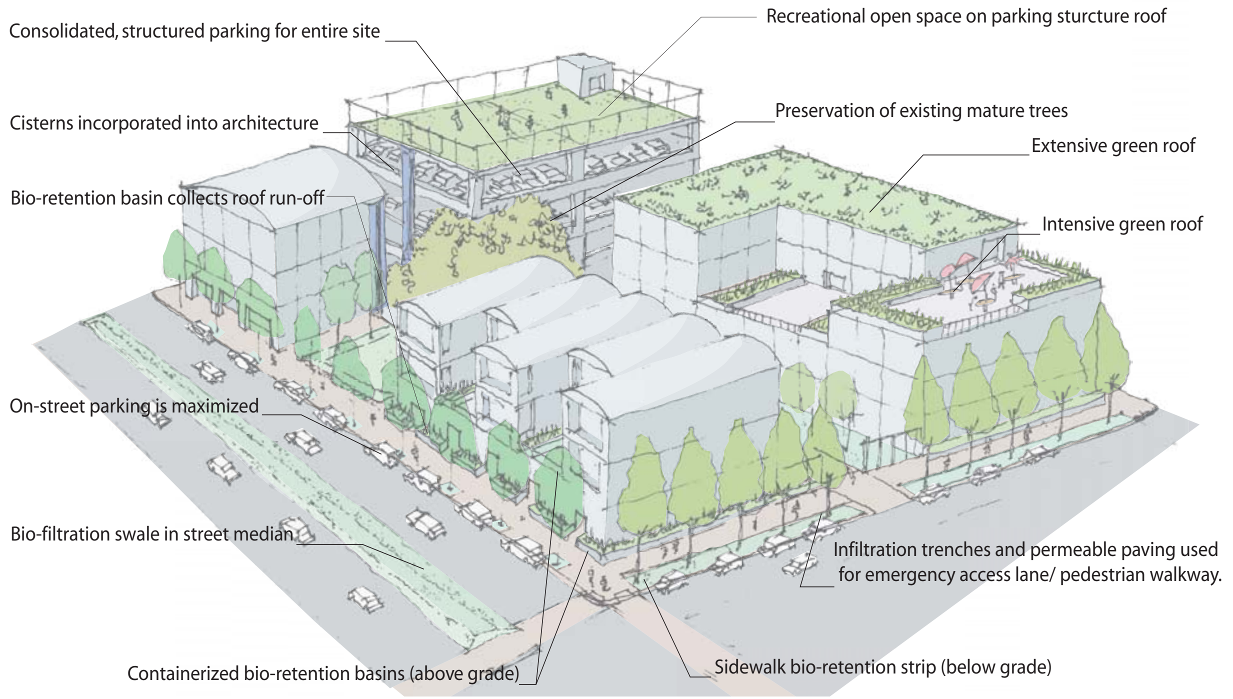
Stormwater Guidelines for Green, Dense Redevelopment

Stormwater Quality Solutions for the City of Emeryville

December 2005



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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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1. INTRODUCTION

1.1 What is the Purpose of the Guidelines?

1.1.1 Who and What Benefits?

Cities must now require development and redevelopment projects to treat stormwater and these guidelines offer ways to meet the requirements in Emeryville, where development patterns are dense, some soils are impermeable or contaminated, and the water table is high. In the past decade, the City of Emeryville has earned a national reputation as a pioneer in reclaiming, remediating, and redeveloping its decaying industrial lands. A massive brownfields pilot program has resulted in a dramatic economic turnaround for the City and has succeeded in attracting new business and new residents to the city. Through an Environmental Protection Agency (EPA) grant, the City is now addressing its next challenge – to meet new standards for water quality and improve the general environmental sustainability of continued revitalization efforts.

These Guidelines, geared specifically to developers and designers, will provide a vision for integrating green stormwater treatment into the site planning and building design of new development. Additional efficiencies in development will also be gained from pedestrian-friendly parking strategies. The parking and green design solutions range from shared district parking facilities to green roofs to containerized bio-retention gardens. All are tailored for Emeryville's unique context: heavily urbanized sites, compacted or even contaminated soils, and a high water table. Because these Guidelines includes a thorough numeric, hydraulic sizing methodology for various facility types, it will enable City staff, planners, designers, and developers to implement sustainable design on many scales throughout Emeryville. Implementation of the guidelines will allow Emeryville to be increasingly competitive in attracting research and knowledge based businesses and develop additional housing opportunities for those interested in Emeryville's urban lifestyle.

Figure 1-1: Aerial photo of green, dense redevelopment on a former industrial site in Malmo, Sweden. This development was created as part of the Bo01 Expo, which showcased sustainable and green design.

1.2 What Is "Green Dense Redevelopment"?

1.2.1 Definition of Terms

These Guidelines use the term "Green Dense Redevelopment" to describe redevelopment and infill projects that create vibrant urban neighborhoods and provide ecological benefits. The thinking behind "green dense redevelopment" is that urban infill projects can benefit water resources by directing growth away from the undeveloped portions of a watershed.

In addition, these projects can be designed to benefit water quality on a site level by reducing the amount of paved surface that exacerbates runoff and by providing on site stormwater treatment facilities. In this sense, green dense redevelopment should contain less impervious paved surface and more pervious, landscaped surfaces than conventional development. Because of their important role in reducing runoff volumes and filtering contaminants, plants are also a critical component of green dense redevelopment. This redevelopment strategy will involve more landscaped areas compared to traditional development. Also, plantings and landscaping will be designed differently to enable them to serve as integral components in the stormwater treatment process, rather than as ornaments.

The types of "dense" development envisioned in these Guidelines include mixed use (combinations of residential, office and retail) and residential projects with densities of 12 units per acre or higher. For the purposes of this workbook, the "green" components of a project may include a range of land use and parking policies, site design strategies, and design details that reduce the amount of impervious surface or provide some degree of stormwater treatment on-site. Many of the "green" design components featured in these Guidelines serve multiple roles, so that "green" often refers to more than stormwater function. Many of these elements play roles in providing green space for recreation, habitat for wildlife, energy savings, improved air quality, reduced heat-island effect, and neighborhood character.

1.2.2 Rethinking the Relationship Between Density and Stormwater

Several studies have found that covering just 10 percent of a watershed's land area with impervious surface can impair hydrological function and water quality within the watershed. Some communities have inferred from this finding that very low-density development is preferable to denser types because on the scale of an individual lot, low-density development may allow the majority of a lot to remain unpaved and unbuilt. Yet this interpretation does not take into consideration the fact that very low-density development requires more impervious coverage off-site, in terms of roads and parking lots, which may increase the amount of impervious surface within the watershed but not on the individual lot.

Figure 1-2: Courtyards and rooftops reduce urban runoff while providing attractive green spaces for residents.

The EPA, the Center for Watershed Protection, and other environmental agencies and organizations are reassessing the water quality impacts associated with different development densities. Their research indicates that higher density infill projects may, in fact, provide more water quality benefits than low-density development. The Center for Watershed Protection reported that, "Increasingly, urban redevelopment and infill projects are emerging as a means to help rejuvenate sagging city centers, while simultaneously providing opportunities for more environmentally-friendly growth."

"Protecting Water Resources with Higher Density Development," published by the EPA, dispels a number of myths and reexamines the underlying assumptions regarding the relationship between density and water quality. It raises five basic points in its critique of conventional arguments for low-density development:

- Higher density does not necessarily mean more impervious surface—multiple units in a compact arrangement may reduce the building footprints and thus, result in less impervious coverage (per unit) than stand-alone units dispersed across the landscape.
- Not all "pervious" surfaces are equal—many disturbed surfaces that appear pervious (like lawns) may be compacted, which greatly reduces their ability to infiltrate runoff.
- Low-density development often requires more off-site impervious infrastructure (roads, parking lots, etc.)
- The rule of thumb that 10 percent impervious cover will impair a watershed should be assessed on the scale of the watershed—not on the individual site.
- Low density development does not reduce impacts—it just spreads them out.

The arguments for dense green development contradict conventional notions that cities are inherently "bad" for water quality. If properly designed, high-density development can, in fact, benefit its natural environment, including water resources.

1.3 Connections Between the Guidelines and Other Efforts and Policies

1.3.1 Federal: Clean Water Act Amendment, Surface Pollutants and the NPDES

The 1972 Clean Water Act was amended in 1987 requiring cities to apply for the same kind of NPDES (National Pollutant Discharge Elimination System) permits for their municipal "separate" storm sewers (as opposed to "combined" systems where storm runoff is treated with sewage) as they would for regular outfalls from sewage systems.

The focus of the NPDES Municipal Separate Storm Sewer System permit is to eliminate pollutant discharges from municipal stormwater into public waters. Local municipalities take an active role in the permitting process to devise stormwater management plans that reduce identified pollutants for specific water bodies. Emeryville is a member of the Alameda County Clean Water Program (ACCWP), which has a joint NPDES permit. The permit requires member jurisdictions to require developers to design projects to treat stormwater.

1.3.2 ACCWP's NPDES Permit

A 1987 revision to the federal Clean Water Act requires cities with more than 100,000 people and smaller cities located in large metropolitan areas to control the amount of pollution entering local storm drain sewer systems. In 1989, a consortium of 17 county and city agencies established the Alameda Countywide Clean Water Program (ACCWP) to facilitate compliance with these regulations. Guidelines for managing, monitoring, and reducing urban runoff were established for the Clean Water Program through the National Pollutant Discharge Elimination System (NPDES) permit to discharge municipal storm waters. This NPDES permit requires that development projects treat approximately 85 percent of annual rainfall, which in the Bay Area is roughly equivalent to a 1-inch storm. The ACCWP developed a Storm Water Management Plan to meet objectives from both: 1) the NPDES permit and; 2) the Bay Basin Plan which was developed by the San Francisco Regional Water Quality Control Board (RWQCB) to prevent urban runoff pollution and to help restore the health of local creeks and San Francisco Bay.

Under the ACCWP private development projects are broken down into two groups: Group 1 are projects creating or replacing more than one acre of impervious surface; and Group 2 are projects creating or replacing more than 10,000 square feet of impervious surface. Implementation start dates vary for each group:

Group 1: Project applications and amendments received between February 15, 2005 and August 14, 2006, or projects that have not submitted a complete application as of February 15, 2005 with one acre or more impervious surface, must comply with hydraulic sizing design criteria for stormwater quality treatment. Projects that have submitted complete applications before February 15, 2005 are considered "deemed complete" and are not required to comply with hydraulic sizing design criteria for stormwater treatment. Projects with Planning Commission approval that propose changes on or after February 15, 2005 requiring Planning Commission re-approval must comply with the hydraulic sizing design criteria for stormwater treatment.

Group 2: Project applications and amendments received after August 15, 2006, or projects that have not submitted a complete application as of August 15, 2006 must comply with hydraulic sizing design criteria for stormwater quality treatment. Projects that have submitted complete applications before August 15, 2006 with 10,000 square feet or more impervious surface are considered "deemed complete" and are not required to comply with hydraulic sizing design criteria for stormwater treatment. Projects with Planning Commission approval that propose changes on or after August 15, 2006 requiring Planning Commission re-approval must comply with the hydraulic sizing design criteria for stormwater treatment.

These guidelines serve as one part of the City of Emeryville's compliance with the requirements associated with the joint NPDES permit. The City prefers vegetative design solutions such as those described in these guidelines rather than mechanical solutions. This is because vegetative solutions treat stormwater more effectively, involve easier maintenance and inspection, improve air quality and provide green aesthetics. Therefore, the City desires to see vegetative solutions whenever possible. Developers of projects subject to numerical treatment requirements shall be required to retain a qualified stormwater consultant to design on-site treatment measures. The consultant shall either be one that is listed by the Bay Area Stormwater Management Agencies Association ("BASMAA") as qualified in stormwater treatment design (www.basmaa.org/documents, Qualified Post-Construction Consultants List), or a consultant that demonstrates similar qualifications to those on the BASMAA List. The stormwater treatment design consultant shall make a good faith effort to meet the entire treatment requirement using vegetative solutions. If the stormwater treatment design consultant concludes that vegetative solutions are not feasible due to site characteristics, building uses or other legitimate reasons, and the City concurs, the City will consider allowing on-site mechanical solutions. In some cases, upon recommendation of the stormwater treatment design consultant, a combination of vegetative and mechanical solutions may be allowed. If mechanical solutions are utilized, the mechanism must be approved by the City, and the developer must demonstrate that the mechanical design will remove fine sediments and dissolved metals as well as trash and oil.

1.3.3 Resources from Agencies

The ACCWP has published a booklet titled *Protecting Water Quality in Development Projects: A Guidebook of Post-Construction BMP Examples*. It can be obtained at www.cleanwaterprogram.org and at www.basmaa.org, the website for the Bay Area Stormwater Management Agencies Association (BASMAA). The BASMAA website also has a list of qualified post-construction consultants, who can help design sites for stormwater treatment. The California Stormwater Quality Association (CASQA) has published a book titled *California Stormwater Best Management Practices (BMP) Handbook: New Development and Redevelopment* (CASQA handbook). It can be downloaded from www.cabmphandbooks.com.

1.4 How to Use These Guidelines

The Guidelines for Green Dense Redevelopment are intended for a variety of users. The chapters are summarized below, to enable different users to identify and locate the information they need.

Developers and Citizens Doing Site Design:

- The regulatory framework
- A method for matching a particular design solution with a development type or element
- A method for effective numeric sizing of a particular design solution
- Conceptual design solutions that will need to be detailed for a specific site

Elected Officials and Public Agency Engineers and Planners:

- Integrating solutions, layering uses and understanding the big picture

Chapter Summaries

1. Introduction

This chapter provides a user's guide to navigating through these Guidelines and an overview of its contents.

2. Goals

This chapter discusses the unique approach that these guidelines are taking to achieve goals related to both parking and stormwater quality.

3. Concepts

A basic understanding of a few key terms, principles, and processes is necessary before the guidelines can be implemented.

4. Designing for the Emeryville Context

These Guidelines is specific to Emeryville's unique environment, which is described in this chapter.

5. Innovative Parking Solutions

This chapter presents a "toolbox" of parking solutions intended for both the City and private developers.

6. Stormwater Management Design Solutions (BMP's)

This chapter describes a range of stormwater design solutions that could be applicable to Emeryville projects.

7. Selecting and Sizing Stormwater Design Solutions

This chapter explains how to integrate stormwater design solutions into the site design process. Also included are detailed instructions on using the accompanying Design Solution Sizing Spreadsheets.

8. Case Studies

This chapter presents case study examples of key components of the parking approaches and design solutions.

9. Appendixes

A glossary of terms, bibliography, credits, and technical notes are presented in the final chapter.

2. GOALS

Environmental sustainability–best defined as the identification, preservation, restoration, and enhancement of natural systems–is increasingly becoming an important public and regulatory concern. Equally so, "Smart Growth" principles involving compact, mixed-use development, preservation of land through infill practices, and the creation of walkable, safe and attractive neighborhoods that provide for the variety of transportation choices are also at the forefront of contemporary planning and urban design.

Establishing the *Emeryville Design Guidelines for Green Dense Redevelopment* understands that solutions to ecological health are found in an integrated approach to urban development that acknowledges needs for a healthy habitat for humans and other species, and the requirements of modern urban living. One must understand that the environment, urban or otherwise, is not a collection of discrete units; rather everything overlaps and everything is connected. In order to have any meaningful impact on complicated problems, solutions must understand this premise.

