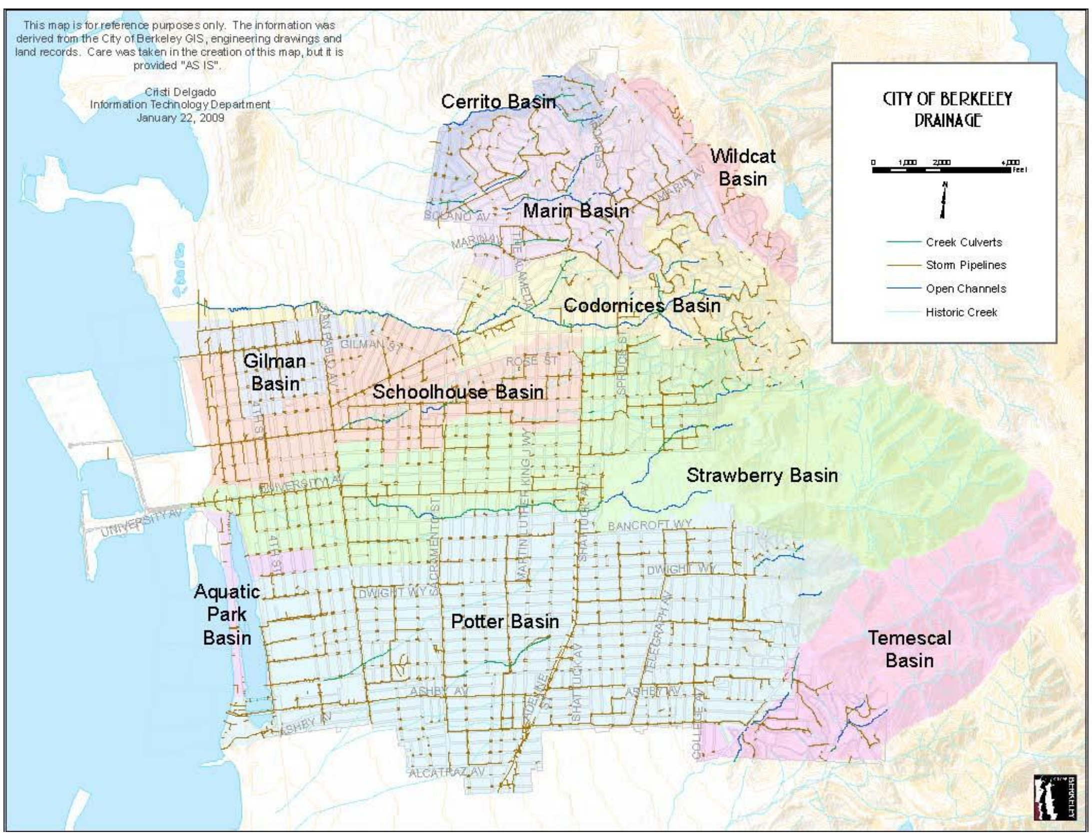
CITY OF BERKELEY

2011 WATERSHED MANAGEMENT PLAN



Public Works Engineering

Version 1.0 October 2011

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EXECUTIVE SUMMARY

The Watershed Management Plan (WMP) presents an integrated and sustainable strategy for managing urban water resources. It is meant to guide future City efforts in promoting a healthier balance between the urban environment and the natural ecosystem. The document is arranged by various topic areas, providing an overview of current City activities and making recommendations for improvements. The WMP should be considered a document that will evolve over time as new information is gathered and analyzed, technologies advance, and regulatory requirements change.

Berkeley is a densely built-out city, comprised of 11 watersheds wholly or partial within City limits. All watersheds in Berkeley eventually drain to the San Francisco Bay, which is an important economic engine and an internationally recognized natural resource. Each watershed is unique with various mixtures of: land uses, demographic communities, and remaining aquatic and wildlife habitats. Chapter 2 provides an overview of watershed characteristics as well as common issues associated with urban settings. These issues include high rates and volumes of stormwater runoff (flooding), stormwater pollution, and degradation of creeks.

The WMP looks at addressing water quality, flooding, and the preservation of creeks and habitats using multi-objective approaches where possible. This entails supplementing the existing engineered storm drain infrastructure with greener approaches that mimic natural hydrologic processes including filtration and infiltration by soils and plants. Chapter 3, discusses various green retrofit measures appropriate for the public right-of-way as well as for public and private property. These green approaches also provide opportunities for the collection and non-potable re-use of stormwater. Additional discussion of water quality programs and recommendations are provided in Chapter 4.

There are an estimated 8 miles of open creeks in the City. Only 7% of this is on public lands, the remainder flows through private properties. There are about 6.5 miles of creek culverts, with about 60% on public property. There is little data available on the physical conditions of both creeks and creek culverts, thus one of the primary recommendations is for additional information gathering. Further discussion of the benefits, functions and associated habitats of creeks is provided in Chapter 5, which also articulates the City's regulatory roles and the distinction between creek culverts and storm drainpipes.

There are about 93 miles of storm drain pipelines under the public right-of-way throughout the City, much of which is nearing or past its design life expectancy. Chapter 6 discusses the public storm drain pipe infrastructure and how the City approaches its management. Additional information gathering is needed to assess the physical conditions and hydraulic capacities of these facilities. Maintenance programs are further discussed in Chapter 7.

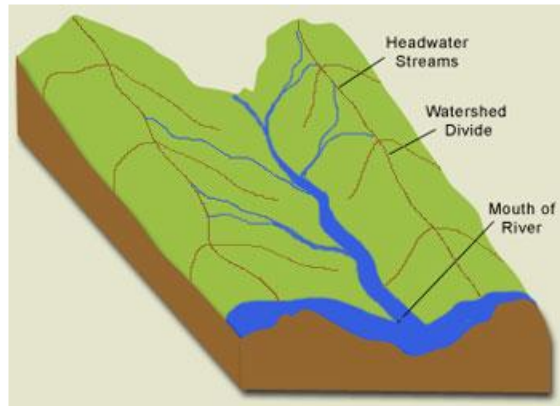
For WMP development, City Council approved funding for the hydraulic modeling of the Potter and Codornices Watersheds (Chapter 8). These two watersheds represent the full range of the drainage spectrum in Berkeley. The Codornices Watershed is drained by one of the most open creeks remaining in the East Bay, while the Potter Watershed (the largest in the City) is drained exclusively by storm drain pipes. The modeling results were used to develop Capital Improvement recommendations for both watersheds. These recommendations call for an innovative combination of conventional measures (such as pipe enlargement) and green right-of-way retrofits to treat, slow, and potentially re-use stormwater. These measures, called Green Infrastructure, include right-of-way landscaping, underground temporary storage piping, permeable surfacing, and trash capture devices.

Implementing WMP recommendations will require coordination among City Departments; participation and support from the public; partnerships with stakeholders; gathering and analyses of information; and financial resources. Chapter 9 provides four funding scenarios with a corresponding level of WMP implementation associated for each.

CHAPTER 1: WMP OVERVIEW

INTRODUCTION

Simply stated, a “Watershed” is the area of land that drains into a common waterbody, such as a creek or the San Francisco Bay. A watershed can be thought of as a large bathtub: when a drop of water hits anywhere in the tub, it eventually finds its way to the drain (the lowest point). In this instance, the bathtub rim defines the watershed boundary. On land, a watershed boundary is determined by topography—ridgelines or high elevation points—rather than by political jurisdictions. A watershed includes surface water bodies (e. g., streams, rivers, lakes, reservoirs, wetlands, and estuaries), groundwater (e.g., aquifers and groundwater basins), and the surrounding landscape.



A single watershed often encompasses a wide variety of land uses, business types, demographics, and natural resources in a densely, urbanized environment such as Berkeley. These components can all influence watershed function, due to cumulative effects on hydrology, water quality, and ecosystem health. In 2008, on the recommendation of the temporary Creeks Task Force[1], the City Council authorized the creation of the Watershed Resources Specialist position within the Public Works Department’s Engineering Division to assist in the creation of a watershed plan.

A Watershed Management Plan (WMP) is a strategy that provides assessment and management information for a geographically defined watershed, including the analyses, actions, participants, and resources related to developing and implementing the plan. The key components of watershed planning are:

- Definition of management goals.
- Characterization of existing conditions.
- Development of protection and remediation strategies.
- Implementation of selected actions (adapted over time as necessary).

The WMP offers guidance for enhancing the City’s efforts to manage watershed resources within the public right-of-way and on public property. It also provides a platform from which to encourage other watershed stakeholders (residents, property-

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[1] The Creeks Task Force was established by City Council in November 2004 and sunset in May 2006. It was tasked with recommending revisions to the Berkeley Municipal Code 17.08, Preservation and Restoration of Natural Water Courses.

owners, businesses, developers, local public agencies, non-governmental organizations, etc.) to participate.

MISSION & INTENDED USE OF WMP

The mission of the Watershed Management Plan (WMP) is to promote a healthier balance between the urban environment and the natural ecosystem, including the San Francisco Bay. The WMP serves to guide the development, enhancement, and implementation of actions to achieve the following goals and objectives:

WMP GOALS	OBJECTIVES
Protect Water Quality	• Improve pollutant removal operations within City right-of-way. • Reduce sources of non-point-source pollution. • Raise public consciousness about water resources and pollution prevention. • Collect/analyze data to better understand issues and plan accordingly.
Reduce Urban Flooding	• Maintain and operate appropriately sized storm drain pipe infrastructure. • Reduce peak runoff volumes and velocities. • Keep stormwater inlets free of obstructions. • Collect/analyze data to better understand issues and plan accordingly.
Preserve Natural Waterways and Habitat	• Preserve /enhance natural riparian spaces. • Increase habitat connectivity. • Collect/analyze data to better understand issues and plan accordingly.
Re-Use Rainwater as Resource	• Reduce use of potable water for non-potable uses. • Reduce peak runoff volumes and velocities. • Encourage public awareness and participation.

Implementing the WMP will require on-going inter-departmental coordination within the City government as well as participation and support from the wider stakeholder community. It will also need adequate funding to plan, implement, and maintain recommended capital improvements and programs.

The WMP is a document that will continue to evolve. The City recognizes that technologies are constantly changing and improving and new information is continually being gathered and analyzed. The WMP should be considered a guide for improving watershed function and health, rather than as a strict plan.