The following represent a preliminary set of goals for these Guidelines, developed through discussion with City staff and the public through a workshop format.

2.1 Improve Water Quality

The water resources of a community are only as healthy as the water that flows through it. Efforts are needed to improve the quality of stormwater runoff through the related processes of retention and infiltration. A retention facility captures and temporarily holds stormwater runoff, allowing it to infiltrate into the soils (i.e. be absorbed by the soils). Bio-retention and bio-filtration are processes closely related to retention and infiltration but incorporate plants to filter pollutants and increase the porosity of the soils. New development, including roads, must reduce impervious surfaces, allowing rain to infiltrate as near as possible to where it falls (typically referred to as "ubiquitous infiltration"). The unique conditions in Emeryville, however, generally preclude direct infiltration into the groundwater, thus requiring a subsurface collection system. When water is conveyed, the flow should go through a process of bio-filtration that enables vegetation to filter and treat runoff.

2.2 Protect Habitat Value

Growth can be accommodated and quality of habitat improved if negative impacts of urban transportation and development are reduced. Strategies should include measures to improve water quality while reducing the overall quantity of urban runoff. Furthermore, protection and enhancement of other natural resources such as wetlands and significant stands of trees and shrubs also improve habitat for wildlife, and have a significant effect on quality of life for people.

2.3 Use Land Efficiently

A city as built-out as Emeryville cannot expand beyond its boundaries, but must utilize Smart Growth infill redevelopment practices in order to increase development potential. Land is essentially a finite resource that necessitates the layering of many uses including alternative infrastructure systems promoting stormwater infiltration, other public utilities, and opportunities for recreation. Efficiently accommodating parking not only reduces overall impervious surface, but also releases land for more intense development.

2.4 Embrace Natural Processes

Modern American urban development has slowly begun to understand the benefits of considering environmental factors in the design, but typically to the minimum required by the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). New development should more fully consider its impact on stormwater filtration, as well as the overall social life of the community. Solutions should be grounded in the appreciation that the natural process of stormwater infiltration (with subsurface collection on contaminated sites) and natural drainage patterns are optimal for providing multiple benefits including attractive pedestrian environments and recreational open space. Furthermore, careful implementation and maintenance of natural processes is affordable.

2.5 Provide Cost-Effective Solutions

Green redevelopment design solutions should be permittable and cost-effective in terms of initial construction, maintenance, and long-term replacement. Design decisions based upon the site characteristics are more efficient when working with, rather than against, natural processes. Cost comparison analysis should be sensitive enough to recognize environmental, social, and quality of life benefits of the green redevelopment design solutions.

2.6 Foster Unique and Attractive Streetscapes and Development

A streetscape design with multiple functions that integrates the "natural" and the "man-made" can provide a unique identity to a community. Green development streetscapes facilitate natural infiltration and therefore have less impervious surfaces such as concrete and asphalt. This allows for greater use of vegetation and other attractive materials such as crushed stone and pavers that can be selected to create an identifiable community character. This design approach, together with a properly funded maintenance program can provide a streetscape that reduces the negative impacts typically associated with streets: visual quality, noise pollution and traffic congestion, and ensures long-term stewardship of natural resources.

3. CONCEPTS

3.1 Introduction

The basic concepts of stormwater treatment are not complicated. The goal is to restore the hydrological cycle as much as possible. This means intercepting the water that falls from the sky before it reaches the ground, and then getting as much of the rest into the ground as quickly as possible. What does become complicated is the breadth of issues involved once the land becomes urbanized. Addressing all the issues can be somewhat daunting.

3.2 The Hydrologic Cycle and Effects of Urbanization

An urban or urbanizing watershed is one in which impervious surface covers a considerable portion of the land area. With urbanization, natural flow paths in the watershed are typically replaced or supplemented by paved gutters, storm sewers, or other elements of artificial drainage.

As the natural landscape is paved over, a chain of events takes place that typically ends in degraded water bodies. This chain begins with alterations to the hydrologic cycle and the way water is transported and stored.

Urbanization changes a watershed's response to precipitation. The most common effects are reduced infiltration and decreased travel time, which significantly increase peak discharges and runoff volumes. The amount of runoff is determined primarily by the amount of precipitation and by infiltration characteristics related to soil type, soil moisture, antecedent rainfall, land surface cover type, impervious surfaces, and surface retention. Travel time is primarily determined by slope, length of flow path, depth of flow, and roughness of the flow surface. Peak discharges are based on the relationship of these parameters and on the total drainage area of the watershed, the location of development, (which includes encroachment into the floodplain and loss of wetlands) the effect of any flood control structures or other human constructed storage facilities, and the distribution of rainfall during a given event.

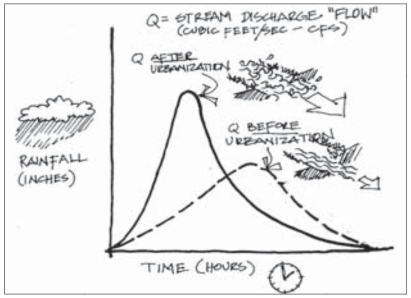


Figure 3-1: Urbanization results in a sharper peak on the storm hydrograph.

The amount, timing, and duration of stream flow events can be visually presented in a hydrograph. A hydrograph is a plot comparing the rate of runoff against time for a point on a channel or hillside.

3.2.1 The Earth as a Sponge ("Normal" conditions: not brownfield)

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as soil intake rates. Soils are classified into four Hydrologic Soil Groups (A, B, C, and D) according to their minimum infiltration rate, which is obtained from bare soils after prolonged wetting. Most urban areas are only partially covered by impervious surfaces; however the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (i.e. sands and gravels) than in watersheds predominantly of silt and clays, which generally have low infiltration rates. Also, development typically results in the removal of topsoil, generally leaving heavily compacted soils that have a reduced pollutant treatment capacity.

3.2.2 Percentage of Impervious Land as Indicator of Ecological Health

Research indicates that impervious coverage over 30 percent is associated with severe, practically irreversible degradation. Degradation occurs in 5 ways:

- Rainwater is no longer trapped by vegetation to the same extent, thereby increasing runoff.

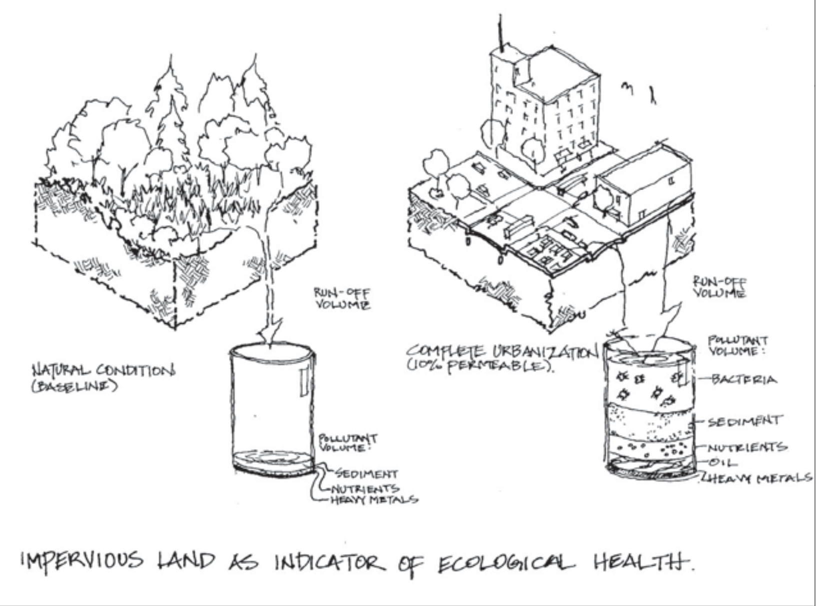


Figure 3-2: As impervious surface increases, so does runoff volume.

- Much of the rainwater is prevented from moving into the soil, where it recharged groundwater, and stream baseflows are thereby reduced.
- Because the larger volume of rainwater cannot infiltrate into the soil, more rainwater runs off thus creating greater flows more frequently. This enlarges the stream channel causing bank erosion and associated reduction of habitat and other stream values.
- Runoff flowing across impervious surfaces collects and concentrates pollutants from cars, roadways, rooftops, lawns, etc. (i.e. “nonpoint” sources) significantly increasing pollution in stream and other waterbodies.
- Impervious surfaces retain and reflect heat, causing increases in ambient air and water temperatures. Increased water temperatures negatively impact aquatic life and oxygen content of water bodies.

The three basic tenets of reducing imperviousness – retaining the natural landscape, minimizing pavement, and promoting natural infiltration to the soil – are simple concepts that can be understood by citizens.

3.2.3 Why is Runoff so Polluting?

For several decades, the nation’s environmental laws were aimed at curbing traditional sources of pollution such as raw sewage and industrial waste–referred to as “point” source pollution. Since the 1980s, however, attention has turned to “nonpoint” pollution, which comes from diffuse sources such as roads, roofs, lawns, driveways, parking lots, etc. Nonpoint source pollution is now the number one cause of water quality impairment in the United States, accounting for 50 percent of water problems in the nation’s water bodies.

So what exactly is flowing off of yards and streets? An overabundance of nutrients such as nitrogen and phosphorous from fertilizers and animal droppings, although not detrimental to soil, threaten water supplies by producing algae blooms that, upon decaying, rob the water of life-sustaining oxygen. Toxic contaminants like heavy metals and pesticides pose threats to aquatic creatures and humans. Sediment from eroded banks or runoff creates turbidity (murkiness) which can also clog waterways and become carriers of other pollutants, as well as being unsightly. Sediment is also a threat to fish by covering over the eggs of trout and salmon and clogging the gills of young fry, essentially choking the fish. Debris such as plastics is harmful to wildlife and extremely unattractive, reducing the recreational value of water bodies.

3.2.4 Impact of Soil Contamination

Past industrial uses and practices have left a significant portion of Emeryville’s former industrial lands contaminated to some extent. Even post-remediation, some contamination likely will remain on some of these sites, making stormwater infiltration undesirable in these cases. If allowed to infiltrate through contaminated soils, stormwater would likely leach the contamination into the water table, ultimately spreading the pollutants to the Bay. To prevent leaching from occurring on contaminated sites (and also due to Emeryville’s unusually high water table), these Guidelines recommend that any stormwater treatment

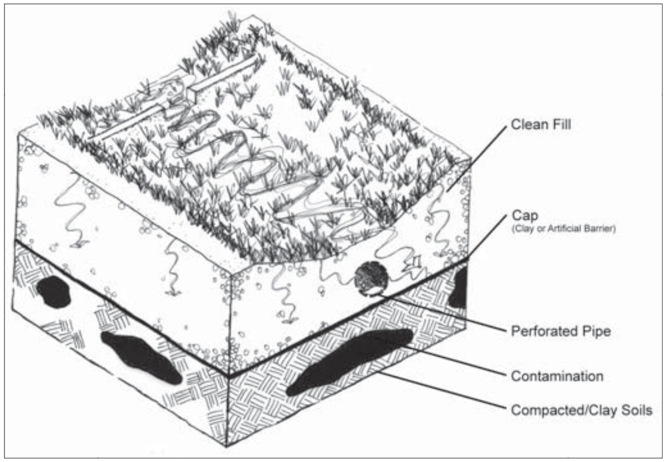


Figure 3-3: In Emeryville, soil contamination, compacted soils, clay soils, and a high water table preclude infiltration into the ground. Instead, stormwater solutions should use clean soils and be capped, lined and equipped with an under-drain system.

facility (detention, retention, bio-retention, infiltration, bio-filtration, etc.) be lined with "clean" soils and/or other media and equipped with a system of under-drains, to collect the stormwater after it is filtered and connect to the existing storm sewer system (Figure 3-2). This ensures that the stormwater receives some degree of treatment before entering the storm sewer and that it does not pick up any additional pollutants from on-site contamination. Perforated pipe should be within 2 feet of the surface.

3.3 Integrating Solutions

3.3.1 Solve Many Issues at Once

The main focus of these guidelines is stormwater quality, yet it is important to remember that dense green redevelopment offers a variety of other benefits. Chapters 5 and 6 present design solutions that, in addition to addressing stormwater runoff, promote walking and bicycling, beautify public and private development, create green space and wildlife habitat, reduce energy consumption, and have the potential to promote environmental equity. Unlike a conventional storm sewer system, which is designed to solve one problem, the green approaches presented in these guidelines serve multiple purposes and confer a range of benefits on the whole community. Therefore, these approaches should be designed and implemented with many objectives, not solely stormwater management, in mind.

Figure 3-4: The parking lot for the EcoTrust building in Portland, OR incorporates several parking and stormwater solutions.

3.3.2 Example Projects

As noted throughout the guidelines, parking and stormwater solutions may work best in concert with each other and with other City land use, transportation, and design policies. The following projects illustrate how multiple solutions can be applied to a site to achieve multiple goals, including, but never limited to, stormwater quality.

Ecotrust Parking Lot, Portland OR

This parking lot's bio-retention areas provide stormwater treatment and infiltration while simultaneously serving as attractive landscaping (shown in Figure 3-4). The clearly defined walkways and sidewalks, outdoor seating, and bicycle racks activate the edge of the parking lot and provide pedestrian and bicycle amenities.

Figure 3-5: Green roof over Soldier Field parking garage, Chicago, IL

Soldier Field Green Roof Parking Structure, Chicago, IL

The intensive green roof that covers the new underground parking structure for Soldier Field provides a monumental green space in addition to reducing runoff (Figure 3-4).

Figure 3-6: Traffic circle and infiltration basin, Arizona

Neighborhood Traffic Circle, Tucson, AZ

This infiltration basin (shown in Figure 3-5) doubles as a traffic circle, collecting stormwater off of the streets and slowing cars as they cross the intersection. This unique design feature lends character to the neighborhood while increasing pedestrian safety. In addition, it increases public awareness of stormwater as a resource by making it a visible, central design

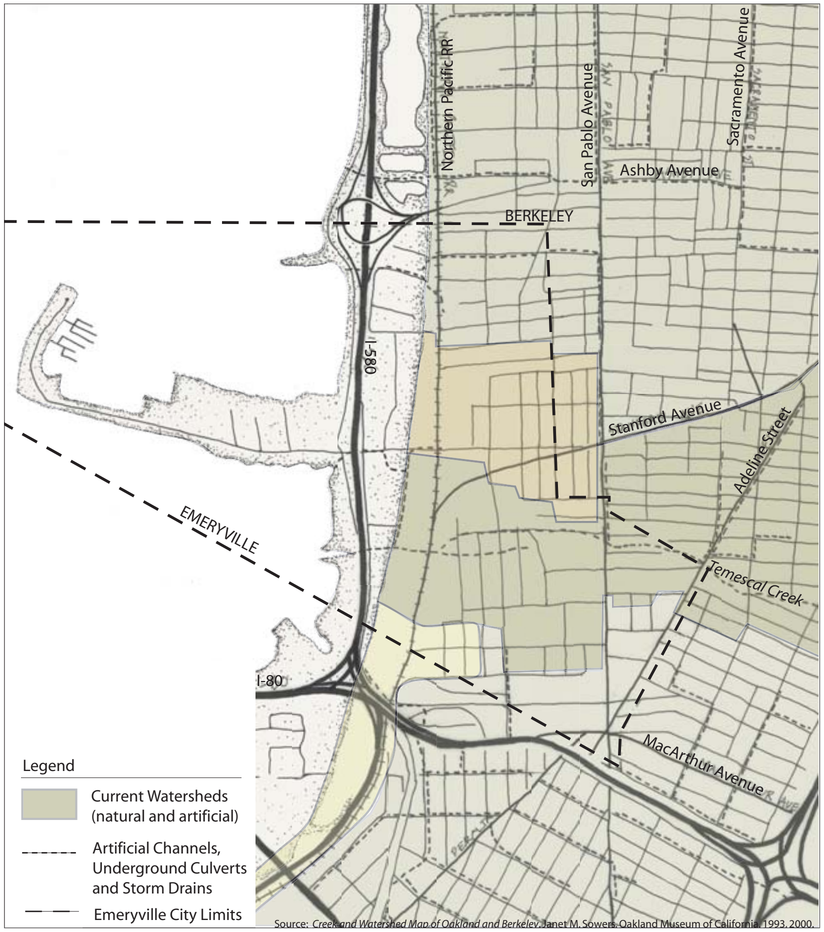
4. DESIGNING FOR THE EMERYVILLE CONTEXT

4.1 Local Characteristics and their Design Implications

4.1.1 Emeryville's Watersheds and their Relationship to San Francisco Bay and Wetlands

The term, "watershed" (or drainage basin), refers to a land area that drains to one downstream water body (a stream, river, lake, bay or ocean). The East Bay historically contained numerous creeks and their watersheds, all of which in turn drained into San Francisco Bay. Since the mid 1800s most of these creeks have been filled or buried in underground culverts and drainage tiles. This is the case in Emeryville, where the lower reaches of two historical creeks, Derby and Temescal Creeks, were placed underground and/or channelized. The city is now drained by a system of man-made storm drains that conveys the stormwater by pipes and channels to the Bay.