WMP DEVELOPMENT PROCESS

The WMP consolidates and builds on existing City activities. The City of Berkeley has long engaged in on-going planning and actions in several distinct areas with watershed implications. These activities include, among others, stormwater quality management, flood management, creek protection, and land use planning. The City has incorporated these interrelated components into a holistic watershed context. The WMP does this, while adding a new element that promotes the harvesting of rain water as a resource for non-potable re-use.

In developing the WMP, staff reviewed existing City policies, programs, plans, and infrastructure inventories to identify opportunities for improvements, efficiencies, and coordination. Most of these City plans and policies are further described within the relevant chapters WMP. Appendix A provides a consolidated summary of many of these plans and policies, emphasizing each one's respective nexus to the WMP.

Sophisticated computer modeling was used on two watersheds (Potter and Codornices) in the City to: 1) identify existing condition drainage capacities and constraints, and 2) determine the feasibility of both traditional and innovative approaches to resolving these issues. The results of this effort are provided in Chapter 8, which includes prioritized lists of recommended capital improvements for these specific watersheds.

Stakeholder Process

The on-going engagement of a wide spectrum of stakeholders will be fundamental to the WMP process. Policies and programs recommended by the WMP potentially affect internal City departments, as well as the broader community. This community includes: other local, regional, and state public agencies and special districts (i.e. Berkeley Unified School District [BUSD], East Bay Regional Parks District [EBRPD], the University of California [UCB], adjacent municipalities, Caltrans, and the Union Pacific Railroad [UPRR]); land developers, designers, and contractors; merchant associations and business owners; non-governmental organizations with environmental, social, and economic missions; and property-owners and residents.

The primary avenues for WMP communication will be City interdepartmental meetings, public community meetings, stakeholder group meetings, and a dedicated WMP webpage on the City's website: www.cityofberkeley.info/WatershedResources.

RECOMMENDATIONS FOR STAKEHOLDER PARTICIPATION

The following activities are recommended initial steps in promoting stakeholder awareness of, support for, and partnerships of the WMP.

1.1 Inter-Departmental Coordination: Conduct on-going inter-departmental coordination of priorities and recommendations to pursue opportunities for joint pilot programs and projects.

1.2 WMP Public Meetings & Presentations: Conduct public meetings and make presentations over the next year to various City Commissions and Council.

1.3 WMP Website: Use electronic media (such as the Watershed Resources webpage on the City's website) and other means to keep public and any interested parties informed of upcoming meetings, volunteer opportunities, and the latest version of the WMP.

1.4 Potter and Codornices Watersheds – Public Meetings: Conduct watershed-specific public meetings in the Potter and the Codornices Watersheds to discuss and refine watershed-specific goals and priorities.

1.5 Partnership Opportunities: Identify partnerships opportunities with institutional/agency stakeholder groups (i.e. UCB, and BUSD) to develop mutually beneficial projects and agreements,

1.6 Other Watersheds – Goals/Modeling/Priorities: As funding becomes available for the hydraulic modeling of each remaining watershed and after completion of the modeling for each, conduct watershed-specific public meetings within the modeled watershed to discuss and refine watershed-specific goals and priorities.

CHAPTER 2: WATERSHED CONDITIONS

Watershed management and planning begins with a basic understanding of the physical setting, landforms, and the key processes that shape the land. This understanding of a watershed's governing forces is important when considering future opportunities and projects, and when identifying appropriate approaches for particular locations. This chapter presents a general overview of the City's physical setting, climate, and watershed conditions. It also briefly describes basic hydrology, geomorphology, and the impacts of urbanization to watershed resources.

PHYSICAL SETTING

The City of Berkeley, approximately 10.5 sq miles, is located on the eastern shoreline of the San Francisco Bay (Bay) and extends east to the ridgelines of the East Bay Hills. In general, the physiography of the Berkeley watersheds reflects their general position or alignment in relation to the primary geologic structures. The watersheds in Berkeley typically drain to the west out of the steeper headwaters (Berkeley Hills, with a maximum elevation of approximately 1,770 ft at Chaparral Peak), across a transitional alluvial fan zone, and then across the more gently sloping Bay plain before discharging into the Bay (approximately at sea-level). One exception is the Wildcat watershed which drains to the north on the eastern side of the ridgelines of the Berkeley Hills.

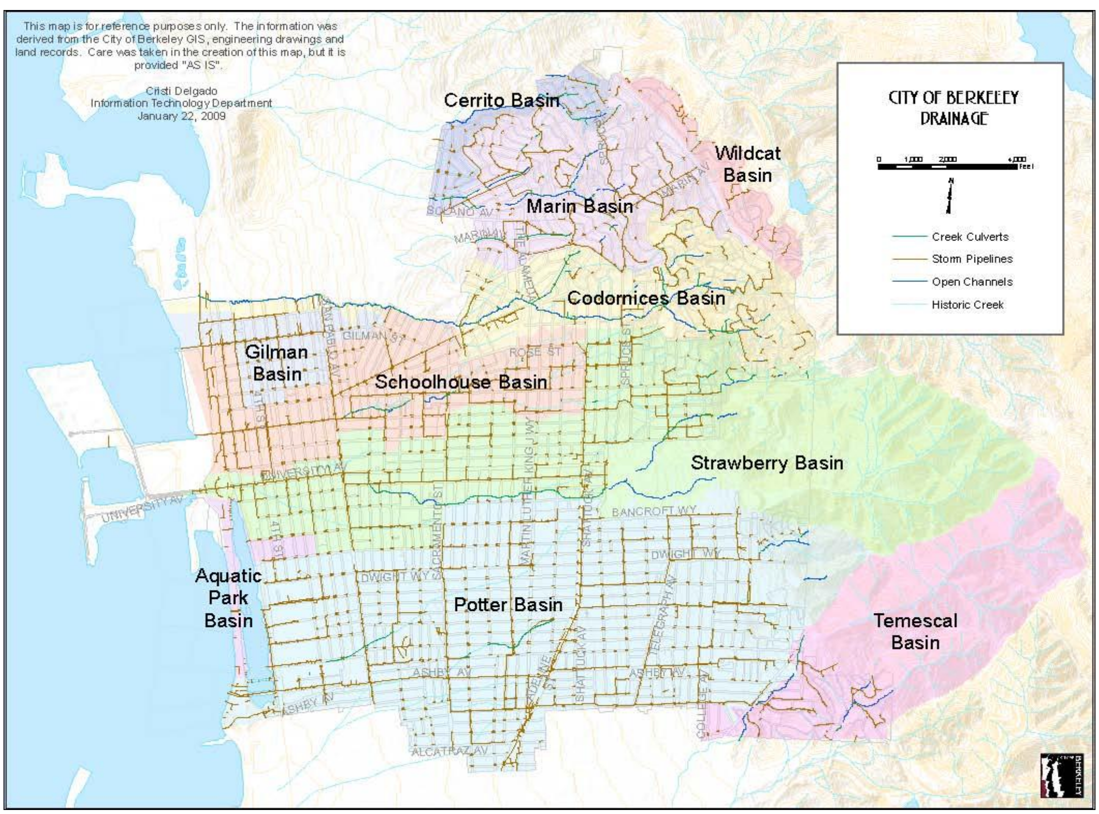

Figure 2-1, Map of Watersheds in City of Berkeley

There are 10 watersheds wholly or partially within the City of Berkeley (not including the Marina). Moving from north to south, these are: Wildcat, Cerrito, Marin, Codornices, Gilman, Schoolhouse, Strawberry, Aquatic Park, Potter, and Temescal (Figure 2-1). Several watersheds extend past Berkeley's municipal boundaries into the City of Emeryville and the City of Oakland to the south, and the Cities of Albany and El Cerrito to the north. The City of Berkeley is predominately urban; however drainage from approximately 2 sq. mi. of non-urban area outside the City boundary flows into the City from Strawberry Canyon and Claremont Canyon east of the City.

CLIMATE

Climate is one of the basic drivers of hydrologic processes such as precipitation, stream flow, soil moisture, and evapotranspiration. Such conditions, in turn, help determine regional and local ecology. Berkeley's climate is largely governed by weather patterns originating in the Pacific Ocean. In winter months, the Polar Jet Stream's southern descent brings mid-latitude cyclonic storms. Climatic conditions in Berkeley are generally characterized as Mediterranean with moist, mild winters and hot, dry summers. Winter temperatures vary between highs of 50º–60ºF and lows of 30º–40ºF. Summer temperatures generally range between highs of 60º–80ºF and lows of 40º–50ºF. Greater than 90% of precipitation falls between November and April, with an annual rainfall amount of about 18-26 inches depending on location (microclimate effects). Areas of higher elevation receive higher rainfall amounts annually due to the rainshadow effects of the Berkeley Hills.

Microclimates

Topography, orientation, wind patterns, and distance from the Bay and the Pacific Coast, create diverse microclimates. These microclimates can present stark climatic variations in only a few miles distance. This is reflected in different water balance conditions across the city, primarily as the result of differences in rainfall amounts and evapotranspiration. These microclimates create the varied vegetation communities and habitats associated with surface water flows.

Summer in the Bay Area is known for its thick marine fog layer in the areas closest to the coast. This fog is brought into the Bay through an advection ("horizontal air/water flow") process. A daily westerly (i.e., from the west, toward the east) breeze is formed by the strong pressure gradient between the hot Central Valley (surface low pressure) and the cooler coastal areas (surface high pressure). This moist air is cooled to dew point when it crosses the cooler waters of the California Current (near the coast). This advection process results in a thick fog forming just offshore, which is pulled eastward through gaps and passes (most famously through the Golden Gate) into the Bay Area. Fog diminishes with distance inland from the Bay, as well as distance north and south from gaps and passes.

Global Climate Change

The U.S. Environmental Protection Agency reports that the Earth's surface temperature has risen by about 1 degree Fahrenheit in the past century, with accelerated warming during the past two decades. This warming is associated with the buildup of greenhouse gases in the atmosphere – primarily carbon dioxide, methane, and nitrous oxide. Scientists expect that the average global surface temperature could rise 2.2 to 10°F (1.4-5.8°C) in the next century, with significant regional variation. Evaporation will increase as the climate warms, which will raise average global precipitation. Soil moisture is likely to decline in many regions, and intense rainstorms are likely to become more frequent. Average sea level may rise two feet or more along most of the U.S. coast. Studies project the Bay to rise between 7" and 55" by the year 2100.

Although specific outcomes of global climate change on the regional climate of the Bay Area are uncertain, potential changes are likely to include increased seasonal mid-latitude type precipitation through a northern migration of the tropical jet stream. Other scenarios might include greater variation in seasonal/annual precipitation due to increased variation along the more northerly Polar Front Jet Stream. Other studies suggest that increased temperatures in the mid latitudes will result in reduced snowfall and increased precipitation in such places as the Sierra Nevada, which may affect drinking water supply for the Bay Area.

BASIC OVERVIEW OF HYDROLOGY AND GEOMORPHOLOGY

Although watersheds are complex systems with multiple and concurrent water inputs and outputs, the simplified hydrologic cycle (Figure 2-2) provides a general overview. The hydrologic cycle comprises a continuous cycle of water movement through the atmosphere (air), lithosphere (ground), and hydrosphere (water bodies). Rainfall is intercepted by vegetation, or directly falls on soil, water, or the built landscape. Precipitation infiltrates into the ground and recharges groundwater or flows as surface runoff to storm drains or waterways both of which drain to the Bay. Water can also return to the atmosphere (either through evaporation or by transpiration from plants)

Surface water flows can initiate the erosion, conveyance, and storage of soil deposits. In the Bay Area, tectonic, faulting, and structural controls often influence the relative distribution of sediment. Landslide and sediment source areas tend to be in the foothills and uplands, while deposition areas tend to be on the alluvial fan after the slope break.

Further discussion of sediment transport is found in Chapter 6, Creeks.

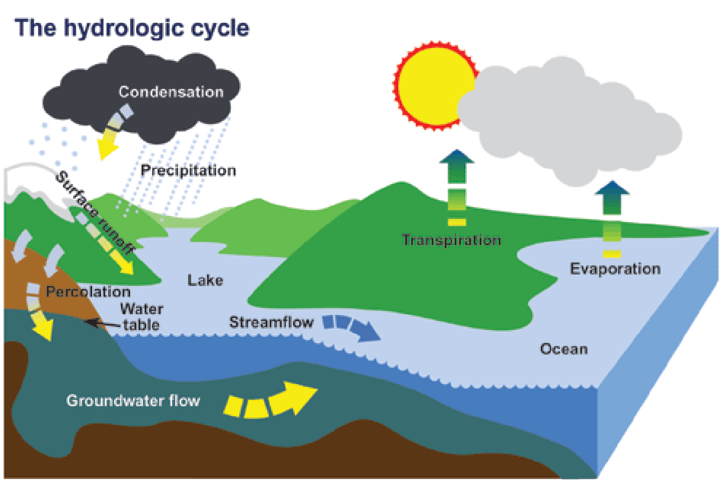

Figure 2-2 Basic Hydrologic Cycle
Source: Environment Canada, http://www.ec.gc.ca/1

EFFECTS OF URBANIZATION

Hydrograph/Peak Flows

Watershed surfaces become more impervious, as land is developed over time to accommodate individual and societal human needs. Like most densely urban communities, much of Berkeley watersheds are covered by hardened surfaces and compacted soils. This condition diminishes the watersheds' natural ability to infiltrate (absorb) stormwater into native soils or evapotranspirate it through plants. The end result is that urbanization increases surface runoff volumes.

Traditional stormwater management approaches have developed efficient drainage measures that favor rapid concentration of excess water and routing it off-site through "hard infrastructure" such as curbs and gutters, inlet structures, and storm drain pipes (Prince George's County, Dept. of Environmental Resource Programs, 1999). This approach increases the rate (or velocity) of runoff.

When runoff volumes and rates are increased, urbanized watersheds experience greater peak flows which contribute to localized flooding (Figure 3-3).

Water Quality/Non-point Source Pollution

In addition to changes in hydrology, urbanization also affects water quality. Natural filtration through soils and vegetative uptake of pollutants is diminished by impervious surface development. The loss of natural filtration processes is exacerbated by the generation of various non-point source pollutants associated with routine activities of the general population and businesses within a densely populated area such as Berkeley. Figure 2-4 describes the impacts of impervious land on stormwater runoff. Table 2-1 lists the most common urban stormwater runoff pollutants and their typical sources.

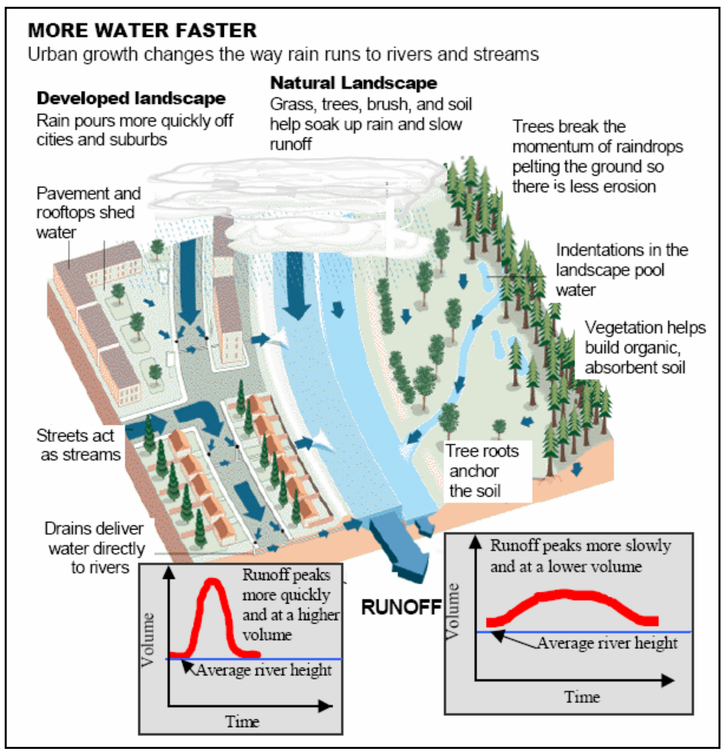

Figure 2-3, Urbanization Effect on Runoff Volumes and Rates

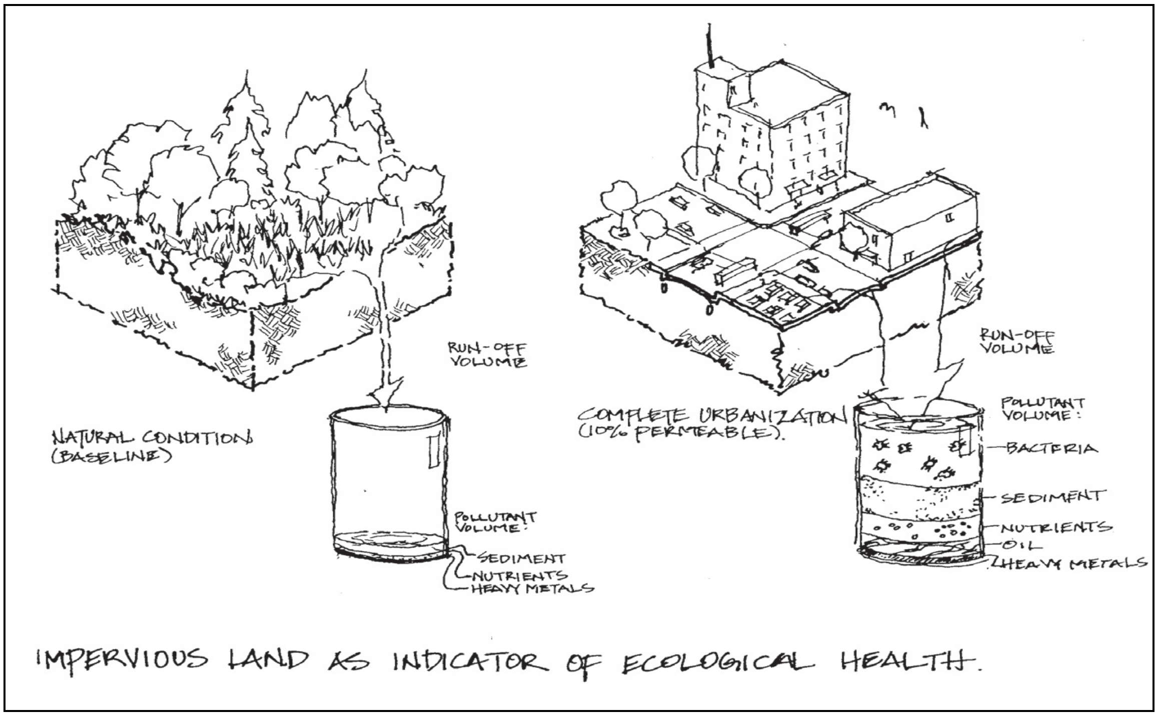

Figure 2-4

Pollutant	Source
Metals	Automobiles, roof shingles
Oil and grease	Automobiles
Oxygen-depleting substances	Organic matter, trash
Sediment	Construction sites, roadways
Trash and debris	Multiple sources
Bacteria	Pet waste, wastewater collection systems
Nutrients	Lawns, gardens, atmospheric deposition
Pesticides	Lawns, gardens
Toxic chemicals	Automobiles, industrial facilities

Table 2-1

Natural Waterways and Habitat

Prior to the arrival of Spanish explorers in the late 1700s, creeks in Berkeley supported a range of terrestrial and aquatic wildlife (including song birds, fish, raptors, rodentia, deer, elk, bear and mountain lions) that used them for water sources, vegetative cover, and food. The indigenous Huchiun-Ohlone peoples used the creeks to fish, hunt, and gather food supplies. (Charbonneau) Watersheds and their associated open watercourses were significantly altered from the mid-1700s to the early 1900s by changes in land uses associated with settlements and subsequent urbanization (such as cattle grazing, building of transportation infrastructure, and subdividing and building on land tracts). These past alterations included physical modifications to the creeks to:

- Impound water for drinking, fire suppression, and irrigation (damming).
- Mine creek beds and banks for road building materials (widening & deepening).
- Dispose of wastewater (sewage) and refuse (dumping).
- Create predictable flow paths resistant to erosion and incision (channel armoring and straightening).
- Maximize developable space by undergrounding creeks in pipes (culverts).

Over time, these changes have resulted in the loss of open watercourses and related terrestrial and aquatic wildlife habitat throughout the city. The greatest losses occurred in the flatlands where developable space was at a premium. For example, Potter and Derby Creeks, respectively, drained two historically distinct watersheds, which are now merged into the current Potter Watershed. Although there are some remaining open channels in the Berkeley Hills, and a mix of active and abandoned creek culverts (needing to be confirmed through field investigations), the Potter Watershed is almost exclusively drained by storm drain infrastructure.