The transformation of natural streambeds into underground pipes has had a substantial negative effect on both the riparian habitat (located in bands along the length of creek bed, usually 10 to 15 feet wide) and the wetland habitat (large, flat areas of marsh that occur at the terminus of the creeks, where they flow into the Bay). When intact, both of these ecosystems play important roles in the bioremediation of stormwater. The soils, plants and microorganisms in these ecosystems are capable of filtering out and breaking down many of the contaminants before they reach the Bay. Without the natural function of the riparian and wetland habitats, the water quality of the stormwater entering the Bay is seriously compromised.



Source: *Creek and Watershed Map of Oakland and Berkeley*, Janet M. Sowers, Oakland Museum of California, 1993, 2000.

Figure 4-1: Map of Emeryville's creeks and drainages

4.1.2 Rainfall

The Bay Area's Mediterranean climate produces mild, dry summers and mild, wet winters. Emeryville receives an average annual rainfall of 18 inches, with roughly 70 percent (12.6 inches) falling during the wet, winter months (November through March). This annual rainfall pattern holds specific implications for water quality. The extended dry spells during the summer (sometimes more than 5 months) allow dust, pollutants, trash, and debris to accumulate on roads, parking lots, roofs, and other hard or paved surfaces. When the rains finally arrive (usually in October or November), the first several storms of the season remove the accumulated contaminants. Thus, the early rains of the season usually contain high concentrations of contaminants, resulting in very low water quality.

The same conditions also hold true on a smaller time scale. Just as the first rains of the season are likely to carry the highest concentrations of contaminants, the flows from the first few minutes of any storm are likely to carry higher concentrations of pollutants than the flows from the end of the storm. This phenomenon is referred to as "first flush," where the "dirtiest" runoff comes from the beginning of a storm. Because the first few minutes of a storm can have the greatest water quality impact, many of the design solutions presented in Chapter 6 can be designed and sized to capture and treat the "first flush" rather than the runoff generated during the entire storm period.

4.1.3 Soil and Groundwater Conditions

Soil Types

Different soil types have different infiltration rates (how quickly water moves through them) based primarily on the size of the soil particles. The western part of the city has been developed on Bay mud and artificial fill; the eastern portion sits on a deposit of alluvial clay. Both Bay mud and alluvial clays are characterized by relatively small particles, which translates into relatively low infiltration rates and poor permeability. The artificial fill materials may have a coarser profile and therefore better drainage characteristics but because these materials are also likely to be contaminated (see Soil and Groundwater Contamination, below), infiltration of stormwater through this material may be inappropriate.

Soil Compaction

Because most of Emeryville is heavily urbanized, soil compaction is a common condition on sites throughout the city. Soils that have received vehicular or extensive foot traffic, construction activity, or development of any sort are likely to be compacted, even if the area has since been vacant for a long period of time. Compaction greatly reduces permeability and infiltration rates because it removes the tiny air the pockets, or voids, which create water storage capacity.

Water Table Levels

The ground water level (also referred to as the "water table") in Emeryville sits within 6 to 10 feet of the ground surface, and during the rainy season, may rise to within 2 to 4 feet of the ground surface at some locations. A high water table constrains development because it can result in flooding of underground parking and basements. Emeryville's high water table, combined with potential ground water contamination, also limits infiltration opportunities within the city.

Soil and Groundwater Contamination

In 1995, approximately 213 acres (55% of Emeryville's designated Commercial, Mixed Use and Industrial properties) were known to have soil and/ or groundwater contamination. In addition, all of the land area created from artificial landfill materials is assumed to contain contaminated debris and soils. While much of Emeryville's remaining commercial land has not been tested (and therefore it is not yet *known* whether it is contaminated) it is highly likely, based on historical land uses and hazardous materials handling practices, that the untested sites are contaminated to some degree. This has led the City and various regulatory agencies to assume that the shallow groundwater in Emeryville's commercial/industrial areas is contaminated as well.

Figure 4-2: Historically, industry occupied much of Emeryville's land.

Figure 4-3: Interface between Emeryville's industrial and residential neighborhoods

4.1.4 Land Use

History of Industrial Use

From the mid 1800s through the mid 1900s, Emeryville established itself as a small but thriving industrial center. Easy access to numerous transportation routes facilitated industrial expansion in Emeryville and throughout the East Bay: railroads, shipping, and trucking provided the backbone for a variety of manufacturing companies. These industries included automobile, canning and packing plants, manufacturers of pesticides, paints, petrochemicals, and transformers, steel recycling and plating. By the middle of the 20th century, Emeryville was a major regional warehousing, transport and employment center, with 25,000 workers. The development of the East Bay freeways in the 1950s and 1960s also supported industries in Emeryville. Eventually, Emeryville ran out of developable land and began to fill in the Bay to increase areas for industry. By the 1970s, when its industrial base began to decline, Emeryville had filled 250 acres of the Bay.

Plan for Mixed-Use Redevelopment

By the 1980s, many of Emeryville's industries began to close or relocate. The city lost approximately half of its jobs, and many of the industries that closed their doors left legacies of contamination and vacant, derelict properties. In order to revitalize the community and restore the local economy, Emeryville began to re-envision itself as a mixed-use, retail, and service center. This shift in economic and employment goals required a dramatic transformation of the city's building stock and infrastructure. The emerging vision for Emeryville called for significant redevelopment projects on abandoned industrial sites but these projects could not get under way until the sites were cleaned.

In the past 15 years, many former brownfield sites in Emeryville have been successfully remediated and redeveloped as mixed-use, retail, residential, entertainment, and office developments. This process has required substantial private and public investment at the local level in addition to funding and oversight by the EPA and other state and federal agencies. Examples of Emeryville's brownfield redevelopment projects include the Emery Bay Market, the Pixar campus, the Chiron office complex, Ikea, and the Bay Street shopping center. The City plans to continue the redevelopment process with projects on the Sherwin Williams site and other, smaller infill projects throughout the city.

Many of the commercial redevelopment projects in Emeryville have included large surface parking lots. Some of the lots are also serving as impervious "caps" on contaminated sites to prevent stormwater from infiltrating through contaminated soils. The result, however, is that stormwater travels across paved surfaces, collects pollutants generated by cars, enters the stormsewer untreated and flows directly into the Bay. The next step in Emeryville's redevelopment is to incorporate innovative parking policies and programs and alternative stormwater management practices into future redevelopment projects.

4.1.5 Existing Infrastructure

Existing Roadways and Parking

Emeryville's existing street network consists of several street types: city boulevards, industrial streets, residential/buffer streets, and others. In addition, the East Shore and MacArthur freeways run through Emeryville's west and south sides.

Much of the city's paved, impervious surface can be attributed to the automobile. By reducing dependency on cars, Emeryville could find opportunities to reduce impervious surface coverage within the City on both public and private land. Less vehicular traffic would allow the narrowing of vehicle travel ways and/or the widening of the pedestrian realm of the street, which can be designed to include landscaped stormwater treatment facilities.

In addition to offering viable transportation alternatives (such as walking, biking, and transit) the City's new development should complement and support alternative transportation modes. New development should be compact, with a mix of uses, where people's everyday needs can be met without making car trips. The parking included with new residential and commercial development should also be compact.

5. INNOVATIVE PARKING SOLUTIONS

5.1 Introduction

This chapter is broken into two sections. The first section identifies innovative parking strategies to reduce and contain runoff. The second section introduces design solutions (often referred to as Best Management Practices – BMPs).

5.2 Parking Strategies to Reduce and Contain Runoff

This memorandum provides a "Toolbox" of potential parking strategies that might be considered within the City of Emeryville to guide parking provision in existing or new development. In some cases, these are strategies that are already in place in parts of the city, but could be strengthened or extended to additional neighborhoods. Others represent entirely new strategies.

All strategies focus on reducing the amount of impervious surface – and therefore environmental impact–that parking demands. This can be achieved in three ways:

- Reducing the demand for parking, meaning that fewer spaces need to be provided;
- Maximizing efficiency of parking utilization, through accommodating the same amount of demand with fewer spaces; and
- Implementing design solutions that reduce the amount of impervious surface per parking space.

5.2.1 Three Ways that Parking Strategies Improve Stormwater Quality

The following section lists several broad strategies that have been used successfully in cities and developments across the country and are appropriate for the City of Emeryville, as well.

Strategies to Reduce Demand for Parking (or match supply to demand)

Pricing Strategies

- Public Parking Pricing
- Parking Cash-out
- Unbundling Parking costs
- Parking Taxes

Transportation Demand Management (TDM) Measures

- Car-sharing
- Residential Transit Passes
- Employer TDM Programs

Changes to Parking Standards

- Parking Maximums
- Transferable Parking Entitlements
- Location- and Use-Specific Parking Standards
- Land Banking and Landscape Reserves

Strategies to Maximize Efficiency of Parking Utilization

- Strategies to encourage Shared Parking and address security and organizational barriers
- Financial Incentives
- In-Lieu Fees
- Parking Information and Guidance Systems

Strategies to Reduce Parking Surface Area for a Given Level of Supply

- Multi-level or stacked parking
- Design Controls

While all strategies bring their own distinct merits and are applicable to Emeryville, many have been implemented already and require only minor tweaking or the addition of other strategies to boost the programs. Therefore, this Toolbox concentrates on the strategies outlined in Section II: shared parking and strategies that support it. Given the current development patterns in Emeryville, these strategies, in conjunction with others in the Toolbox, have tremendous potential to maximize the efficiency of existing parking, thereby reducing impervious surface and improving the capacity for stormwater mitigation.

5.2.2 Strategies to Reduce Demand for Parking

Parking Pricing Strategies

Pricing Public Parking

Provide gates and fee collection facilities in off-street parking structures and meters on private streets.

Unbundling Parking Costs

Physically separating the cost of parking from the cost of housing or leasable space allows the buyer or tenant to choose how much parking they actually need and are willing to pay for.

Figure 5-1: City Car Share at MacArthur BART station, Oakland,CA

Transportation Demand Management Strategies

Car-Sharing

Car-sharing is a neighborhood-based, short-term vehicle rental service that makes cars available to people on a pay-per-use basis. Car-sharing dramatically reduces the need to own a vehicle, particularly a second or third car that is driven less than 10,000 miles per year.

Car-sharing services are provided in the San Francisco Bay Area by City CarShare (CCS). CCS entered the East Bay market for car-sharing over two years ago, and has several locations in Berkeley and Oakland, with pods at BART stations, residential developments and downtown locations. Developers in Emeryville could provide support for the expansion of car-sharing by incorporating car-share facilities and stations in development projects.

Car-sharing works best in dense, mixed-use neighborhoods where businesses tend to use the vehicles during the day and residents use them in the evenings and on weekends.

Residential Transit Passes

Transit passes are provided free of charge or at discounted rates to many employees in commercial developments in the Bay Area. This can be a requirement of development agreements, or implemented through voluntary TDM programs.

The same principle can also be extended to residential developments, whereby residents of a development are given free or subsidized transit passes on the local carrier (most likely AC Transit, potentially BART), in addition to access to transit and carpooling information. Or, as a cost-effective alternative, developers could contribute to Emery-Go-Round, Emeryville's local shuttle service.

At one residential development in Portland, OR, transit use increased from 30% of residents to 83% in one year after free residential transit passes were given to residents and a new light rail line opened. At a second Portland development, the program led to a 79% increase in transit use. In Boulder, CO, the residential transit pass program led to a 50% increase in transit ridership.

Figure 5-2: Residential transit passes may be used on AC Transit.

The City could reduce parking requirements for developments where residents are granted free transit passes. Alternatively, such a program could be required through development agreements.

Employer TDM Programs

Employer Transportation Demand Management Programs encompass a variety of elements to encourage employees to use alternatives to driving. Bicycle facilities might include:

- Secure parking for residents, students, and workers;
- On-street bicycle parking racks for guests;
- Showers and/or changing rooms for students and workers.

5.2.3 Maximizing Efficiency of Parking Supply

Shared Parking and Associated Strategies

Shared parking allows for the most efficient use of parking supply by serving different land uses that have different times of peak demand. For example, an office use with demand peaks during the day can share parking with restaurants, where demand is greatest during the evenings, and to some extent residential uses, where demand peaks are in the evenings, nights and on weekends. Shared parking allows the supply to be used more efficiently, since peaks in demand are smoothed out by the larger number of users.

Parking information and guidance systems

In virtually every community in the United States, there is a major gap between the perceived availability of parking, and the actual number of spaces that are available at any one time. Parking information and guidance systems help to address this gap, by directing motorists to locations where parking is available and thereby maximizing efficient use of the system.

Electronic signs, or “Real-Time Information,” strategically placed at key “gateways” to a project, indicate the number of spaces available in a parking facility or section of a facility at any given moment. The same information can be provided on the web, or relayed to cellphones or personal digital assistants.

Parking information and guidance systems work best for large, centralized, publicly operated shared parking facilities. They are more difficult or expensive to implement where parking resources are spread out in smaller lots or garages, or the participation of many different or competing operators is required.

5.2.4 Strategies to reduce parking surface area for a given level of supply

Structured or Vertical Parking

An efficient way to reduce parking’s contribution to stormwater runoff, if not reducing demand or traffic, is to reduce the physical amount of land devoted to parking. Vertical parking strategies, such as structured parking, parking lifts, movable parking systems, and stacked/valet parking are several such examples.

Figure 5-3: Parking lifts maximize the efficiency of parking facilities, resulting in less impervious surface area dedicated to parking.

Structured parking can be integrated with usable space in buildings that also house office or residential space, or include ground floor retail lining the street. Structured parking is an excellent way to facilitate shared parking strategies.