Urbanization also contributes to the degradation of water quality and the ecological integrity of creeks. As concentrated flows are discharged to creeks, excessive stream bank erosion and channel overflows can occur, resulting in damage to aquatic habitat (scour or excessive sedimentation) as well as to property (loss of land and undermining of adjacent structures). Groundwater supplies, which contribute to summer flows of Bay Area creeks, are less able to be replenished as the percentage imperviousness in a watershed area increases. Although urbanization leads to significant increases in flooding during and immediately after wet weather, in many instances it results in lower stream flows during dry weather, which can compromise the survival of native fish and other aquatic life.

BERKELEY WATERSHEDS CHARACTERISTICS

A number of statistics have been compiled to provide a snapshot of important characteristics of the watersheds in Berkeley (Table 2-2). These include: drainage area, annual precipitation averages, land use types and sizes, and estimated percent of impervious coverage. This data can be used to generate estimated gross runoff volumes and calculate runoff estimates associated with different storm intensities. Also provided in the table are estimated lengths of the various drainage pathways for each watershed, including creeks (open and culverted) and storm drain pipelines. Finally the table provides the estimated area within each watershed that is at higher risk for hazards, such as flooding, landslides, seismic activity, and soil contamination. These hazard areas may be inappropriate for certain WMP recommended measures.

Watershed Characteristic Parameter		Citywide	Cerrito	Marin	Codornices	Gilman	Schoolhouse	Strawberry	Aquatic Park	Potter	Temescal	Wildcat
Drainage Area Total (acres)		6,156[1]	1,927[5]	1,063[5]	796[2]	249[4]	703[1]	1,977[5]	134[1]	2,693[5]	4,324[5]	6,326[5]
Drainage Area in City Boundary (acres)		6,156[1]	149[1]	699[4]	570[4]	249[4]	703[4]	1,385[1]	134[1]	2,053[2]	205[1]	152[1]
Annual Precipitation (inches)		18-26[4]	22[5]	22[5]	24[2]	20	21[5]	23[5]	20	22[2]	24[5]	23[5]
Land Use Area by Type (acres)	Recreational	6%[3]	1[1]	7[4]	26[4]	0	13[4]	29[4]	78[1]	143[4]	0	NC
	Open Space		0	0	26[4]	25[4]	46[4]	588[4]	78[1]	294[4]	NC	NC
	Institutional	9%[3]	0	4[4]	15[4]	1[4]	50[4]	470[4]	30[1]	185[4]	NC	NC
	Industrial	4%[3]	0	0	0	80[4]	71[4]	28[4]	11[1]	184[4]	NC	NC
	Industrial/ Residential		0	0	0	0	0	0	7[1]	0	NC	NC
	Commercial	7%[3]	0	16[4]	6[4]	38[4]	51[4]	170[4]	NC	174[4]	6	NC
	Com/Res		0	0	0	2[4]	0	10[4]	NC	101[4]	NC	NC
	Low Density Res	48%[3]	148[1]	672[4]	496[4]	101[4]	438[4]	498[4]	NC	931[4]	194[1]	152[1]
	Med Density Res		0	0	1[4]	2[4]	25[4]	102[4]	9[1]	101[4]	6	NC
	High Density Res		0	0	0	0	9[4]	82[4]	NC	230[4]	NC	NC
	Vacant	2%[3]	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	City Streets (848 acres)[6]	24%[3]	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	City Sidewalks (182 acres)[6]		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Est. % Impervious[2]		NC	NC	NC	34	NC	NC	NC	NC	55	NC	NC
Avg. Annual Wet Season Runoff Volume (acre ft.)[5]		NC	1,700	802	596	NC	653	2,482	NC	2,460	3,386	4,020
Annual Wet Season Runoff Volume, Avg. (1998-2007) (af)[5]		NC	2,201	1,024	740	NC	884	3,123	NC	3,200	4,027	5,031

Table 2-2 (continued on next page)

Part 2 of Table continued on next page.

Watershed Characteristic Parameter	Citywide	Cerrito	Marin	Codornices	Gilman	Schoolhouse	Strawberry	Aquatic Park	Potter	Temescal	Wildcat
Estimated Open Channel Length (ft)[1]											
Total	42,139	5,063	6,116	15,477	NA	1,690	7,092	NA	2,254	4,447	NA
City Property	3,010	211	508	1,873	NA	0	298	NA	0	120	NA
Private Property	39,129	4,852	5,608	13,604	NA	1690	6,794	NA	2,254	4,327	NA
Estimated Active Creek Culvert Length (ft)[1]											
Total	35,059	2,220	4,284	11,435	NA	2,309	9,501	NA	3,037	1,848	426
City Property	19,959	924	3,066	6,083	NA	1,287	5,796	NA	1,676	1,127	UNK
Private Property	14,674	1,297	1,218	5,351	NA	1,022	3,705	NA	1,360	721	UNK
Storm Drain Pipe Length (ft)[1]											
Public ROW only	492,365	1,880	61,584	40,088	23,856	65,637	82,758	3,583	187,020	20,698	5,262
Hazard Study Areas (acres)[1]											
FEMA 100yr Flood Zone	105	0	0	25	0	0	0	80	0	0	0
FEMA 500yr Flood Zone	203	1	0	16	39	72	13	0	49	12	0
Landslide	1,104	54	232	378	0	0	326	0	31	19	64
Fault Zone	647	63	186	106	UNK	UNK	170	UNK	69	54	UNK
Liquefaction	1,423	UNK	UNK	64	193	194	286	46	640	1	UNK
Soil Contamination	1,727	UNK	11	61	162	258	720	134	377	4	UNK

Table 2-2 (continued)

Key: NA = Not Applicable; NC = Not Calculated (to be added at a later date); UNK = Unknown

Sources:
1. City GIS Database
2. Balance Hydrologics Report (see Appendix E)
3. City of Berkeley General Plan, 2002
4. CH2MHill Report, 1994
5. San Francisco Estuary Institute, *Hydrology Estimates in Small Urbanized Watersheds Paper*, 2010
6. Email Communication, W. Wong, Public Works Engineering – Streets & Sidewalk Group, May 26, 2009

RECOMMENDATIONS FOR WATERSHED CONDITIONS

2.1 Global Climate Change Monitoring: Monitor and review scientific reports and information on Global Climate Change, and amend WMP as appropriate.

CHAPTER 3: LOW IMPACT DEVELOPMENT/ GREEN INFRASTRUCTURE

A variety of stormwater management strategies can be employed to achieve the stated goals of the WMP. This chapter describes technologies and methods currently available to the City as well as property owners, developers, and residents. As new approaches become available and accepted, they will be added to the watershed management best management practices.

LOW IMPACT DEVELOPMENT/GREEN INFRASTRUCTURE OVERVIEW

Low Impact Development (LID) and Green Infrastructure (GI) describe a strategy that emphasizes conservation and the use of distributed, small-scale stormwater controls to mimic natural hydrologic patterns in residential, commercial and industrial settings. GI is the term used for LID measures the City can undertake within the public right-of-way. LID/GI measures entail managing runoff as close to its source as possible using landscape-based practices to promote the natural processing (removal of pollutants) of runoff by filtration, infiltration, adsorption, and/or evapotranspiration.

LID/GI also provides runoff volume and velocity reduction benefits, which become most effective when used on a wide scale, or in combination with other means and methods. This approach can lead to cost savings in the form of reduced traditional stormwater conveyance infrastructure. LID/GI practices also protect downstream resources from adverse pollutant and hydrologic impacts that can degrade stream channels and harm aquatic life.

LID/GI TYPES and EXAMPLES

There are four fundamental types of LID/GI best management practices (BMPs), which can be applied within the he public right-of-way, institutional facilities, or on lot-level property (public or private) as appropriate. These are categorized as Site Planning BMPs, Building BMPs, Street/Sidewalk Retrofit BMPs, and Landscape BMPs. The following is a summary of the different categories.

Site Planning BMPs

(also known as “Conservation Design”)
Site Planning BMPs are important because planning occurs prior to earth-moving and construction activities. Use of Site Planning BMPs minimizes the generation of runoff by preserving open space and pervious surfaces. Site Planning BMPs preserve important features on the site such as wetland and riparian areas, forested tracts, and areas of porous soils. Proper planning can enhance natural drainage patterns and preserve the infiltration capacity of the existing soil. Examples of Site Planning BMPs include: open space preservation, reduced pavement widths for streets and sidewalks, and shared driveways.

Building BMPs

Building BMPs typically focus on the capture, storage, and potential reuse stormwater that is shed from a building. The captured stormwater can be discharged to landscaped areas or to existing storm drainpipe infrastructure (as metered flow); or it can be reused for non-potable applications as appropriate. Harvested rainwater is chemically untreated 'soft water' that is suitable for gardens and compost and other non-potable needs, free of most sediment and dissolved salts. Building BMPs include rainwater harvesting and green roofs.

A. Rainwater Harvesting

Rainwater harvesting systems can range from a simple barrel (Figure 3-1) at the bottom of a roof gutter downspout to multiple cisterns, pumps, and treatment systems. In Berkeley, a simple rain barrel system (less than 100 gallons) that collects from a roof downspout can be used for outdoor irrigation without permits. These smaller units can accommodate a small fraction of roof runoff and should be emptied between storms if they are to help reduce peak flows.

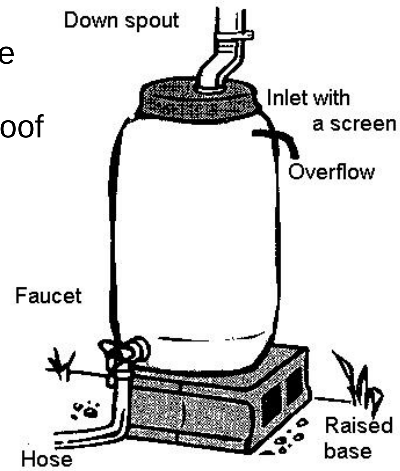

Figure 3-1, Simple Rain Barrel

Cisterns are larger systems (greater than 100 gallons) and may include pumps to move rainwater to the garden or thorough treatment systems and plumbing for indoor non-potable use such as toilet flushing and laundry (Figures 3-2 and 3-3). In Berkeley, cisterns must be permitted and need a zoning certificate if above ground. Linked barrels providing over 100 gallons of storage per downspout are also considered a cistern and are subject to permitting requirements. More information about the City of Berkeley's Rainwater Harvesting Guidelines can be found on the City's website: www.cityofberkeley.info/ResidentialRainwater.

Figure 3-2, Large Cistern at Chicago Center for Green Technology
Source: http://glasscityjungle.com/wordpress

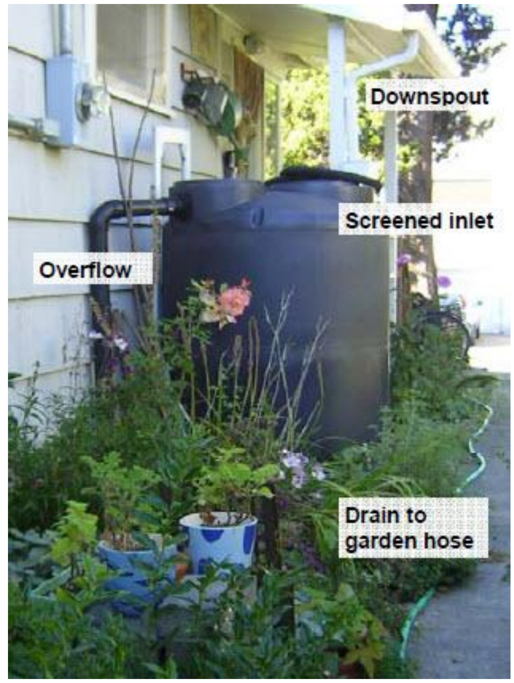

Figure 3-3, Residential Cistern, Seattle

https://rainwise.seattle.gov/city/seattle/solution_brochures/cistern?lightview=true

B. Green Roofs

Also known as Eco-Roofs), Green Roofsare roofs (entirely or partially) covered with vegetation and soils, which improve water quality and reduce runoff through filtration, absorption, and detention. Modern green roofs can be categorized as "intensive" or "extensive" systems depending on the plant material and planned usage for the roof area. Intensive roofs, or rooftop gardens, are heavier, support larger vegetation and can usually be designed for use by people.

Extensive green roofs are lightweight, uninhabitable, and use smaller plants.

Figure 3-4, Great City Hall Chicago

Green roofs (Figures 3-4 and 3-5) can be installed on most types of commercial, multifamily, and industrial structures, as well as on single-family homes, garages, and sheds. Green roofs can be used for new construction or to re-roof an existing building. Candidate roofs for a “green” retrofit must have sufficient structural support to hold the additional weight of the green roof, which is generally 10 to 25 pounds per square foot saturated for extensive roofs and more for intensive roofs (San Francisco Public Utilities Commission, 2007). Vegetated roofs have a longer life span than standard roofs because they protect the roof structure from ultraviolet radiation and fluctuations in temperature that cause roof membranes to deteriorate. (Water Environment Research Foundation)

Figure 3-5, Garage Green Roof in Mount Baker

Street and Sidewalk Retrofit BMPs

Berkeley has an estimated 49 million sq. ft. of streets and sidewalks comprising the public right-of-way. Brekeley streets and sidewalks can be retrofitted to reduce impervious surface area and reduce runoff volumes by:

- Replacing concrete sidewalks with permeable materials.
- Installing bio-swales within the existing planter-strip area of sidewalks.
- Installing curb extensions for bio-retention cells.
- Converting medians and traffic circles to vegetated bio-filtration areas.
- Replacing impermeable asphalt with permeable surfacing on low volume traffic streets.
- Using open-graded gravels and amended soils as subsurface media for storage and treatment.

- Installing underground stormwater storage pipes or cisterns that meter outflow to the storm drainpipe infrastructure (or for potential non-potable re-use) Additional benefits common to most of these BMPs are aesthetic improvements to the local neighborhood.

A. Permeable Paving

Permeable paving may be constructed of three basic material types: Porous concrete, Porous asphalt, and Pervious Joint Pavers. Porous concrete (Figure 3-6) and porous asphalt (Figure 3-7) often look the same as their conventional counterparts but are mixed with a low proportion of fine aggregates, leaving void spaces that allow for infiltration. Permeable joint pavers (Figure 3-8) themselves are impervious, but gravel- or grass-filled voids in between the blocks allow stormwater to enter the subbase.

Figure 3-6, Porous Concrete

www.nrmca.org/greenconcrete/default.asp

Permeable paving is primarily used in parking lots, driveways, sidewalks, and roadways with low-traffic speeds and volumes. When used in as a driving surface, permeable paving systems must be designed to support the same loads as conventional paving to support the weight and forces applied by vehicles. When using pervious joint paving in pedestrian or bicycle lane applications, tightly spaced non-chamfered (beveled-edge) unit pavers provide the smoothest surface for wheel-chairs and cyclists. Some patterns and orientations also provide a smoother surface.

Figure 3-7, Porous Asphalt (adjacent to conventional asphalt)

Source: http://3.bp.blogspot.com

The amount of drainage from the subbase to native soils depends on the permeability of the existing soil. In full exfiltration systems, all stormwater is expected to exfiltrate into the underlying subsoil. Partial exfiltration systems are designed so that some water exfiltrates into the underlying soil while the remainder is drained by an overflow device to prevent ponding. No exfiltration occurs when the subbase is lined with an impermeable membrane and water is removed at a controlled rate through an overflow device. Tanked systems are essentially underground detention systems and are used in cases where the underlying soil has low permeability and low strength, there is a high water table, or there are water quality limitations. (Water Environment Research Foundation)

Figure 3-8, Pervious Joint Paving in Parking Lanes of Residential Street

Source: nevue ngan associates, San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook

B. Vegetated Swales

Also known as Bioswales, vegetated swales are broad, shallow channels designed to convey and filtrate stormwater runoff. The swales are vegetated along the bottom and sides of the channel, with side vegetation at a height greater than the maximum design stormwater volume.

Vegetated swales (Figure 3-8) are often designed with highly permeable soils and an underdrain to allow the entire stormwater volume to convey or infiltrate away from the surface of the swale shortly after storm events. (Water Environment Research Foundation)

Figure 3-8, Vegetated Swale at Curb Extension
Source: flickr.com/photos/84977575@N00/2570180671

C. Tree Well Filters

A tree well filter's basic design is a vault filled with bioretention soil mix, planted with vegetation, and underlain with a subdrain (Figure 3-9). However, design variations are abundant and evolving.

Tree well filters are especially useful in ultra-urban settings where there is no existing planter strip in the sidewalk area. This application can also be used in the design of an integrated street landscape where multiple tree wells are connected through piping or other means--a choice that transforms isolated street trees into stormwater filtration devices.

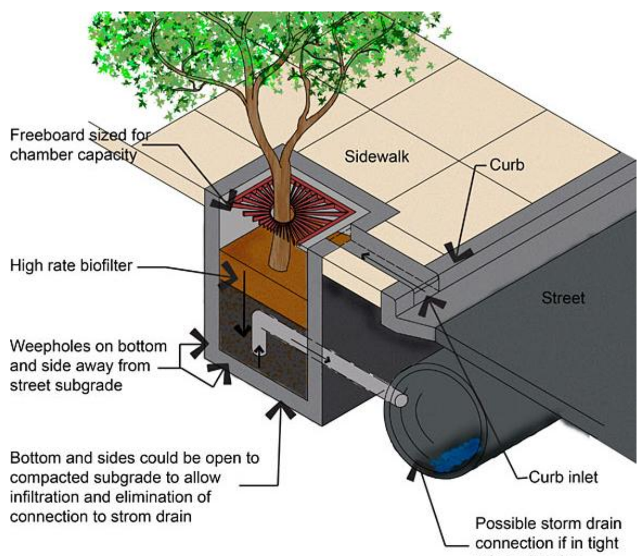

Figure 3-9, Typical Tree Well Filter
ladstudios.com/LADsites/Sustainability/Strategies/Strategies_TreeWell.shtml

D. Hydrodynamic Separator Units

These are devices used for water quality improvement where there is little opportunity for landscape-based treatment measures. A Hydrodynamic separator unit (HSU) is an underground gross pollutant removal device that funnels runoff flow though a circular vault to form a vortex that separates floatables and solids from stormwater (Figure 3-10). The floatables and suspended solids become trapped in a sump for removal typically by vactor truck, while the screened water is allowed to flow though the device back into the drainage pathway. The HSUs are intended to screen litter, fine sand, and larger particles that can have other pollutants adsorbed to them. They can act as a first screen influence for trash and debris, vegetative material, oil and grease, and heavy metals. Because these devices can hold the separated gross pollutants along with residual water, it is recommended that they be serviced soon after storm events to prevent mosquito breeding or the organic breakdown and re-suspension of pollutants which may escape the vault as they become soluble.

Figure 3-10, Hydrodynamic Separator Unit
ngenvironmental.cam.au/septic1

Landscape BMPs

Landscape-based BMPs use various arrangements of vegetation and soil media to function as filtration devices that remove pollutants through a variety of physical, biological, and chemical treatment processes. They also reduce runoff rates by detaining stormwater. Landscape BMPs include trees, swales, bioretention cells, and open spaces.

A. Trees

A healthy tree canopy can provide substantial stormwater management benefits. The branches and foliage at the top of a tree can intercept and store about 50-100 gallons of rainwater. This not only reduces runoff rates and volumes, but also reduces erosion associated with the impact of raindrops on exposed soils. Tree roots create channels in the soil, which increase the soil's ability to store water.

The City recognizes the important role of trees in stormwater management, plus the additional benefits they provide by absorbing CO_2 (a greenhouse gas) and shading city streets to reduce the urban "heat island effect." Native trees are well-suited as landscape BMPs because of their ability to use large amounts of water when available, but can still withstand long periods of reduced soil moisture. Berkeley's on-going urban forestry program, not only supports the goals of the WMP, but also results in cooler temperatures, improved aesthetics, and enhanced property values.

B. Bioretention Cells

Figure 3-11, El Cerrito Rain Garden Project, San Pablo Ave.

Also known as rain gardens, Bioretention Cells (Figure 3-11) are vegetated depressions that can resemble miniature ponds or long strips. Bioretention Cells may be lined or unlined, depending on site requirements, but are typically designed to avoid ponding for longer than 24 hours. These measures are appropriate for median strips, planter strips and curb extensions within the public right-of-way. They are also appropriate for parking lot islands, yard areas, and park spaces.

Benefits of LID/GI

In 2007, the US Environmental Protection Agency released a report called, *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices*. This report used 17 case studies of LID/GI projects located throughout the country to compare the costs associated with this stormwater management approach relative to conventional methods. In addition to this cost analysis, this report provides a summary of both the actual and assumed benefits of LID/GI.