Parking Lifts and Valet Parking

Another effective way to "go vertical" is to provide parking lifts. These devices stack two to three cars via a mechanical lift for each surface space. They can be operated manually by residents or employees, or by a valet or parking attendant. Some tenants may be skeptical that the lifts are difficult to use or can be damaging to the car, but with the proper training on use for residents, or attendants for employer lifts, the strategy can be a practical option to double or triple the parking capacity given a set amount of land. Valet parking–where attendants park cars much closer and tighter in a given amount of parking space–can also be an effective way to maximize parking supply while minimizing impervious surface.

Structurally supported lawn can be used for peak or overflow retail parking spaces. Also, parking spaces located farthest from business entrances can be constructed on structurally supported lawn or planting areas. These types of surfaces can also be used on upper levels of garages as well as on the ground.

6. DESIGN SOLUTIONS FOR STORMWATER TREATMENT

The following sections provide detailed descriptions of potential stormwater design solutions. Due to Emeryville's unique context and variations in site-specific conditions, discussed in Chapter 4, all design solutions that involve infiltration should be equipped with under-drains connected to the storm sewer system. This measure is intended to reduce risk of groundwater contamination while allowing for stormwater treatment on site. Also, due to the increased awareness of West Nile Virus, a rare but potentially serious mosquito-borne illness, the elimination of potential mosquito breeding grounds has become a an important public health issue. To address concerns over this disease and other vector-control and public health issues associated with standing water, all of the stormwater design solutions presented in Chapter 6 should be designed and maintained to drain within 72 hours. The mosquito breeding and gestation period requires standing water conditions to persist longer than 72 hours. To reduce use of pesticides, pest resistant plants should be used.

Figure 6-1: Street trees not only provide numerous stormwater benefits but also improve the quality of the pedestrian environment.

6.1 Tree Preservation and Planting

Trees perform a variety of functions that reduce runoff volumes and improve water quality. Leaf canopies intercept and hold large quantities of rainwater on the leaf surface, preventing it from reaching the ground and becoming runoff. Root systems create voids in the soil that facilitate infiltration. Trees also absorb and transpire large quantities of ground water, making the soil less saturated, which allows more stormwater to infiltrate. Through the absorption process, trees remove pollutants from stormwater and stabilize them. Finally, tree canopies shade and cool paved areas.

The following characteristics will determine how effectively a tree performs the functions described above:

- Persistent foliage
- Canopy spread
- Longevity
- Growth rate
- Drought tolerance
- Tolerance to saturated soils
- Resistance to urban pollutants (both air and water borne)
- Tolerance to poor soils
- Root pattern and depth
- Bark texture
- Foliage texture
- Branching texture
- Canopy density

Soil volume, density, and compost, along with appropriate irrigation the first three years, are important to tree performance. Other aspects that have an influence on how street trees perform include resistance to exposure (wind, ice and heat) and resistance to disease and pest infestations.

6.1.1 New Development vs. Retrofit

During their construction phase, retrofit projects should provide protection to existing trees (including street trees) in accordance with the City's Urban Forestry Ordinance. On retrofit project sites with constrained planting space available for trees, engineered products such as root barriers and structural soils (see section 6.2 for detailed description of structural soils) can greatly increase the success rate and life span of new and existing trees.

Retrofit or new development projects with minimal constraints and no existing trees, should be planted with large trees with wide-spreading canopies. On retrofit or new development sites with overhead constraints, determine if small to medium trees and shrubs will work within the clearance. In cases where space or soil conditions are a limiting factor, small trees and shrubs may be incorporated into large containerized bio-retention gardens that receive and treat stormwater (see section 6-5 for more detail).

6.1.2 Maintenance

Most trees will generally require irrigation during their establishment period (usually up to two years after planting). Appropriate irrigation systems and watering regimes will depend on tree species and soil conditions. In addition, some species will require staking and/or pruning.

6.2 Structural Soils

Structural soils are an artificial growing medium that serve the multiple functions of encouraging root growth, satisfying pavement design and installation requirements, and increasing stormwater holding capacity.

The major challenges to tree growth within paved areas are the lack of sufficient space for tree root systems and poor soil conditions. Typically, soils located under pavement are highly compacted to meet load-bearing requirements and engineering standards. These conditions can stunt root growth, which further reduces the nutrients, oxygen and water available to the plant.

Structural soils are gap-graded gravels that consist of crushed stone, clay loam, and in some cases, a hydrogel stabilizing agent. This material can be compacted to satisfy pavement standards while still allowing roots to penetrate. The structural soil system creates a load-bearing matrix with voids filled with soil and air, essential for tree health. This allows for greater tree growth, better overall health of trees, and reduced uplifting of the pavement by tree roots. In addition, the voids that benefit the tree roots also provide increased stormwater storage capacity, allowing tree pits in paved areas to serve as a series of small detention basins.

Structural soils can add costs to a project due to additional excavation, drainage systems and the structural soil material itself. These costs are offset to some degree over the long term because of higher tree survival rates and reduced pavement maintenance costs.

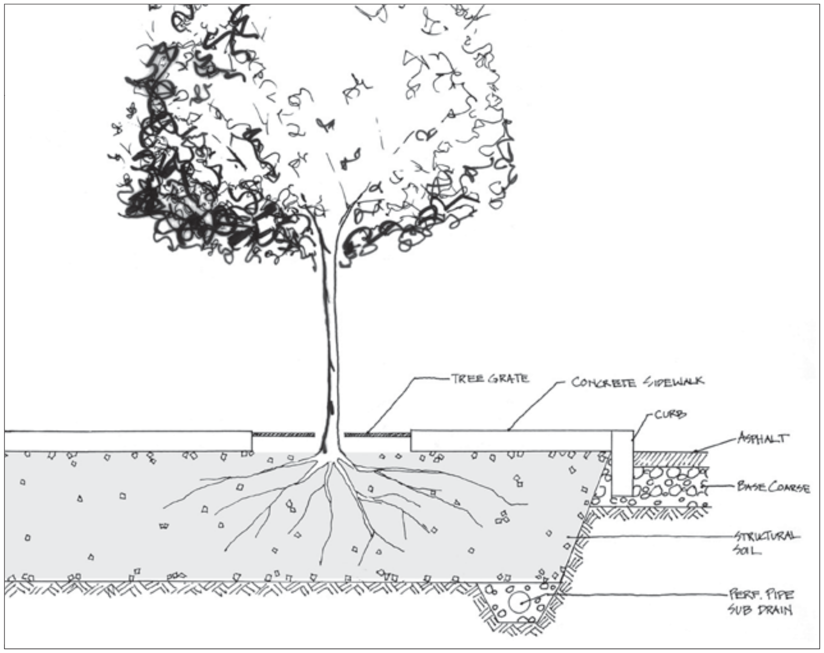


Figure 6-2: Structural soils can greatly improve the health of trees in urban settings. Their increased pore capacity is also an opportunity to retain more stormwater.

Figures 6-3: A local example of intensive green roofs include the roof-top gardens on the Oakland Museum.

6.2.1 New Development vs. Redevelopment

Structural soils can be installed at the time when trees are either first installed or replaced. Due to fact that these this process involves extensive excavation, it is easier to apply to sites that have either new construction or existing infrastructure replacement or repair.

6.3 Green Roofs

Green roofs serve a wide range of functions including stormwater runoff reduction. In urbanized areas where a large percentage of the ground is dedicated to buildings, green roofs have the potential to capture a large percentage of rainfall. By reducing the quantity of runoff that leaves a site, they attenuate peak stormwater flows, reducing frequency of sewer overflows and releases. In addition, green roofs can provide valuable green space for humans and habitat for wildlife, especially in highly urbanized areas that may otherwise lack these resources. Green roofs have also proven to reduce heating and cooling costs due to the additional insulation that they provide.

Figures 6-4: The Kaiser building, in downtown Oakland, illustrates how water storage and harvesting techniques may be used to irrigate intensive green roofs, increasing their stormwater benefit and reducing fresh water consumption.

In general, green roofs consist of a planted area integrated into the roof of a building. A green roof system requires a waterproof membrane to contain water and plant roots, a drainage system, filter cloth, a lightweight growing medium, and plants. Building air intake can be on the roof or on the sides of the building.

There are two types of green roofs: intensive and extensive. Extensive green roofs consist of a thin layer of planting medium and vegetation (6 inches or less). The planting layer can be in flats that can be lifted. These roofs usually are not intended or designed for people to access (other than construction and maintenance workers). In contrast, intensive green roofs require highly engineered structural components and much thicker layers of growing medium in order to support park-like landscapes, including trees, lawns, hardscape, etc. This type of roof can serve as a recreation space or garden area, either privately or publicly accessible. Because the two types of green roofs satisfy different goals and require different investments, the City's or developer's objectives for the green roof should determine its type and design.

Figures 6-5 and 6-6: Extensive green roofs can thrive in a Mediterranean climate. The Gap Headquarters Building, in San Bruno, CA (top) and the Ford building, in Irvine, CA (bottom).

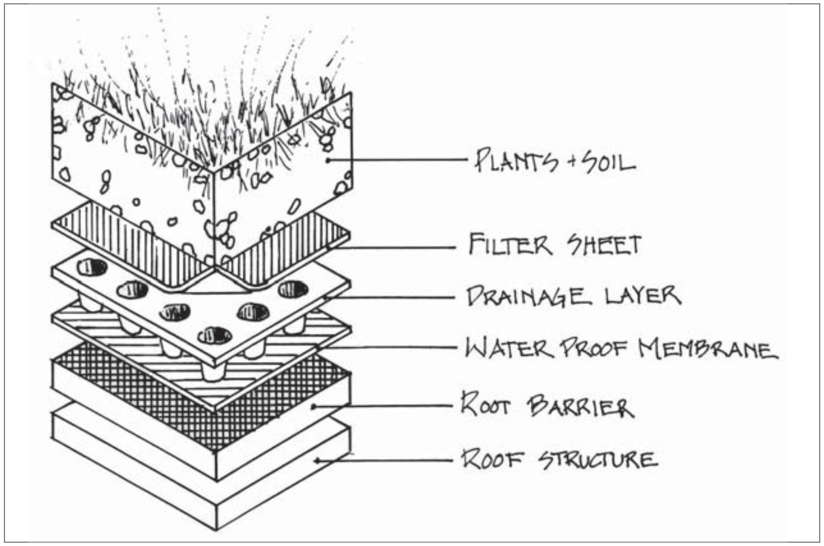


Figure 6-7: Extensive green roof technology incorporates water storage capacity and bio-retention capability.

6.3.1 New vs. Retrofit

Retrofitting an existing structure with a green roof is often (but not always) feasible. Prior to any roof retrofit project, a licensed structural engineer must determine whether the roof will be able to support the additional load. In some cases it may be possible to improve a structure by shoring up its load-bearing walls or the reinforcing the roof itself. This process can be quite expensive, however. In general, extensive green roofs are usually more suitable for retrofit situations because they have lower load and accessibility requirements than intensive green roofs.

Retrofit situations require that the roof have a small slope, rather than be totally flat. Green roofs typically work well with slopes between 5 and 20 degrees, which is steep enough to ensure proper drainage while still providing stormwater retention capacity. If the slope of the existing roof is less than 5 degrees, water will tend to pond. In order to compensate for flat roofs, the roof design may include an inclined layer of material to increase the slope. On roofs steeper than 20 degrees, a grid matrix is usually necessary to secure the growing medium and plants in place. This feature may also increase the project's cost.

6.3.2 Maintenance

Over the course of its lifetime, a green roof's maintenance demands can be minimized through proper installation and plant selection. During the first 6 months of the plant establishment period, however, maintenance is the key factor in determining the roof's success. Due to the restricted amount of growing medium and the extreme light, wind, and temperature conditions on most roofs, applying proper maintenance practices during this period is absolutely necessary to ensure that the plants fill-in and adequately cover and protect the roof's surface. Regular weeding by hand and weekly watering is usually necessary during the first 6 months after planting. Once the plants mature, maintenance schedules may include only biannual weeding, annual fertilizer application, and irrigation during droughts.

The level and type of maintenance necessary primarily depends on the types of plants selected. The plants need to be able to withstand the harsh conditions on the roof (sun, wind, temperature changes) and the shallow soil depths. Most plants on green roofs will tend to remain low-growing in these conditions but some groundcovers, such as sod, will require regular mowing and therefore should be avoided. Native succulents and wildflowers are often successful and attractive options for green roofs.

Irrigation is an important component of a green roof's maintenance. Although irrigation systems add cost, they are necessary in the short-term, during the plant establishment period, and in the long-term, in the case of droughts. Drip-line irrigation systems (embedded in the growing medium) are often an efficient means of delivering water directly to the root systems. Irrigation water for green roofs may be supplied or at least supplemented by rainwater harvesting systems.

Provided that proper construction and maintenance techniques are applied, a green roof will usually last 50 years or more. The plants, growing medium, and drainage substrate protect the roof's membrane from the elements, and the system as a whole prevents water from pooling on the roof's surface. This greatly increases the lifespan of the roof compared to conventional roofs, which usually last less than 30 years.

Figure 6-8: A containerized bio-retention garden provides bio-retention opportunities on constrained sites.

6.4 Bio-Retention

Bio-retention facilities are engineered stormwater solutions that mimic the natural hydrological cycle and rely on the biological and chemical processes that occur in nature to treat stormwater. Bio-retention facilities are designed to utilize soil, vegetation, hardscape elements and other materials to support and enhance the infiltration and bioremediation processes.

Bio-retention facilities include a variety of gardens and plantings (sometimes referred to as "rain gardens"), which may be planted in the ground or in containers, and artificial wetlands. Planters can be deep, treating considerable volumes of water in small areas. A bio-retention system usually consists of a splash pad to slow the velocity of runoff and a slightly depressed planting bed or container that allows shallow ponding of the stormwater (approximately 6 inches deep). The planting bed may incorporate swales, grass filter strips and/or sand filters to "pre-treat" the stormwater before it reaches the vegetation. The stored water in the bio-retention area slowly exfiltrates over a period of days into the storm sewer system or, if site conditions are favorable, into the underlying soils.

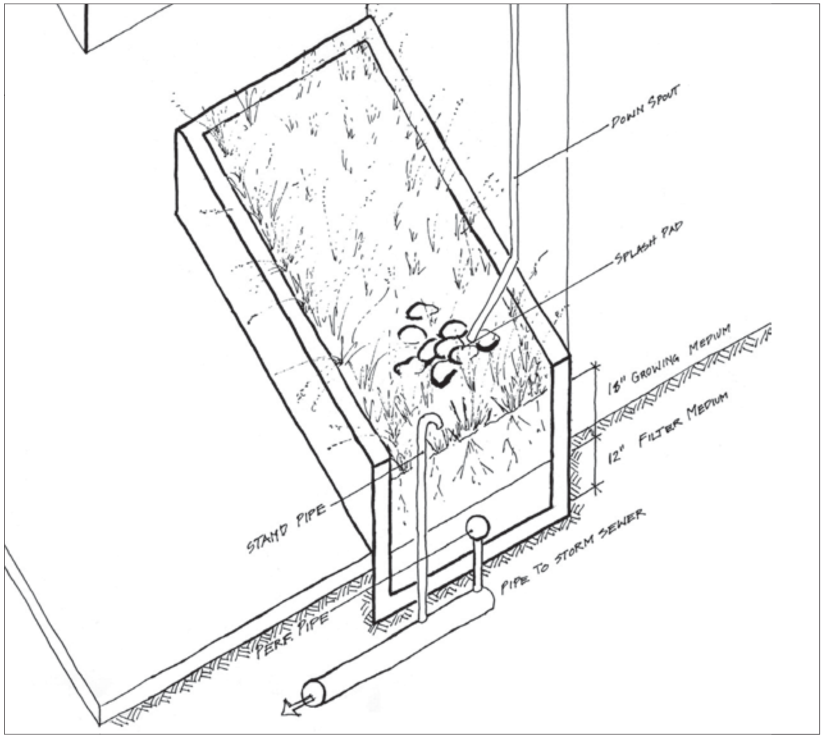


Figure 6-9: Bio-retention planters can be raised (as shown above) or at-grade to create containerized rain-gardens.