Environmental, Land Value, and Quality of Life Benefits (modified from EPA Report)

1. Pollution abatement – Urban runoff pollutants are removed through the various processes of settling, filtration, adsorption, and biological uptake of stormwater. This benefits the receiving waterways by improving aquatic and terrestrial wildlife habitat.
2. Protection of Natural Waterways – Excessive erosion and sedimentation within creeks can be reduced through the runoff volume and velocity reductions associated with infiltration, detention, and retention.
3. Groundwater Recharge – Infiltration practices can be used to replenish groundwater and increase stream baseflow. Groundwater resources are critical as water shortages seem to increase nationwide and globally. Adequate baseflow in creeks during dry seasons is essential for the survival of aquatic life.
4. Water Quality Improvements/Reduced Treatment Costs – As urban runoff is processed by vegetated filtration and/or infiltration into native or amended soils, the water is cleansed before it reaches stormdrain inlets and pipelines. This saves on the costs of installing expensive end of pipe treatment facilities.
5. Reduced Sanitary Sewer Overflows – LID/GI can reduce wet weather infiltration and inflow (I/I) into sanitary sewer systems though the disconnection of downspouts from sanitary sewer lines and directing flow to landscaped areas or storage devices. The City of Berkeley is mandated to reduce I/I by Stipulated Order of the EPA.

6. Habitat Improvements – The addition of increased vegetation through decentralized green infrastructure measures can create additional wildlife habitat in a densely built city like Berkeley.
7. Reduced Flooding and Property Damage – The reduction of peak flows and runoff volumes associated with green infrastructure can aid the City's flood prevention activities. It also can reduce the hydraulic loading to the city's already stressed stormwater conveyance infrastructure, which is currently operating at or near capacity.
8. Aesthetic Value – LID/GI relies on landscape-based approaches that can be designed to be attractive amenities to the site. The use of designs that enhance a site's aesthetics can increase property values and result in faster sales due to the perceived value of "extra" landscaping.
9. Public Spaces/Quality of Life/Public Participation – Placing water quality practices on individual lots or at surface level in the public right-of-way provides opportunities to involve residents in stormwater management and enhances awareness of water quality issues.

LID/GI Constraints

To ensure long-term functionality and minimize unintended negative impacts, it is important to understand the limits and site-specific constraints associated with LID/GI approaches. When selecting LID/GI measures, the following factors should be considered (further detailed information on these techniques, including sizing, location, design, and maintenance can be found in the Alameda Countywide Clean Water Program's *C.3 Stormwater Technical Guidance Handbook, Version 2.0*, cleanwaterprogram.org/):

- **Space/Real Estate Requirements** – Surface-level space is at a premium in the built out City of Berkeley. LID/GI measures must be sized appropriately to provide the desired stormwater treatment, flow volume control, and/or storage capacity for future non-potable re-use. A rule of thumb for many landscaped-based measures is that the space needed is 4-6% of the drainage area being captured.

- **Soils** – Soils and subsoil conditions are critical to LID/GI effectiveness. These conditions affect infiltration rates, vegetation growth, and surface loading capacities. The use of underdrains can provide positive subdrainage for bioretention practices located on clayish soils. Use of infiltration practices can threaten groundwater quality if high levels of soil contaminants are present.

- **Slopes** – The steeper the slope, the higher the erosion potential and flow velocities. Many LID measures are limited to slopes under 5-10%. Infiltration measures are not appropriate for steep slopes or in areas of landslide hazards.

- **Water Table** – The general criterion is to provide at least 10 feet of separation between the bottom of the GI measure and the top of the seasonally high water table elevation. Also, the potential for contamination should be considered.

- **Proximity to Foundations** – Care must be taken not to locate infiltration measures too close to building foundations and other structures. Considerations include distance, depth, and slope.

- **Existing Utilities** – Much of the GI opportunity sites are located where gas, electric, water, sewer, and telecommunication conduits are. Care must be taken to avoid disrupting these utilities when constructing and maintaining GI measures.

LID/GI Pollutant Removal Efficiency Matrix

Over the last 10-15 years, numerous municipal agencies[2] across the nation have used LID/GI BMPs (in varying degrees) as stormwater management strategies. The high costs of laboratory analyses and rigorous technical quality assurance and quality control requirements inhibit many agencies' abilities to scientifically monitor the pollutant removal performance of LID/GI BMPs. However, over time there has been enough monitoring data collected and analyzed to characterize the relative effectiveness of these measures. Table 3-1 provides a "High", "Medium", "Low" scorecard of expected pollutant removal efficacy for various LID/GI BMPs.

BMP TYPE	Pollutant Removal/Avoidance Effectiveness – Water Quality						
	Trash	Sediments	Nutrients	Metals	Oil & Grease	Organics	Bacteria
Bioretention Cell[1]	H	H	H	H	H	H	H
Vegetated Swale[1]	L	M	M	M	M	M	L
Permeable Paving[1]*	H	L	H	H	H	L	L
Green Roof[1]	H	H	M	H	H	H	H
Cistern[1]	H	H	H	H	H	H	H
Hydrodynamic Separator Unit[2]	H	M	L	L	M	L	L

H = High; M = Medium; L = Low; NA = Not Applicable; ND = No Data
*assumes no exfiltration to native soils
[1]Source: *Low Impact Development Standards Manual*, County of Los Angeles, 2009
[2]Source: California Stormwater Best Management Practices Handbook for New Development and Redevelopment, CASQA, 2003

Table 3-1, Pollutant Removal Effectiveness of LID/GI Types

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[2] Green Infrastructure strategies have been adopted and piloted by cities such as Portland, Seattle, Los Angeles, Santa Monica, San Francisco, Chicago, Washington D.C., and Philadelphia. Each has implemented demonstration projects to better understand the effectiveness and costs of these methods. Some have developed guidelines and programs for integrating GI/LID methods into their existing design review, capital improvement, and maintenance activities. A commonality among most of these cities is that they have combined stormwater/sanitary sewer systems (CSS). Cities with a CSS are under regulatory requirements to reduce overflows and have a funding resource through Sanitary Sewer fees to undertake these innovative approaches.

LID Hydrologic Impacts

Two fundamental goals of the WMP are to reduce urban flooding and protect natural waterways and habitat. Table 3-2 provides a summary of the hydrologic impacts of various LID/GI BMPs. All categories under "Hydrologic Impacts" provide benefits associated with these goals.

BMP TYPE	Hydrologic Impacts		
	Runoff Volume Reduction	Peak Flow Reduction	Groundwater Recharge*
Bioretention Cell[1]	H	H	H
Vegetated Swale[1]	M	L	M
Permeable Paving[1]*	L	H	L
Green Roof[1]	L	H	L
Cistern[1]**	M	L	L
Hydrodynamic Separator Unit[1]	NA	NA	NA

H = High; M = Medium; L = Low; NA = Not Applicable; ND = No Data
*assumes infiltration to native soils, no subsurface storage
**varies depending on size of storage unit
[1]Source: Low Impact Development Manual for Southern California, Low Impact Development Center, 2010

Table 3-2, Hydrologic Impacts of LID Types

LID/GI BMP Siting Considerations

Landscape-based LID/GI measures rely on some degree of runoff holding (residence) time to promote maximum vegetative uptake and/or filtration through soil media. Thus these BMPs need certain amount of surface level area for effectiveness. Stormwater capture and storage measures require a much smaller footprint, but should also be sized approximately to meet reuse needs or should be frequently discharged to accommodate runoff from the next storm. Detailed information on sizing criteria can be found in the Alameda Countywide Clean Water Program's *C.3 Stormwater Technical Guidance Handbook*, *Version 2.0*, 2010.

Some land use types provide excellent opportunities for LID/GI retrofits, while others will need site-specific analysis to ensure that BMPs will not contribute to the mobilization of pollutants (such as industrial areas, where there may be existing soil contamination) or create potential public safety hazards (such as permeable paving in high volume travel lanes of streets).

Table 3-3 provides a summary of available space needs associated with various LID BMPs. It also provides a general summary of the suitability of LID BMPs by land use types, including Residential (Res.), Commercial (Com), Industrial (Ind.), and Recreational/Institutional (Rec/Instit). The streetscape category includes sidewalks, streets, alleys, and medians.

BMP TYPE	Site Suitability: Space Needed and Potential Land Use Applications						
	Space Needed	Res.	Com.	High-Density	Ind.	Rec/ Instit	Street Scape
Bioretention Cell[1]	M	H	H	L	H	H	H
Vegetated Swale[1]	M	H	H	L	H	H	H
Permeable Paving[1]	L	H	H	H	L	H	L-H**
Green Roof[1]	L	H	H	H	H	H	NA
Cistern[1]	L	H	H	H	H	H	NA***
Hydrodynamic Separator Unit	L	M	H	H	M	L	H

H = High; M = Medium; L = Low; NA = Not Applicable; ND = No Data

**Primary source describes permeable paving applicability in streets as "limited," as recognized in the WMP. However use of permeable paving is suitable for the City right-of-way on a site-specific basis.

***Primary source describes capture and reuse as not applicable to streets. However, the storage pipes described in the GI Approaches section below can be considered cisterns (with a potential for reusing stored water in the City right-of-way).

[1]Source: Low Impact Development Manual for Southern California, Low Impact Development Center, 2010 Low Impact Development Standards Manual, County of Los Angeles, 2009

Table 3-3, Space Needs for LID Types

RECOMMENDATIONS FOR LID/GREEN INFRASTRUCTURE

3.1 San Pablo Stormwater Spine Project: participate in grant-funded multi-City demonstration project installing LID retrofits on San Pablo Avenue sites from Oakland to Richmond. The City is a partner in this grant-funded effort spearheaded by the San Francisco Estuary Partnership to identify, design, install GI retrofits along San Pablo Ave with each site treating one acre of impervious surface run-off.

3.2 LID/GI Coordination Opportunities with other Public Works Programs: seek opportunities for incorporating LID/GI measures as a standard element in the design and implementation of various Public Works projects and programs. The City undertakes numerous capital improvement projects annually to enhance transportation, public safety, community aesthetics, environmental processes, and internal and external services. The City can and should be a model for others to follow in designing and implementing LID/GI BMPs for future projects.

Potential PW programs to coordinate with include:

3.2.1 Streets & Sidewalks Group: The reconstruction of streets and sidewalks can incorporate Landscape and Street & Sidewalk Retrofit BMPs

3.2.2 Sanitary Sewer Group: Disconnecting roof drain downspouts from sanitary sewers is one preferred method of reducing infiltration and inflow (I/I) to the sanitary sewers, which can become overwhelmed during the wet season rains. The Downspout Disconnection Program can promote the use of LID measures (such as rain barrels, cisterns or landscape-based BMPs) for properties subject to disconnection. Connections are currently being investigated through smoke-testing.

3.2.3 Buildings and Facilities Group: Integrate LID measures into building and facility renovations and new construction. Examples of City projects that have LID measures include the new Animal Shelter at Aquatic park (green roof) and the Fire Station Warehouse on Folger (rainwater harvesting cistern).

3.3 Technical Guidance on LID BMPs: Review and edit LID technical guidance information distributed at Permit Service Center and public events. Because of the cumulative nature of the benefits of LID throughout a watershed, it is important to encourage voluntary use of LID BMP installations within the private sector. Appropriate and consistent LID BMP guidance information should be available to the general public, project proponents (including developers, landscape architects, architects, and contractors), and City staff responsible for Plan Check and Design Review.

3.4 Investigate the Potential and Use of “In-Lieu” Pilot Program for LID: the City could develop a pilot program to allow for the (partial or full) financing of adjacent public right-of-way GI retrofits and long-term maintenance as an “in-lieu” condition of approval. While it is always preferable to treat and manage stormwater on-site, in ultra-urban settings like Downtown Berkeley it may be challenging to incorporate on-site LID measures in design plans due to limited space or other constraints.

CHAPTER 4: WATER QUALITY

This chapter describes the variety of urban runoff pollution prevention activities the City currently performs. It also provides an overview of the regulatory framework and collaborative approach that helps organize these efforts.

URBAN RUNOFF POLLUTANTS OVERVIEW

Urban runoff has been identified as one of the leading contributors of nonpoint source pollution[3] to "receiving waters in the United States". In Berkeley, urban runoff mobilizes the accumulation of various pollutants from land and building surfaces and carries them into local waterways and the SF Bay. When pollutants are discharged into local waterways or the San Francisco Bay, they can harm fish and wildlife populations, kill native vegetation, and make recreational areas unsafe and unpleasant.

The primary sources of urban runoff pollutants include the following areas and operations: industrial and commercial areas; highly active parking lots; material storage and handling areas; vehicle and equipment fueling, washing maintenance and repair areas; erodible soil; streets and highways; and handling and application of landscape maintenance products. (LA Reference of BMPs, 2000, pg 20). The most common urban stormwater run-off pollutants include:

- **Sediments** – Sediments are soils or other surficial materials transported or deposited by the action of wind, water, ice, or gravity, as a product of erosion. Primary sources are lands disturbed by a construction activity or heavy rainfall. Sediments can increase turbidity, clog the gills of fish, reduce spawning, lower the ability of young aquatic organisms to survive, smother bottom dwelling organisms, and suppress the growth of aquatic vegetation.
- **Nutrients** – Nutrients are inorganic substances, such as nitrogen and phosphorous. They commonly exist in the form of mineral salts that are either dissolved or suspended in water. The primary source of nutrients in urban runoff has been identified as fertilizer products. Discharge of nutrients to water bodies and streams can result in excessive aquatic algae and plant growth. As this excessive organic matter decays, it can deplete oxygen in the water, leading to the eventual death of aquatic organisms.
- **Heavy Metals** – At small concentrations naturally-occurring in soil, heavy metals (such as lead, mercury, copper, and chromium) are not considered toxic.

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[3] "Nonpoint source" pollution is defined to mean any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act. "Point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

However, at higher concentrations, certain heavy metals can be toxic. A primary source of heavy metal pollution in stormwater is the degradation and leaching of commercially available metals and metal products. These metals are also used as raw material for fuels, adhesives, paints, and other coatings.

- **Toxic Chemicals** – Toxic chemicals are either organic or inorganic substances, which at certain concentrations can indirectly or directly constitute a hazard to life or health. Some commercially available or naturally occurring toxins include cyanides, solvents, organic compounds, and hydrocarbons. For example, the excessive application of pesticides may result in runoff containing toxic levels of the pesticide's active component. Also, when rinsing off objects, toxic levels of solvents and cleaning compounds can be discharged to the storm drain. Other sources of potentially toxic or hazardous substances include: automotive fluids that drip and leak from vehicles; illegally discharged motor fluids (such as motor oil and radiator fluid); cleanup wastes (such as concrete mixers, paints, adhesives, etc.); industrial, sanitary, and animal wastes; and certain types of litter.
- **Oxygen-Demanding Substances** – Oxygen-demanding substances are those substances that require oxygen as part of their natural, biological, or chemical processes. The oxygen demand of a substance can lead to depletion of natural oxygen resources in a water body and possibly the development of septic conditions. Proteins, carbohydrates, and fats are examples of oxygen-demanding substances. They can also be referred to as "biodegradable organics." The presence of oxygen-demanding substances in water is measured as biochemical oxygen demand (BOD) and chemical oxygen demand (COD).
- **Floatable Materials** – Trash (e.g., paper, plastic, polystyrene packing foam, aluminum materials, etc.) and biodegradable organic matter (e.g., leaves, grass cuttings, food waste, etc.) are considered floatable materials. The presence of floatable materials has a significant impact on the recreational value of a water body and can potentially impact aquatic species habitat. Excess organic matter can create a high biochemical oxygen demand in a stream and thereby, lower the water quality of the stream. Also, in areas where stagnant water exists, the presence of excess organic matter can promote septic conditions resulting in the growth of undesirable organisms and the release of odorous and hazardous compounds such as hydrogen sulfide.
- **Oil and Grease** – Primary sources of oil and grease are petroleum hydrocarbon products, motor products, esters, oils, fats, waxes, and high molecular-weight fatty acids. Migration of these pollutants to the water bodies are very possible due to the wide uses and applications of some of these products in either municipal, residential, commercial, industrial, or construction areas. Elevated oil and grease content can decrease the aesthetic value of the water body, as well as the water quality.
- **Bacteria and Viruses** – Bacteria and viruses are micro-organisms that thrive under certain environmental conditions. Water, containing excessive bacterial and viral levels, can alter the aquatic habitat and create a harmful environment

for humans and aquatic life. This type of water pollution is characterized by high coliform bacterial counts. It is typically caused by excess animal or human fecal wastes in the water. Also, the decomposition of excess organic waste causes increased growth of undesirable organisms in the water. (City of LA , Reference Guide for Stormwater BMPs, 2000, pg 3-5)

EXISTING REGULATORY FRAMEWORK

Beyond the City's proactive activities to protect water quality and steward watershed resources, there are also water quality regulations and requirements with which the City must comply and/or enforce. This section briefly describes fundamental regulatory drivers and provides electronic links for further information. The City recognizes that there are other regulatory agencies and laws which may be applicable to WMP implementation as it relates to water quality

Municipal Regional Stormwater NPDES Permit (MRP), *California Water Quality Control Board, San Francisco Bay Region, Order No. R2-2009-0074-NPDES Permit No. CAS612008*

The MRP is the current National Pollutant Discharge Elimination System (NPDES) Permit under which the City discharges urban runoff. It covers municipal dischargers in Alameda (such as the City of Berkeley as a Permittee), Contra Costa, San Mateo, and Santa Clara counties, and the cities of Fairfield, Suisun City, and Vallejo. The MRP establishes quality and monitoring requirements for discharging urban runoff. These requirements include the use of best management practices for new and significant redevelopment projects, public education and outreach, industrial inspections, and guidance to the City's own Public Works staff to reduce or remove pollutant loads from urban runoff to the maximum extent practicable. The MRP also requires that trash be reduced by 40% by July 2014 when the permit expires. Permittees submit annual reports evaluating their efforts in meeting the NPDES performance standards. swrcb.ca.gov/rwqcb2/water_issues/programs/stormwater/mrp.shtml

Stormwater Quality Management Plan (SQMP)

The SQMP describes a framework for the management of stormwater discharges designed to fulfill the requirements of the MRP. In the SQMP, performance standards are established for each program area component and serve as the reference points upon which municipal stormwater pollution prevention effectiveness evaluations and consideration of opportunities for improvement are made. (NPDES Permit, Findings, pg 5).

California Porter-Cologne Act, *California State Legislature (1969*)
The Porter-Cologne Act is the principal law governing water quality in California. It applies to both surface water and ground water. Porter-Cologne establishes the State Water Resources Control Board as the statewide water quality planning agency, while the nine Regional Water Quality Control Boards are responsible for developing Regional Water Quality Plans (basin plans). These statewide and regional plans include the

identification of beneficial uses of water, water quality objectives, and implementation plans. swrcb.ca.gov/laws_regulations/docs/portercologne.pdf

Federal Clean Water Act, *33 U.S.C. §1251 et seq. (1972)*
The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The basis of the CWA was enacted in 1948 and was called the Federal Water Pollution Control Act, but the Act was significantly reorganized and expanded in 1972. "Clean Water Act" became the Act's common name with amendments in 1977. epw.senate.gov/water.pdf

CITY ACTIVITIES TO PROTECT WATER QUALITY

The City of Berkeley has been engaged in water quality protection activities such as street sweeping, installing and servicing trash receptacles, and cleaning of storm drain inlets well before the issuance of the first NPDES Permit. However, the introduction of the NPDES Permit established many additional stormwater pollution prevention requirements. It also provided a framework for formalizing and tracking the City's stormwater pollution prevention activities.

Alameda Countywide Clean Water Program

With the development of the NPDES permit, the City joined other municipalities in Alameda County, the county, and its special flood control and water conservation district in creating the Alameda Countywide Clean Water Program (ACCWP) in 1991. The ACCWP assists its member agencies by developing model policies and programs, scientific studies, and materials to educate their respective employees, policy-makers, local residents and business communities about stormwater pollution prevention. The program is funded by member agencies through contributions proportional to their area and population —the City of Berkeley contributes about $100,000 annually. By pooling resources and sharing information, all member agencies are continually improving the effectiveness of their urban runoff pollution prevention and control efforts.

There are eight components to the ACCWP:

1. Planning and Regulatory Compliance
2. Municipal Maintenance
3. New Development and Construction Controls
4. Illicit Discharge Controls
5. Industrial/Commercial Discharge Controls
6. Public Information and Participation
7. Watershed Assessment
8. Monitoring and Special Studies

These components are coordinated through subcommittees. All subcommittees report to the Management Committee which is the official decision-making body for the

ACCWP. The presence of staff from each member agency on subcommittees and the Management Committee ensures that program activities and benefits are equitably distributed and responsive to agency needs.