Because their basic components are water and naturalistic elements, bio-retention facilities have the potential to provide habitat and aesthetic value. Planting native plants, particularly native grasses and shrubs, can increase the effectiveness of the bio-retention facility.

The CASQA handbook refers to this solution as TC-32 Bioretention.

6.4.1 New Development vs. Retrofit

Containerized bio-retention gardens that release treated runoff into the sewer system may be appropriate on retrofit sites where space constraints, a high water table, and compacted or contaminated soils preclude the use of conventional bio-retention facilities. On these sites, planters should be designed to preserve the building's relationship to the street as much as possible.

6.4.2 Maintenance

Clogging of the bio-retention facility due to sedimentation will occur if the runoff entering the bio-retention facility contains high sediment content. Sand filters or sediment traps may be necessary to reduce the amount of sediment entering the planted area. To prevent clogging by construction debris, these facilities should be built last or runoff should be diverted around them until two months after construction is completed.

Maintenance levels greatly depend on plant selection. Although all plants will require careful maintenance and potentially irrigation during the plant establishment period, some perennial natives may require simple seasonal mowing once the plants mature.

6.5 Bio-filtration

Bio-filtration facilities include grass filter strips and vegetated swales, which filter runoff through soils and plant material to remove suspended sediments. The design solutions in this category differ from bio-retention facilities in that their primary purpose is usually to convey stormwater rather than to retain or store it. Often, bio-filtration facilities can be used to pre-treat runoff before it enters bio-retention facilities or infiltration basins/trenches, which require low sediment loads to prevent clogging. Grass filter strips are gently sloped grassy areas that are used to treat small quantities of sheet flow (0.5 inches deep) and they often are used to pre-treat runoff. Swales also rely on grassy vegetation to remove suspended sediments but, unlike filter strips, swales are channel-like and designed to accommodate a flow depth of up to 3 inches. If the underlying soil conditions preclude infiltration, the bio-filtration facility should also include an impervious liner, a pipe system to convey overflow to the storm sewer, and clean soils.

The length and slope of filter strips and swales determine their effectiveness, sizing and design. A linear swale should be approximately 200 to 250 feet in length in order to achieve an optimal 9-minute residence time. However, a swale's length can be flexible: shorter lengths can meet the minimal residence time of 5 minutes or provide effective treatment in areas with smaller discharges. A swale's longitudinal slope should be between 1 and 6 percent to allow maximum contact between water and vegetation and to prevent scouring and erosion. For slopes between 2

Figure 6-10: Swales in parking lots also buffer pedestrians from parked cars.

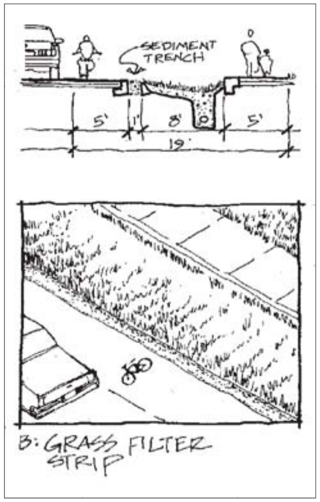


Figure 6-11: Grass filter strip

and 6 percent, features should be added to the swale to slow and spread the flow and increase residence time. Conventional check dams, curbs, trees or other landscape elements can be used to create this effect. Filter strips and swales function best when the water they treat is no more than 3 inches deep. The treatment area needs to be of adequate width to maintain these depths.

The CASQA handbook refers to these solutions as TC-10 Infiltration Trench and TC-11 Infiltration Basin.

6.5.1 New vs. Retrofit

Applications for bio-filtration in new development, redevelopment or retrofit projects in Emeryville may be limited by space constraints and soil conditions. In retrofit situations, in particular, existing underground utilities may also pose serious conflicts with bio-filtration facilities.

6.5.2 Maintenance

Maintenance plans for bio-filtration facilities should include yearly or twice yearly mowing, depending on plant types. Clippings and trimmings should usually be removed from the facility following mowing to prevent decaying material from resulting in nutrient loading. Irrigation and weeding by hand is usually necessary during the plant establishment period. Irrigation may also be necessary during drought periods, depending on plant types selected. If the infiltration facility fills with sediments, soil removal, regrading and replanting may be necessary.

6.6 Infiltration

Infiltration facilities can take a number of forms, including infiltration basins, trenches, sand filters, and French drains, all of which slow and filter runoff, thereby improving the water quality and reducing the volume of runoff leaving a site. In general, following treatment in an infiltration facility, stormwater may seep into the ground or enter a stormwater storage facility or a sewage system. However, due to Emeryville's unique context and variations in site-specific conditions, discussed in Chapter 4, all design solutions that involve infiltration should be equipped with under-drains connected to the storm sewer system. This measure is intended to reduce risk of groundwater contamination while allowing for stormwater treatment on site. It also helps to reduce flooding.

Infiltration systems often work in concert with bio-filtration facilities such as filter strips or swales, which direct stormwater from impervious surfaces into the infiltration facilities. In addition to conveying the stormwater to the infiltration facilities, swales and filter strips also treat the stormwater by removing sediments and some pollutants that could potentially clog the infiltration facility and inhibit the infiltration process.

To construct infiltration basins and trenches, the area is excavated, then back-filled with layers of coarse gravel, sand or other media to filter the runoff before it reaches the underlying soils or alternatively, a storage facility or sewer system.

Figure 6-12: This infiltration basin doubles as a traffic circle.

6.6.1 New Development vs. Redevelopment & Retrofit

Compacted soils, which are common on retrofit sites, can be problematic for infiltration systems. However, infiltration trenches and basins can be designed with larger reservoirs and some degree of exfiltration to compensate for compacted soils and/or permeable soils and under-drains can be added.

Because infiltration trenches can be both linear and narrow, they can be integrated into retrofit projects where soil and slope conditions are suitable. Existing underground utilities may complicate installation and drive up costs. Site designs for parking structures can also include infiltration facilities to collect and treat the garage's roof runoff.

6.6.2 Maintenance

Soil compaction and sedimentation, particularly during the construction phase of an infiltration system, can severely impair an infiltration facility's effectiveness. Once an infiltration facility becomes "clogged" with sediment, it can be difficult or impossible to restore. Maintenance should include regular inspections for and removal of leaf littler, trash, and debris. Installing the facility last or diverting stormwater around it until after construction can help prevent this problem.

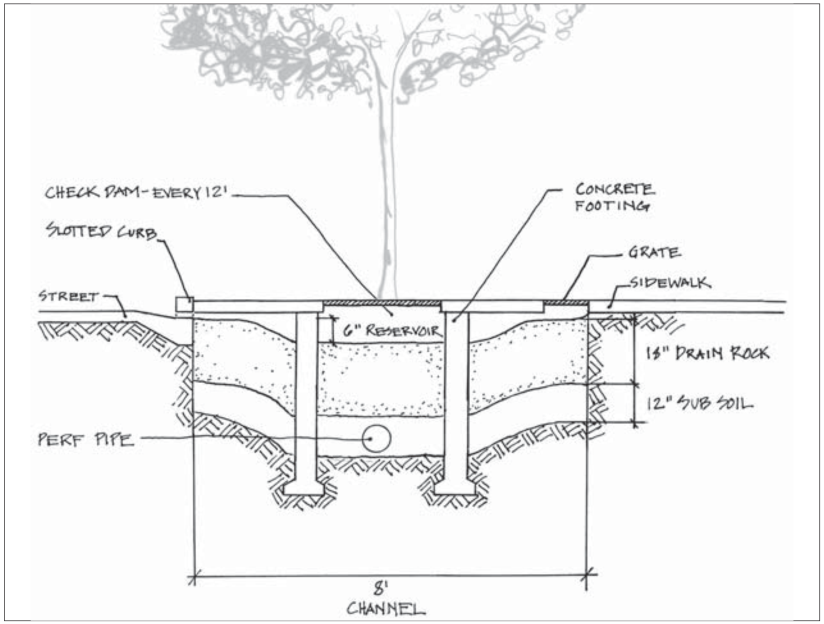


Figure 6-13: Infiltration capacity can be incorporated into the design of street tree trenches.

6.7 Permeable Paving

Permeable paving systems facilitate infiltration by allowing stormwater to soak through the voids in the pavement into an underlying basin that is filled with gravel, a layer of filter fabric, and a stone reservoir. These layers provide support for the pavement layer above and facilitate percolation into the subsoil or underdrain below. If properly installed and maintained, permeable paving can be applied to low-traffic areas such as streets, sidewalks, parking lots, recreation facilities, and pedestrian plazas to reduce runoff without limiting use or necessitating separate infiltration facilities.

The three primary types of permeable paving systems are: permeable paver block systems, pervious asphalt, and pervious concrete mixes. Permeable pavements are not suitable for all paved areas and may not be appropriate for some sites in Emeryville. Loose pavers such as cobbles should be fixed into position with a ridged edge and should comply with all applicable requirements and standards under the Americans with Disabilities Act (ADA).

Figure 6-14: Permeable pavers may be appropriate in low traffic areas such as parking stalls.

Permeable paving materials reduce runoff and lower the temperature of runoff. Permeable pavements, particularly paver systems, can incorporate aesthetically pleasing textures and patterns. They may be ineffective in areas with high volumes of traffic, their pores are easily clogged by sediment, and without proper under-drains, they may increase the potential for groundwater contamination. Therefore, it may be necessary to combine sediment control measures with permeable pavements to minimize the sediment load. High volumes of sediments will clog the pavement and compromise its ability to infiltrate stormwater.

The CASQA handbook refers to this solution as SD-20 Pervious Pavements.

6.7.1 New Development vs. Redevelopment

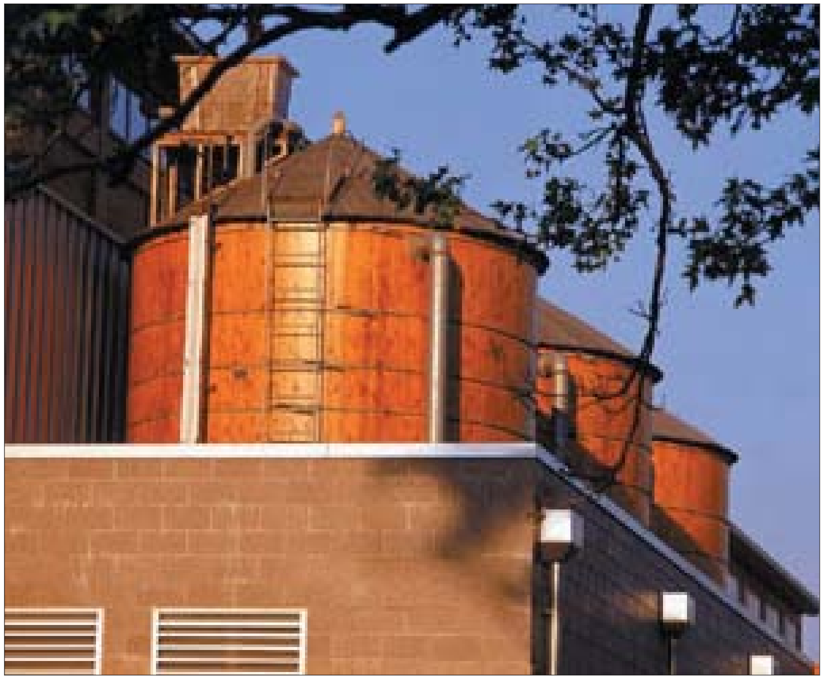
In retrofit situations soils are generally compacted; thus, permeable paving systems would need a gravel subbase/stone reservoir and under-drain. Permeable pavement can easily be integrated into new construction where soil, slope and traffic conditions are suitable.

Figure 6-15: Cisterns can serve as public amenities such as the water feature pictured above.

6.8 Water Storage

Water storage systems collect rainwater from impervious building surfaces (such as roofs) and store it so it may be released soon after a storm or utilized for irrigation and other non-potable uses. This technique treats stormwater, attenuates peak runoff flows, and may conserve potable water.

Rainwater storage systems connect to a building's gutters and downspouts and convey the water to storage vessels, such as rain barrels or above- or below-ground cisterns. In "metered detention and discharge," the collected stormwater is slowly released into the landscape beds in the hours following the storm at a rate that allows for better filtration and is less taxing to the overall community storm drain. This is not necessarily an irrigation strategy, as irrigation is not required in the Bay Area during the rainy season. It is possible, however, if the water is filtered and re-



Figures 6-16: Cisterns can also be incorporated into a building's architecture.

Figure 6-17: Decorated rain barrel for a residential building

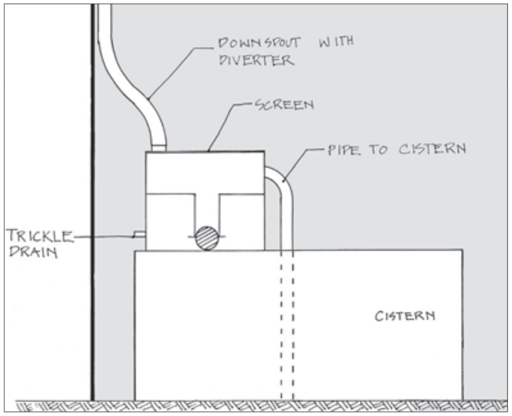


Figure 6-18: Roof washer devices separate the initial (and dirtiest) runoff and divert it away from the water storage facility.

pressurized, to distribute the collected stormwater through the irrigation system into landscape areas when other discharge points are not available. For rain water to serve as useful irrigation in the Bay Area, it would need to be stored until the dry season, requiring more storage capacity.

The CASQA handbook discusses these solutions as TC-12 Retention/ Irrigation, and as cisterns and rain barrels under SD-11 Roof Runoff Controls.

Water storage systems should include preventive measures for contamination and vector control. The initial rainfall of any storm often picks up the most contamination from dust, bird droppings and other particles that accumulate between rain events on the roof surface. A roof washer device separates the dirtier, early rainfall and diverts it so that it does not mix with the cleaner runoff that follows. A roof washer will, through a simple valve design, automatically divert the first 0.02 inches of rainfall per 24 hour period per square feet of roof area away from the rainwater harvesting storage tanks or cisterns. Roof washers should be installed in such a way that they will be easily accessible for regular maintenance. Also, water storage facilities should be equipped with covers, to reduce mosquito breeding risk.

Most roofing materials are compatible with rainwater storage and harvesting systems. However, rainwater should not be collected from roofs with redwood, cedar, or treated wood shingles or shakes, which may contaminate water and soil by leaching toxic materials when wet. In addition, food-producing gardens should not be watered with rainwater from roofs with asphalt shingles.

6.8.1 New Development vs. Retrofit

Retrofitting existing buildings with above ground planters and rain barrels is usually feasible. These storage facilities can be sized to accommodate roof runoff from a major storm event provided that enough space exists between the building edge and the property line. Below ground cisterns can be more difficult and more expensive to incorporate into a retrofit project because these facilities require substantial excavation and grading, which may not be feasible due to the high water table.

Designs for new development projects can incorporate extensive water storage and harvesting measures including underground cisterns. In addition, new buildings can be designed to store water within their walls and basements.

6.8.2 Maintenance

Maintenance plans for rainwater storage and harvesting facilities should include twice yearly inspections of the cisterns and rain barrels, in addition to their components and accessories, to determine if repair or replacement is necessary. Inspection and maintenance plans should cover the following items:

For Cisterns

- Roof catchment
- Gutters
- Roof washer and cleanout plug
- Cistern screen
- Cistern cover
- Cistern
- Cistern overflow pipe.
- Any accessories, such as the sediment trap, if needed

For Rain Barrels

- Roof catchment,
- Gutters and downspouts
- Entrance at rain barrel
- Rain barrel
- Runoff / overflow pipe
- Spigot
- Any accessories, such as rain diverter, soaker hose, linking kit, and additional guttering

Figure 6-19 and 6-20: Rain catchers and sun shades create visual interest and provide pedestrian amenities.

6.9 Other Devices

6.9.1 Rain Catchers

In some cases, site conditions or other factors may preclude the implementation of the numerous design solutions discussed so far in this chapter. For these projects, devices such as rain catchers should be considered as an option for intercepting stormwater before it reaches contaminated pavement surfaces. These structures can collect and direct rain water into cisterns for detention, infiltration, or reuse. In addition, rain catchers are a highly visible design component and can be used to add vertical elements and visual interest to a project.

New Development vs. Retrofit

The raincatchers may be particularly useful in retrofit situations where space and soil constraints may not permit tree planting, the development of bio-retention or bio-filtration facilities or even green roofs.

6.9.2 Sun Shades

Sunshades are an example of a relatively simple intervention whose primary purpose is to increase pedestrian comfort but also provide stormwater benefits by intercepting runoff. Sunshades can also be used to mount solar cells, which provide sustainable energy.

6.10 Putting it All Together: Site Design with Design Solutions

The following description and illustrations explain how to apply the individual parking Toolbox and stormwater design solutions described in Chapters 5 and 6 at the building and site scales. The parking and design solutions are intended to be used in combination with each other and, depending on the amount of runoff and available space, will likely prove most effective for water quality when integrated with each other and dispersed throughout a site. Generally, site designers can minimize impervious surface, especially connected impervious surface; include and consolidate open space; drain paved areas toward landscaping; include vegetated courtyards; design through, landscaped interior streets with 20-foot travel ways; limit width of residential driveways serving a small number of units to 18 feet if two-way and 9 feet if one-way; use two-track driveways with permeable paving and vegetated strips; cover equipment maintenance and cleaning areas; cover trash and recycling areas; and use native or pest resistant plants

Recent development projects located in Emeryville have typically employed similar design elements, such as fire access roads, deck gardens above podium parking, street trees, and recreational open spaces. Figures 6-19 and 6-20 illustrate how stormwater design solutions can be layered onto these “typical” Emeryville design elements. For example, cisterns can collect stormwater from parking structures, roof decks can provide vegetated areas for bio-retention and rainwater harvesting. Fire access lanes can utilize porous pavements; sidewalk bio-retention basins, filled with structural soils, promote street tree growth and provided water storage capacity. Shed roofs or other moderately sloped roofs can incorporate extensive green roof technology to dramatically reduce runoff.

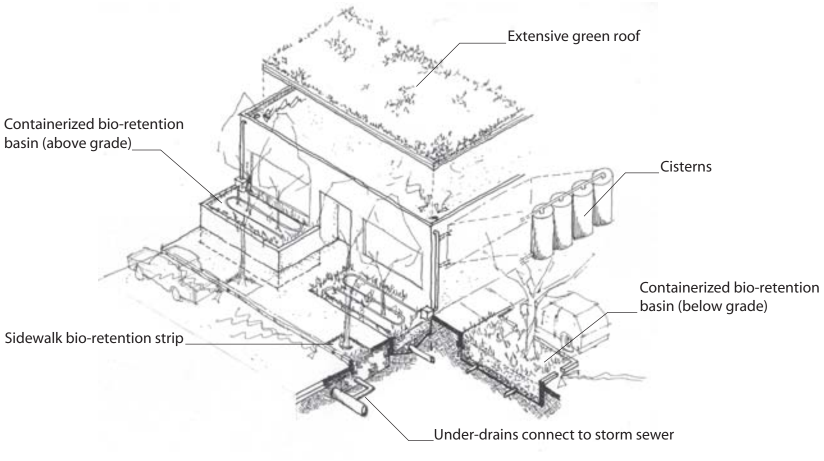


Figure 6-21: Multiple design solutions applied to the individual building scale.

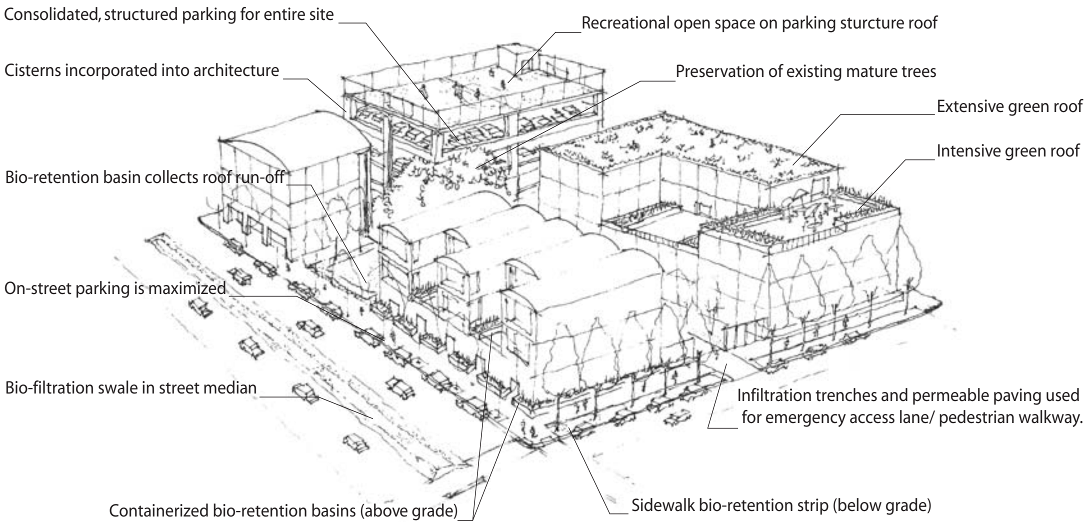


Figure 6-22: Design solutions applied to a redevelopment project at the block scale.

7. SELECTING AND SIZING STORMWATER SOLUTIONS

7.1 Overview of Design Solution Selection and Sizing Process

The following section provides guidance on effectively incorporating stormwater design solutions into the design process. The project designer can begin to consider which stormwater design solutions are most appropriate for the site and project early in the design development phase. The site design process and the selection and sizing of stormwater features are parallel processes that should overlap throughout the project's design. The selection and sizing of stormwater design solutions should not be viewed as an add-on or a band-aid applied after the fact to an otherwise completed site design. Incorporating stormwater design solutions into a development project should be viewed as an integral part of the design process - the site design should inform the stormwater design solutions and the stormwater solutions, in many respects, may inform the design of site elements. A conceptual site plan can be used to estimate a site's runoff volume. Designers appropriately select and size stormwater solutions when such data is effectively integrated with detailed site analysis including soil type and infiltration rates, slope, precipitation, soil contamination analysis, etc.

7.1.1 Site Analysis

Designers should become familiar with the conditions of the region, community, and site when selecting and sizing stormwater solutions. Collect Soil Analysis data including soil type, infiltration rates, and potential soil contamination based on historic and contemporary use. Other critical site analysis would include slope and orientation, annual average and extreme rainfall, existing vegetation or habitat zones worth incorporating into the design, and existing site stormwater flows. Where are the points on the site that receive inflowing, and discharge outflowing stormwater? What advantages do inherent site stormwater patterns yield to the overall function of the site plan and the general stormwater strategy?

7.1.2 Identify Pervious and Impervious Surfaces

Estimate what percentage of the site will be covered with roofs, parking lots, turf, hardscape, planting beds, and other surfaces. Early in the design phase the designer can begin to identify opportunities to reduce impervious areas in the site plan:

- Can parking spaces be reduced? Is a vertical parking structure possible? Can the building footprint be reduced?
- Is there an opportunity to install a green roof?
- Can turf areas be irrigated with captured rainwater? Or replaced with bio-retention gardens?
- Can pervious paving be incorporated into the paving plan?

7.1.3 Identify Appropriate Design Solutions

Once the designer has considered conditions specific to the site and community, and the pervious and impervious areas on the site plan have been established, appropriate design solutions (described in Chapter 6) can be incorporated into the site stormwater plan. Stormwater designs may be enhanced if the designer considers the following:

- Can design solutions be incorporated into site elements that are already typical for development in Emeryville such as: roof top gardens, fire access lanes, podium parking garages, etc.
- Can large shade trees be incorporated into the parking plan and in the landscape plan in general?
- Can stormwater from impervious areas on the site be directed to and filtered or infiltrated in lowered landscape beds, bio-swales, rain gardens, etc.?
- Are soils adequately protected from erosion?
- Do the landscape specifications call for a minimum of 2” of coarse mulch?
- Can rainwater from the roof be harvested and used for dry season irrigation and water features?

- Can site fixtures "rain catchers" be used to direct rainwater to catchment cisterns or ponds?
- Do the soil and planting amendment specifications prohibit synthesized chemicals and emphasize the use of compost and mulch?
- Do the maintenance specifications prohibit synthesized chemicals?

7.1.4 Siting Stormwater Design Solutions

Stormwater conveyance is ideally powered by gravity. When handling the stormwater from a parking lot or any other surface at grade it is recommended that the landscape areas and planting beds directly adjacent to the impervious surface be utilized for stormwater bio-filtration or infiltration. Street medians and parking planters are excellent candidates for bio-filtration beds. Stormwater can be directed into lowered bio-filtration beds with grading and by installing slotted curb or parking stops that allow stormwater to drain directly into landscape areas. Ideally, parking and street beds are well sized and evenly distributed throughout paved areas.

If stormwater must be conveyed from one source on the site to another zone on the property, every effort should be made to keep water flow rates slow and meandering. When stormwater is conveyed in pipes flow rates increase, filtration is negligible, and sediment and debris lead to system failure. Ideally stormwater can be conveyed in open trenches that model natural arroyos and seasonal percolation zones. The meander will help reduce flow rate, drop sediments, increase filtration, and reduce erosion. Plants and trees significantly enhance the filtration and transpiration qualities of the stormwater conveyance landscape feature. Cobble and gravel, at appropriate dimensions for flow rates, also help to improve filtration and prevent erosion.

When conveying water from a roof, however, gravity allows for stormwater to be discharged anywhere on site below the elevation of the roof gutter. Cisterns, ponds, and bio-swales therefore need not be located directly adjacent to roof sources. A closed pipe from the roof gutter will push water back up to a discharge point at the other end of the pipe at the same elevation. The key here is to allow for a drain at the low point in the pipe that is opened annually in the dry season. This drain can discharge into a simple gravel pit vault if it is subterranean.

When siting stormwater solutions, it is critical to consider the proposed site infrastructure and soil type. For instance, when the soil type is poorly drained and expansive, filtration strategies may be more appropriate than infiltration strategies in areas adjacent to infrastructure like building foundations or parking lots. Retention ponds may require lining systems when sited in well drained, large particle soil types.

7.1.5 Sizing the Design Solutions

Once the potential design solutions have been identified and located on the site, the designer is ready to calculate runoff volumes and size the stormwater design solutions accordingly. Accompanying these Guidelines is an Excel spreadsheet (available on CD or via the City's website) that calculates runoff volumes and the appropriate sizing of some of the stormwater design solutions presented in Chapter 6. The spreadsheet is intended to aid the designer during the initial stages of the design process, and can be used in two ways. First, the assumptions built into the tables can be used. The spreadsheet sizing parameters for the stormwater design solutions are consistent with the NPDES permit, which requires that development projects treat approximately 85 percent of annual rainfall, roughly equivalent to a 1-inch storm in the Bay Area. Alternatively, the designer can use the tables as a starting point, change dimensions as desired, and document those changes. Illustrations of the spreadsheet tables and a sample spreadsheet exercise are also included in this chapter.

How to use the Design Solution Sizing Spreadsheet

The process of sizing the stormwater design solutions requires at minimum a conceptual site plan. Read through the steps outlined and the example sizing exercise that follows. Identify impervious and pervious drainage areas, and select a stormwater design solution for each area. Use Tables 7-2 to 7-6 to match design solutions to drainage areas. Use Table 7-7 to "balance" design solutions and drainage areas until all drainage areas are accounted for. *Note: Blue cells indicate that the user should enter a value.*

Table 7-1: Drainage Parcels

Divide the entire site (including rooftops) in drainage parcels, each discharging into a single location.

For roof parcels, enter:

- The impervious area of roof
- The pervious area of roof garden, either intensive or extensive (extensive is typically approximately 6" of growing substrate)
- The volume of roof catchment cisterns (if applicable).

For land parcels, enter:

- The square footage of impervious area in the parcel.
- The square footage of pervious area in the parcel, using the column corresponding to the appropriate slope.

The maximum number of parcels this spreadsheet can accommodate is 9 for roof areas and 20 land areas.

Next, determine which design solution will be used for each parcel and use the appropriate spreadsheet to determine the design solution design size for each roof and land parcel.

Table 7-2: Metered Detention Design

- Enter the ID number for each parcel from Table 7-1 that will utilize Metered Detention Design in column 1. Enter roof parcel IDs in the format R1, R2, etc. in the top cells, and the site parcel IDs (in the format 1, 2, 3, etc.) in the lower cells. Do not add or remove rows. The table will automatically look up the water quality volume associated with the parcel (from Table 7-1).
- Enter the available area to receive stormwater discharge in column number 5. The table will calculate the minimum irrigation area required (assuming 0.1 in/hour soil permeability for 30 hours). The word "shortage" will appear at the end of the row if the entered area available for stormwater discharge is less than the required area.
- There is a quick calculator on this table to determine the number of gallons of stormwater an entered square footage of available landscape area can accomodate, and the reverse.

Table 7-3: Bio-Retention Basin Design

Bio-retention refers to the strategy of directing stormwater from impervious surfaces like roofs and parking lots into landscape areas specifically designed to retain, filter and sometimes infiltrate rainwater using soil, plants, bacteria and other biological means.

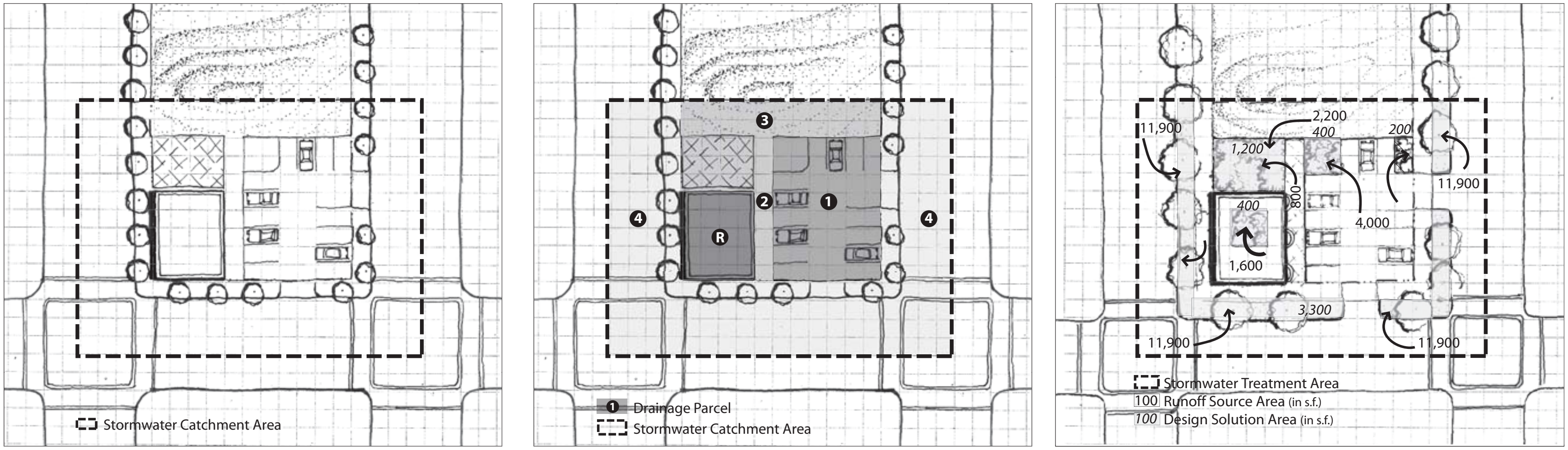
- Enter parcel ID number in column 1, as described above.
- Enter the area available to construct the bio-retention solution as width and length in columns 4 and 5, or as an area in column 6.
- The quick calculator will show the parcel area that a given bioretention area can accomodate.

Further design considerations for bio-retention are listed at the bottom of the table.

Table 7-4: Lowered Planter Strip Design

Lowered planter strips utilize the same principles as the above described bio-retention basin, however the landscape area in question is confined to the dimensions of the planter strip.

- Enter the ID number as described above.
- Enter the available length or area for a planter strip. The minimum width is set at 5' unless a new value is entered in the yellow "Enter Planter Width" box.
- Table 7-4 includes a quick calculator that tells the user how much can be treated for a given area, using the planter width as defined in the "planter width" box.
- Further design considerations are listed below the table.



Figures 7-1, 7-2, 7-3: The diagrams above illustrate the process of establishing a total drainage area for a site, dividing it into drainage parcels, calculating pervious and impervious area, and using these steps to determining runoff volumes using the worksheets provided in this section.

Table 7-5: Flow-Through Planter Box

A flow-through planter box is another form of bio-retention facility, confined to a planter box.

- Enter parcel ID number as described above.
- Enter the area of the planter box (inside dimension).
- See additional design considerations at the bottom of the spreadsheet.

Table 7-6: Bio-Filtration Swale

- Enter Parcel ID number in column 1, as described above.
- Enter the length, bottom width, side slopes and ground slope for the swale. Note: these entries must conform to the parameters indicated at the top of the column.
- Adjust design variables until:
    - Design flow is equal to or less than calculated Manning's flow.
    - Hydraulic residence time is greater than 9 minutes
    - All design parameters fall within acceptable limits.

Table 7-7: Stormwater Balancing Sheet

If there is not enough available area to accommodate the design solution for certain parcels within the site, the user can use Table 7-7: Parcel Balancing to redistribute the parcel areas among the four volume-based design solutions (metered detention, bio-retention, lowered planter strip, and planter box). To redistribute area to a flow-based design solution (biofiltration swale), use Table 7-1 to redefine parcel areas.

This worksheet tracks the total shortage for each parcel from all four volume based design solution design spreadsheets. It also tracks the extra area available from each design solution to treat additional water quality volumes.

To balance the water quality volumes among parcels:

- The TOTAL shortage for each parcel is listed in column 4.

- The EXTRA area that other parcels can accommodate is listed in column 6. To move area from a parcel with a shortage to an adjacent area with a surplus of available area:
    - First enter the destination parcel ID number in column 5 of the parcel row with a shortage.
    - Then enter the parcel area being transferred to an alternate parcel in column number 3 of the destination parcel row.
    - Continue to redistribute the areas until the sum of all the parcel shortages (column 4) is equal to the total areas redistributed (column 3).
    - The columns are summed at the bottom of the table.

7.2 Example Sizing Exercise

The following tables and images illustrate how the spreadsheets can be applied to actual sites. Figure 7-1 depicts an example project located on a roughly 0.6-acre site (each of the grid boxes represents 100 square feet). The site is surrounded by a sidewalk and road on three sides, and the project site boundaries extend beyond the property lines to include the adjacent sidewalks and roughly half of the area of the adjacent streets. The example project consists of three impervious surfaces that will generate runoff: one commercial building, a parking lot, and pathway. The undeveloped portion of the site is a steep hillside that will also generate some runoff due to its slope. The data entered in Tables 7-1 to 7-4 correspond with the area take-offs and water quality volumes for the example site.

By following the steps outlined above, several design solutions were identified and the site has been divided into 5 drainage parcels: one roof parcels and four ground parcels. The areas for each were calculated and entered into Table 7-1. The types of design solutions that were selected for this site include: a lowered planting strip, a green roof garden with cisterns, and bio-retention gardens. These design solutions were placed in close proximity to the runoff sources and then sized using Tables 7-1, 7-2, 7-3, and 7-4 which follow this discussion.

- The runoff from the roof will be stored in cisterns and used to irrigate the roof garden. The roof garden is 400 square feet total, sufficient to accommodate stored rainwater.
- The parking lot requires 160 square feet of bio-retention area, which can be provided through a 200 sf bio-retention cell located in the parking lot.
- The path will require 32 square feet of bio-retention area, which will be provided by the raingarden located adjacent to the building. The raingarden is 1200 square feet, which leaves 1197 square feet of unused capacity.
- The hillside will require 70 square feet of bio-retention capacity. Because the raingarden has extra capacity and is located downhill and adjacent to the hillside, it can also drain to the raingarden. Once the designer decides that there is sufficient capacity in the raingarden for the path and the hillside to “share” the design solution, the two areas could be combined into one drainage area, to simplify the table.
- The sidewalk will require 476 square feet of lowered planter strip.

Note: Table 7-5, used for sizing swales, is not needed for this exercise but is included in the set of worksheets.

Figure 7-3 illustrates one of many potential site designs which treat the stormwater generated by the development entirely on site. Table 7-7, which enables the designer to quickly check the runoff “balance “ for the site, indicates that not only is there adequate space for each of the design solutions, all but one has additional, surplus capacity that could be available to treat runoff from a neighboring property.

TABLE 7-1

Drainage Parcels

ROOF

ID#	ROOF Parcel Description	Impervious Area	Pervious Area (Extensive Rooftop Garden)	Total Area	Pervious Area (Intensive Rooftop Garden)[1]	Volume of Cistern Storage	Roof "C"	Water Quality Volume		Equivalent Impervious Area
		(feet^2)	*(feet^2)*	*(feet^2)*	*(feet^2)*	*(gallons)*		*(feet^3)*	*(gallons)*	*(feet^2)*
	C=	***0.85***	***0.4***							
R1	rooftop	1,600		**2,000**	400	650	*0.85*	0	0	*1,600*
R2				**0**			*0.00*	0	0	*0*
R3				**0**			*0.00*	0	0	*0*
R4				**0**			*0.00*	0	0	*0*
R5				**0**			*0.00*	0	0	*0*
R6				**0**			*0.00*	0	0	*0*
R7				**0**			*0.00*	0	0	*0*
R8				**0**			*0.00*	0	0	*0*
R9				**0**			*0.00*	0	0	*0*
		100%	*85%*							

TOTAL ROOF AREA **2,000**

[1] *Intensive rooftops (roof gardens) assumed to be self-mitigating; not included in WQ volume calc.*

[2] *Extensive rooftops (green roofs) assumed to include 6" of substrate*

SITE

ID#	LAND Parcel Description	Impervious Area	Pervious Area[2,3]			Total		Parcel "C"	Water Quality Volume		Equivalent Impervious Area
			Flat	Average	Steep						
		(feet^2)	*(feet^2)*	*(feet^2)*	*(feet^2)*	*(feet^2)*	*(acres)*		*(feet^3)*	*(gallons)*	*(feet^2)*
	C=	***0.85***	***0.25***	***0.33***	***0.37***						
1	parking	4,000				**4,000**	**0.09**	*0.85*	217	1,626	4,000
2	path	800				**800**	**0.02**	*0.85*	43	325	800
3	slope				2,200	**2,200**	**0.05**	*0.37*	51	384	1,760
4	streets and sidewalks	11,900				**11,900**	**0.27**	*0.85*	647	4,837	11,900
5						**0**	**0.00**	*0.00*	0	0	0
6						**0**	**0.00**	*0.00*	0	0	0
7						**0**	**0.00**	*0.00*	0	0	0
8						**0**	**0.00**	*0.00*	0	0	0
9						**0**	**0.00**	*0.00*	0	0	0
10						**0**	**0.00**	*0.00*	0	0	0
11						**0**	**0.00**	*0.00*	0	0	0
12						**0**	**0.00**	*0.00*	0	0	0
13						**0**	**0.00**	*0.00*	0	0	0
14						**0**	**0.00**	*0.00*	0	0	0
15						**0**	**0.00**	*0.00*	0	0	0
16						**0**	**0.00**	*0.00*	0	0	0
17						**0**	**0.00**	*0.00*	0	0	0
18						**0**	**0.00**	*0.00*	0	0	0
19						**0**	**0.00**	*0.00*	0	0	0
20						**0**	**0.00**	*0.00*	0	0	0
		100%	*70%*	*75%*	*80%*						

TOTAL SITE/ROOF AREA **20,900** sq.feet

NOTES

[2]

Pervious Area	Ground Slope
Flat	2% or Less
Average	2%-7%
Steep	Greater than 7%

Assuming Fair Condition of Pervious Surface (Grass cover on 50%-75% of total Area)

Source:Chow V., Maidment, D., Mays, L., Applied Hydrology, McGraw-Hill, Inc., 1988

[3] Pervious Areas includes grassy areas, areas paved with pervious pavers/pavement as well as other pervious surfaces (ie gravel, vegetated, etc.)

Equivalent impervious area is a percentage of pervious area (70-80% depending on slope)

Resources:

General References:
http://www.sanjoseca.gov/planning/stormwater/index.htm#6
(this site includes several links to other stormwater treatment resources on the web)
http://www.stormwatercenter.net/
(click on "Assorted Fact Sheets" link, and then browse the fact sheets on different Stormwater BMPs

California Stormwater Best Management Practice Handbook, January 2003
Camp Dresser & McKee, et al., California Stormwater Quality Association: Stormwater Best Management Pract
online at:
http://www.cabmphandbooks.com/Development.asp
(note, if above link will not open, go to : www.cabmphandbooks.com, and click on the picture link entitled "New

Portland Stormwater Management Manual, revision #3, September 2004
http://www.portlandonline.com/bes/index.cfm?c=35122

Hydrology Reference
Chow V., Maidment, D., Mays, L., Applied Hydrology, McGRaw-Hill, Inc., 1988

Greenroofs run-off coefficients
http://www.biw.kuleuven.be/lbh/lbnl/ecology/pdf-files/pdf-art/jeroen/procgreenroofs.pdf

TABLE 7-2

Metered Detention Design

Enter: Parcel ID (R1-9 for roofs, 1-20 for Land Parcels) and site area available for irrigation with stormwater

1	2		4	5				
Parcel ID#	**WQ Volume to be Stored (from Table1)**	**Equivalent Impervious Area**	**Minimum Irrigation Area Required**	**Irrigation Area Available On-Site**		**Facility Area Shortfall**	**Surplus Facility Area**	**Treatment Capacity (Contributing Area)***
ROOF	*(feet^3)*	*(feet^2)*	*(feet^2)*	*(feet^2)*		*(ft^2)*	*(ft^2)*	*(ft^2)*
r1	**87**	1600	348	**400**	OK	0	**52**	**1,839**
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
LAND AREA								
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
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	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0
	0	0	0		OK	0	0	0

* Treatment Capacity is the contributing pervious area (or equivalent

Quick Calculator

Enter Available Area for Irrigation: **400** sq. ft

You can use:

100 feet^3 **OR** *748* gallons

Enter gallons of cistern storage: gallons

You need irrigation area of: *0* sq ft

TABLE 7-3

Bioretention Basin Design

Enter: Parcel ID (R1-9 for roofs, 1-20 for Land Parcels) and available width and length -OR- area (square feet) available to construct the facility

1	2	3	4	5	6	7	8	9	10	11
Parcel ID#	Equivalent Impervious Area	Minimum Required Facility Area	Available Width (5ft min)	Available Length	-OR- enter available area	Available Area		Facility Area Shortfall	Surplus Facility Area	Treatment Capacity (Contributing Area)
ROOF	*(feet^2)*	*(feet^2)*	*(feet)*	*(feet)*	*(feet^2)*	*(feet^2)*		*(ft^2)*	*(ft^2)*	*(ft^2)*
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
LAND AREA										
1	**4,000**	160	5	0	200	200	OK	0	**40**	**5,000**
2	**800**	32	5	0	32	32	OK	0	0	**800**
3	**1,760**	70	5	0	1,197	1,197	OK	0	**1,127**	**29,925**
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0
	0	0	5	0		0	OK	0	0	0

Quick Calculator

Enter area of Bioretention facility ☐ square feet

You can treat runoff from:
0 square feet
of impervious (or equivalent imp.) area

- Minimum facility width is 5' (using parameters below)
- Minimum bottom width is 3'
- Line facility with at least 12" topsoil with minimum 5"/hour infiltration rate
- Maximum side slope is 2:1'
- Maximum ponding depth is 18"; minimum 6"
- Underdrains recommended due to high water table
- Provide overflow outlet to storm drain
- Do not install in locations with frequent pedestrian traffic
- Plant and irrigate

TABLE 7-4

Lowered Planter Strip Design *(Linear Feature)*

Enter: Parcel ID (R1–9 for roofs, 1–20 for Land Parcels) and available width and length –OR–
area (square feet) available to construct the facility

1	2	3	4	5	6	7	8	9	10	11
Parcel ID#	Equivalent Impervious Area	Minimum Required Facility Area	Available Width (5ft min)	Available Length	-OR- enter available area	Available Area		Facility Area Shortfall	Surplus Facility Area	Treatment Capacity (Contributing Area)
ROOF	*(feet^2)*	*(feet^2)*	*(feet)*	*(feet)*	*(feet^2)*	*(feet^2)*		*(ft^2)*	*(ft^2)*	*(ft^2)*
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
LAND AREA										
4	**11,900**	476	8	330		2,640	OK	0	**2,164**	**66,000**
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0
	0	0	5			0	OK	0	0	0

Quick Calculator

Enter area of lowered planter strip ☐ square feet

You can treat runoff from:
0 square feet
of impervious (or equivalent imp.) area

- **Minimum facility width is 5' (using parameters below)**
- **Minimum bottom width is 3'**
- **Line facility with at least 12" topsoil with minimum 5"/hour infiltration rate**
- **Maximum side slope is 2:1'**
- **Maximum ponding depth is 18"; minimum 6"**
- **Underdrains recommended due to high water table**
- **Provide overflow outlet to storm drain**
- **Do not install in locations with frequent pedestrian traffic**
- **Plant and irrigate**

TABLE 7-5

Flow-Through Planter Box Design *(Linear Feature)*

Enter: Parcel ID (R1-9 for roofs, 1-20 for Land Parcels), Design planter area (interior dimension)

1	2	4	6	7	8	9	10
Parcel ID#	Equivalent Impervious Area	Minimum Required Facility Area	Available Area on Site		Facility Area Shortfall	Surplus Facility Area	Treatment Capacity (Contributing Area)
ROOF	*(feet^2)*	*(feet^2)*	*(feet^2)*		*(ft^2)*	*(ft^2)*	*(ft^2)*
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
LAND AREA							
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0
	0	0		OK	0	0	0

Quick Calculator

square feet

Enter area (interior dimension) of planter box

You can treat runoff from:

0 square feet

of impervious (or equivalent imp.) area

- **Minimum planter box width is 18" (inside dimension)**
- **Minimum depth is 40" (between overflow and underdrain as outlined below)**
- **Underdrain and overflow outlet required**
- **Allow for 8" of ponding above topsoil**
- **18" topsoil with minimum 5"/hour infiltration rate required**
- **Pea gravel layer beneath topsoil (12" recommended)**
- **Plant and irrigate**

TABLE 7-6

Biofiltration Swale Design

Enter Parcel ID; enter facility design variables; check design flow<Mannings flow (column 6); check residence time >9 min (column 9)

1	2	3	4	5	6	7	8	9	10	11	12	13
Site Specific Information							Design Variables					
Parcel ID#	Parcel Area		Parcel "C" Value	Intensity	Design Flow	Manning's Flow (calculated)	Length	Bottom Width	Side Slopes	Ground Slope	Hydraulic residence time	Swale Area
	(feet^2)	*(acres)*		*(inches/hour)*	*(feet^3/sec)*	*(feet^3/sec)*	*(feet)*	*(feet)*	*(H:V)*	*(feet/feet)*	*(minutes)*	*(feet^2)*
					(<Mannings Flow)		**(MIN 100')**	**(2'-10')**	**(>3)**	**(0.01-0.025)**	**(MIN 9 minutes)**	**(depth = 1')**
ROOF												
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
LAND AREA												
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***
	0	*0.00*	**0.00**	*0.20*	*0.00*	*0.00*					*0.00*	***0***

TABLE 7-7

Parcel Balancing (Volume Based)

1	2	3	4	5	6		7	8	9	10	11	12	13	14	15
							TREATMENT AREA SHORTAGE					SURPLUS TREATMENT AREA			
Roof Parcels	Initial Treatment Area Requirement	Treatment Area from Adjacent Parcels	TOTAL SHORTAGE	PARCEL SHORTAGE MOVED TO	AVAILABLE EXCESS		Metered Detention	Infiltration/ Bioretention	Flow-Through Planter Box	Lowered Planter Strip		Metered Detention	Bio-retention	Flow-Through Planter Box	Lowered Planter Strip
	(feet^2)	(feet^2)	(feet^2)	parcel ID	(feet^2)		(ft^2)	(ft^2)	(ft^2)	(ft^2)		(ft^2)	(ft^2)	(ft^2)	(ft^2)
Roof Area							8	9	8	9		9	10	9	10
R1	0		0		52		0	0	0	0		52	0	0	0
R2	0		0		0		0	0	0	0		0	0	0	0
R3	0		0		0		0	0	0	0		0	0	0	0
R4	0		0		0		0	0	0	0		0	0	0	0
R5	0		0		0		0	0	0	0		0	0	0	0
R6	0		0		0		0	0	0	0		0	0	0	0
R7	0		0		0		0	0	0	0		0	0	0	0
R8	0		0		0		0	0	0	0		0	0	0	0
R9	0		0		0		0	0	0	0		0	0	0	0
Land Area															
1	0		0		40		0	0	0	0		0	40	0	0
2	0		0		0		0	0	0	0		0	0	0	0
3	0		0		1,127		0	0	0	0		0	1,127	0	0
4	0		0		2,164		0	0	0	0		0	0	0	2,164
5	0		0		0		0	0	0	0		0	0	0	0
6	0		0		0		0	0	0	0		0	0	0	0
7	0		0		0		0	0	0	0		0	0	0	0
8	0		0		0		0	0	0	0		0	0	0	0
9	0		0		0		0	0	0	0		0	0	0	0
10	0		0		0		0	0	0	0		0	0	0	0
11	0		0		0		0	0	0	0		0	0	0	0
12	0		0		0		0	0	0	0		0	0	0	0
13	0		0		0		0	0	0	0		0	0	0	0
14	0		0		0		0	0	0	0		0	0	0	0
15	0		0		0		0	0	0	0		0	0	0	0
16	0		0		0		0	0	0	0		0	0	0	0
17	0		0		0		0	0	0	0		0	0	0	0
18	0		0		0		0	0	0	0		0	0	0	0
19	0		0		0		0	0	0	0		0	0	0	0
20	0		0		0		0	0	0	0		0	0	0	0
	TOTAL	0	0		3,383		CHECK TOTALS -- Column 3 should be equal to or greater than 4, and less than 6								

8. CASE STUDIES

8.1 Buckman Heights and Buckman Terrace, Portland, OR

Location: 430 and 303 NE 16th Avenue, Portland, OR

Summary: These two projects represent an example of green, mixed use and mixed income developments. The buildings have been widely recognized locally and nationally, particularly for their transportation/land use strategies and stormwater management techniques.

Site Area: 2.8 acres

Units: 274

Density: 72 units per acre and 152 units per acre

Parking: 128

Design: Murase

Developer: Prendergast & Assoc.

Owner: Prendergast & Assoc.

General Contractor: Walsh Construction

Date Completed: 1998, 2000

Stormwater Benefits: Stormwater infrastructure includes: landscape infiltration, landscaped swales, permeable surfaces, stormwater planters, a 2,000 square foot green roof, and a back-up dry well. Native plants in landscaped areas reduce the need for irrigation. Rain sensors in irrigation system shut off irrigation when it isn't needed.

Parking Strategies: Bicycle facilities provide incentives not to use a car. Included in the facilities are the following: secure indoor bike storage for 90 bikes, a loaner bike, a bike repair work stand, tire pump, lockers, and the presence of bike lanes in the surrounding area. Another alternative to owning a car (and parking it) is the car sharing program offered by the development. When residents cannot get somewhere via the four high-frequency bus lines, light rail, bike lanes or pedestrian routes, they can call and reserve a car, enter a code to access it in the garage, and return it when finished (trip data is sent wirelessly to the service provider). The parking that is offered at the apartments is mostly under-building parking to reduce impervious surface coverage.

8.2 The Crossings, Mountain View, CA

Location: 2255 Showers Drive, Mountain View, CA

Summary: The Crossings is a mixed use, transit- and pedestrian-oriented community. The neighborhood provides a range of housing and retail opportunities, including single-family homes, townhouses, rowhouses, apartments, and retail. The narrow (27-foot wide) tree-lined streets allow for connectivity through a grid pattern, thus creating a walkable neighborhood with several small parks and playgrounds. Demand for housing in the Crossings has been high and the units have sold and re-sold quickly.

Site Area: 18 acres

Units: 397

Density: 22 units per acre

Parking: unknown

Design: Calthorpe Associates

Developer: TPG Development

Owner: Plymouth Group

General Contractor: unknown

Date Completed: 1999

Figure 8-1: Disconnected downspouts drain to planted bio-filtration strips.

Stormwater Benefits: Transportation-related pollutant reduction, disconnected downspouts drain into landscaping, turf block fire lanes, landscaped center of driving circles, reduced impervious surface area, reduced velocity of runoff, and reduced directly-connected impervious surface area (DCIA).

Parking Strategies: All parking for the apartments is located underneath the building footprint; the rowhouses have first floor garages; the close proximity of transit and neighborhood retail decreases parking demand at walker and rider destinations. According to a 2001 Caltrain survey, over 60% of all passengers access the Crossings-San Antonio Caltrain Station by walking or biking.

8.3 Agilent, Palo Alto, CA

Location: 395 Page Mill Road, Palo Alto, CA

Summary: The corporate headquarters facility for Agilent Technologies in Palo Alto, California employs numerous green stormwater features and promotes alternative forms of transportation to reduce parking demand. According to Agilent maintenance staff, the efforts and costs of maintenance are comparable to that for typical landscaping. In addition to their environmental benefits, features like the detention basin provide visual amenities for employees and a visual buffer for the neighboring residential community.


Figure 8-2: A cobble "swale" at Agilent

Site Area: 10 acres

Total SF: 215,000

Density: 0.49 FAR

Parking: unknown

Design: DES Architects

Developer: unknown

Owner: Agilent

General Contractor: unknown

Date Completed: unknown

Stormwater Benefits: A detention basin with native vegetation along banks, a parking lot with vegetated swales, roof downspouts draining to landscaping, it promotes alternative transportation by providing bike racks and lockers, an onsite bus stop, and carpool/vanpool parking, and it has a two level structure parking that drains to a rock filter bed.

Parking Strategies: Agilent's strategy to reduce parking demand focuses on the promotion of alternative transportation. The company provides bike racks and showers to encourage employees to bike to work, and additional bike lockers and a bus stop are located at the Page Mill Road entrance. Agilent also encourages employees to carpool by providing designated car/van pool areas.

8.4 Google, Mountain View, CA

Location: 1600 Amphitheatre Parkway, Mountain View

Summary: This public/private venture with the City of Mountain View resulted in 500,000 square feet of research and development and administrative space for Google's corporate headquarters. The entire ground level of the complex, including landscaped areas, is built above an underground parking lot


Figure 8-3: Google's green roof deck over parking.

Site Area: 29.5 acres

Total SF: 500,000

Density: 0.53 FAR

Parking: 1,735

Design: Studios Architecture

Developer: unknown

Owner: Google

General Contractor: Devcon

Date Completed: 2004

Stormwater Benefits: Green roof, permeable paving, native vegetation, natural treatment of runoff, transportation related pollution reduction, reduced velocity of runoff, and reduced impervious surface area.

Parking Strategies: Underground parking lot and bike racks to promote bicycle commuting.

9. APPENDICES

Glossary of Terms

Base Flow – The portion of stream flow that is not runoff and results from seepage of water from the ground into a channel over time. The primary source of running water in a stream during dry weather.

Best Management Practice (BMP), **nonstructural** – Strategies implemented to control stormwater runoff that focus on pollution prevention, such as alternative site design, education, and good housekeeping measures.

Best Management Practice (BMP), **structural** – Engineered devices implemented to control, treat, or prevent stormwater runoff.

Bio-filtration – The use of vegetation such as grasses and wetland plants to filter and treat stormwater runoff as it is conveyed through an open channel or swale, or collects in an infiltration basin (see **Bio-retention**).

Biological Diversity – The concept of multiple species or organisms living together in balance with their environment and each other.

Bio-retention – The use of vegetation in retention areas designed to allow infiltration of runoff into the ground. The plants provide additional pollutant removal and filtering functions.

Detention - The storage and slow release of stormwater following a precipitation event by means of an excavated pond, enclosed depression, or tank. Detention is used for both pollutant removal, stormwater storage, and peak flow reduction. Both wet and dry detention methods can be applied.

Evapotranspiration - The loss of water to the atmosphere through the combined processes of evaporation and transpiration, the process by which plants release water they have absorbed into the atmosphere.

Filter Strip - Grassed strips situated along roads or parking areas that remove pollutants from runoff as it passes through, allowing some infiltration, and reductions of velocity.

Floodplain - Can be either a natural feature or statistically derived area adjacent to a stream or river where water from the stream or river overflows its banks at some frequency during extreme storm events.

Green Roof - A contained space over a building that is covered, partially or entirely, with living plants.

Groundwater - Water that flows below the ground surface through saturated soil, glacial deposits, or rock.

Hydrology - The science addressing the properties, distribution, and circulation of water across the landscape, through the ground, and in the atmosphere.

Impervious surface - A surface that cannot be penetrated by water such as pavement, rock, or a rooftop and thereby prevents infiltration and generates runoff.

Imperviousness - The percentage of impervious cover within a defined area.

Infiltration - The process or rate at which water percolates from the land surface into the ground. Infiltration is also a general category of BMP designed to collect runoff and allow it to flow through the ground for treatment.

Metered Detention and Discharge - A system where stormwater is collected in a cistern pond and then slowly released into the landscape beds or the storm drain in the following hours at the rate that allows for better filtration and is less taxing to the overall community storm drain.

National Pollutant Discharge Elimination System (NPDES) - A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the EPA, a state, or (where delegated) a tribal government or and Indian reservation.

Outfall - The point of discharge from a river, pipe, drain, etc. to a receiving body of water.

Peak discharge - The greatest volume of stream flow occurring during a storm event.

Polluted runoff - Rainwater or snowmelt that picks up pollutants and sediments as it runs off roads, highways, parking lots, lawns, agricultural lands, logging areas, mining sites, septic systems, and other land-use activities that can generate pollutants.

Porous pavement and pavers - Alternatives to conventional asphalt that utilize a variety of porous media, often supported by a structural matrix, concrete grid, or modular pavement, which allow water to percolate though to a sub-base for gradual infiltration.

Retrofit - The creation or modification of a stormwater management practice, usually in a developed area, that improves or combines treatment with existing stormwater infrastructure.

Runoff - Water from rainfall, snowmelt, or otherwise discharged that flows across the ground surface instead of infiltrating the ground.

Sanitary sewer system - Underground pipes that carry only domestic or industrial wastewater to a sewage treatment plant or receiving water.

Sedimentation - A solid-liquid separation process utilizing gravitational settling to remove soil or rock particles from the water column.

Siltation - A solid-liquid separation process utilizing gravitational settling to remove fine-grained soil or rock particles from the water column.

Storm sewer system - A system of pipes and channels that carry stormwater runoff from the surfaces of building, paved surfaces, and the land to discharge areas.

Stormwater - Water derived from a storm event or conveyed through a storm sewer system.

Surface water - Water that flows across the land surface, in channels, or is contained in depressions on the land surface (e.g. runoff, ponds, lakes, rivers, and streams).

Swale - A natural or human-made open depression or wide, shallow ditch that intermittently contains or conveys runoff. Swales can be equipped with an underdrain or other man-made drainage device. and can be used as a BMP to detain and filter runoff.

Urban runoff - Runoff derived from urban or suburban land-uses that is distinguished from agricultural or industrial runoff sources.

Water (hydrologic) cycle - The flow and distribution of water from the sky, to the Earth's surface, through various routes on or in the Earth, and back to the atmosphere. The main components are precipitation, infiltration, surface runoff, evapotranspiration, channel and depression storage, and groundwater.

Water table – The level underground below which the ground is wholly saturated with water.

Watershed - The land area, or catchment, that contributes water to a specific waterbody. All the rain or snow that falls within this area flows to the waterbodies as surface runoff, in tributary streams, or as groundwater.

Acronyms

BMP - Best Management Practice

CCS - City Car Share

CEQA - California Environmental Quality Act

EPA - United States Environmental Protection Agency

MS4 - Municipal Separate Storm Sewer System

NEPA - National Enviornmental Policy Act

NPDES - National Pollutant Discharge Elimination System

NRDC - Natural Resources Defense Council

TDM - Transportation Demand Management

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