PLANNING AND REGULATORY COMPLIANCE

This component encompasses the major planning, regulatory compliance, watershed management, and administrative activities of the ACCWP and member agencies. This includes the development of partnerships with other organizations and agencies with compatible objectives, such as the Green Business Program and StopWaste.Org. , Under the umbrella of the ACCWP and as an individual permittee, the City engages in the regulatory permit development process by reviewing and commenting on draft legislation and proposed regulations. Every year, the City submits its Annual Report to the SF Regional Water Quality Control Board describing the range of activities completed to comply with the MRP.

MUNICIPAL MAINTENANCE

General Operations

The City's Department of Public Works, Maintenance Division provides the maintenance service for streets, sanitary sewers, storm drain pipelines and its appurtenances, and City-owned creek culverts. City workers employ BMPs to minimize or eliminate the potential discharge of stormwater pollutants in their daily operations. This begins at the City's Corporation Yard and Solid Waste Transfer Station (where vehicles are fueled, washed, and serviced; and chemical-products are used and stored) and extends to field operations such as road repair, asphalt and concrete removal, and graffiti removal.

Proper Handling of Materials & Spill Response

City Maintenance crews often use or handle asphalt and other petrochemical materials, paints, solvents, and other products that if mishandled can become environmental pollutants. Thus, Maintenance staff are trained in the proper collection and disposal of waste materials and chemicals (including recycling when appropriate).

Maintenance staff are also called upon to contain and clean up non-hazardous spills to prevent the discharge of pollutants into storm drains and inlets. Thus, maintenance staff are trained for such activities. When dispatched to handle a non-hazardous spill, Maintenance staff follow spill response notification and reporting protocols to appropriate environmental safety and protection agencies.

Watercourse Water Quality Maintenance

There remain only a small percentage of open water courses on City-owned property. Within City parks, the Parks, Recreation, and Waterfront Department's landscape gardeners remove litter and service trash receptacles. Additionally, City forces from Public Works and Parks inspect and service in-stream trash racks.

More discussion of the watershed-related maintenance programs are provided in Chapter 7.

NEW DEVELOPMENT AND REDEVELOPMENT

Design Review and Post-Construction Inspections

New development and redevelopment project design is critical in that it defines the scope of a project, including its impacts to site-specific natural resources and the potential creation of additional impervious cover. Proposed public or private development and redevelopment projects (outside the public right-of-way) are reviewed at the City Planning Department's Permit Service Center (PSC). The PSC provides pre-application and educational materials containing information on stormwater controls and requirements to developers, contractors, construction site operators, and owners/builders. Through this process, City staff ensure project designs conform to the City's building codes and design standards, which include impervious area limitations and, when necessary, stormwater pollution control measures.

Where runoff from a proposed project may impact the hydrology of an open creek, the project proponent is required to incorporate design measures that prevent additional discharge volumes. The City's *Preservation and Restoration of Natural Water Courses* ordinance (BMC 17.08), also limits a proposed new or redevelopment project's encroachment into the riparian corridor, which provides natural water quality benefits.

Required stormwater runoff treatment and control measures are expected to be in place and maintained over the life of the constructed project. After construction, the City inspects a portion of these sites annually to ensure these measures are in place and are adequately maintained. The City has authority take enforcement actions for violations by its *Discharge of Non-Stormwater into the City's Storm Drain System – Reduction of Stormwater Pollution* ordinance (BMC 17.20).

Construction Controls

In addition to issuing Conditions of Approval for private and public projects outside the public right-of-way, which may require inclusion of stormwater controls in the project design, the City also mandates the construction process follow best management practices to minimize or eliminate the discharge of pollutants. This includes requiring contractors to submit and follow erosion and sediment control plans, appropriate equipment refueling practices, and so on. The City dispatches inspectors to routinely visit construction sites to ensure these BMPs are in place and are adequately maintained. The City has authority take enforcement actions for violations by its *Discharge of Non-Stormwater into the City's Storm Drain System--Reduction of Stormwater Pollution* ordinance (BMC 17.20).

INDUSTRIAL/COMMERCIAL INSPECTIONS

Both the Planning Department's Toxics Management Division (TMD) and the Public Health Department's Environmental Health Services Division conduct routine inspections of industrial or commercial business sites that have high potential to be stormwater pollution sources. These business types include, but are not limited to: restaurants, dry cleaners, corporation yards, automotive repair facilities, gas stations, and photo-processing and printing shops. Sites are inspected once every three years to ensure detergents, cleansers, solvents, food waste grease, oil, liquids from dumpsters, mop water, and pressure washer effluent are properly handled and not discharged to storm drains or creeks. The City has authority take enforcement actions for violations by its *Discharge of Non-Stormwater into the City's Storm Drain System--Reduction of Stormwater Pollution* ordinance (BMC 17.20). Enforcement actions are taken against non-compliant businesses.

ILLICIT DISCHARGE CONTROL ACTIVITIES

The Public Works Department is tasked with removing illegally dumped material. Annually, 160 tons of materials, debris and waste are dumped on the streets of Berkeley. The cost to clean up illegal dumping is over $100K a year. The Public Works Department conducts additional targeted litter control activities, such as the hand sweeping and steam-cleaning of sidewalks in designated areas of the City (i.e. Downtown, San Pablo Avenue, Telegraph Avenue, South Berkeley, and North Shattuck). Approximately 360 tons of materials are collected and disposed of through the City’s illegal dumping and targeted litter abatement programs. The City also provides and maintains litter receptacles in commercial areas and other litter source areas.

The Toxics Management Division implements the MRP-required Illicit Discharge Screening Program by conducting a survey of 10 strategic check points each year in dry weather conditions. The screening points include:

- Potter Outfall
- University Outfall (behind Seabreeze Market, Strawberry Watershed)
- Virginia Outfall (Schoolhouse Watershed)
- Gilman Outfall
- Strawberry Creek Park (near Corp Yard)
- Strawberry Creek @ Oxford
- Codornices Creek at Albina (St. Mary’s College High School)
- Codornices Creek Park/Rose Garden
- Capistrano Creek behind Thousand Oaks School
- Harwood Creek @ Brookside Ave. (located near the Oakland border, off of Claremont, and is the Temescal Watershed)

By ordinance the discharge of non-stormwater into storm drains and watercourses is prohibited. Reports of non-stormwater discharges to the 311 customer service system are routed to the appropriate City Department for investigation and enforcement. The Department of Public Works or the Planning Department’s Building and Safety Division staff respond to construction-related discharges. Environmental Health inspectors respond to restaurant and sewage related discharges. The Toxics Management Division responds to hazardous substance discharges.

PUBLIC INFORMATION AND PARTICIPATION

The diffuse sources of urban runoff pollutants (many generated by activities outside the City’s control, such as over-use of pesticides and fertilizers) make them particularly difficult to minimize or eliminate. As the general public becomes more aware of the sources and impacts of non-point source pollution, individual and community behaviors and actions that contribute to the problems are likely to change. In addition to its numerous maintenance activities, commercial and industrial business inspection programs, and design and construction requirements, the City also strives to increase public awareness about stormwater pollution prevention.

The City participates in fairs and public events (such as the Solano Stroll, the Spice of Life Festival, and the Watershed Poetry Festival) by staffing information booths to provide information and explanation on BMPs and alternative methods for pest control, automobile maintenance and washing, animal care, etc. intended to reduce urban runoff pollution. For the 2011 Berkeley Bay and Earth Day Festivals, city staff emphasized a pesticide-use reduction message by distributing non-toxic pest control recipes, coupons, and other educational materials.

As part of its Group Activities, the ACCWP also develops regional, countywide, and local public outreach campaigns and materials. This can take the form of targeted outreach, educational pamphlets and booklets, or public service announcements in electronic and print media. The ACCWP also funds school-based programs and awards small grants ($5,000 maximum) for local community watershed stewardship activities.

Volunteer Opportunities

The City also encourages citizens to volunteer in activities designed to reduce or eliminate water pollution. These activities include:

- Storm Drain Inlet Stenciling: Public Works staff provide safety training, maps, and equipment needed for volunteers to paint the "No Dumping, Drains to Bay" message onto storm drain inlets. Volunteers typically include school groups, community-service organizations, and environmental stewardship organizations. This message is designed to make people aware that storm drain inlets are not trash receptacles. The City will use a new metallic medallion with a similar message on storm inlets in commercial areas this year. The medallions should last much longer that painted stencils, which tend to wear out after a few years.

- Adopt-A-Drain Program: On-going program where a citizen or business commits to proactively removing accumulated debris and litter from around a particular (set of) storm drain inlets. Public Works staff provide safety training and equipment needed for volunteers to rake, scoop, and bag debris for City pick-up. There are about 70 Adopt-A-Drain volunteers throughout the City.

- Coastal Clean-Up: annual event where Berkeley citizens and city forces (Parks and Recreation and Public Works) work to collect and count litter and debris from Berkeley's shoreline and Aquatic Park Lagoons. This effort is combined with shoreline and watercourse clean-up activities across the state to ascertain the amounts and types of litter most common in local waterbodies. This information is used to develop local and state policies designed to curb these pollutant sources. Plastics, food packaging, and cigarette butts are consistently at the top of items removed.

- UC Berkeley Community Enhancement Projects Days: Up to three times a year, the University of California and the City of Berkeley partner to provide hundreds of student volunteers for community enhancement projects around the City. These volunteer efforts usually include a few dozen volunteers dedicated to cleaning around and/or stenciling storm drain inlets, often in areas around the UCB campus.

- Open Space/Watercourse Stewardship: The City coordinates with and supports the efforts of citizen-based, non-governmental groups wanting to provide additional maintenance or approved improvements to City-owned open spaces or creeks on City-owned property. These efforts can include weed abatement, trash collection, trail building, and planting activities.

  The City conducts annual trash clean up and assessment activities at three Hot Spots along waterbodies, as a requirement of the MRP. The goal not only is to remove trash, but also to quantify the volume and identify the dominant types of trash removed. The 3 Hot Spots are:

  1. Brickyard Cove, Bay shoreline just south of University Avenue.
  2. Aquatic Park Main Lagoon, north-east shoreline from Touchdown Plaza towards Bancroft.
  3. Codornices Creek, from Second Street upstream to UPRR.

  The work is performed by volunteers under supervision of City staff either during the Coastal Clean Up or scheduled separately. Volunteer groups also perform clean-up activities along these sites on other occasions, without the coordination or supervision of City staff. It is recommended the City develop Volunteer Trash Assessment Protocols so non-supervised volunteer groups can collect trash data that the City can use to monitor rates of accumulation, likely sources, and volumes removed.

ACCWP Group Activities

The implementation of most MRP requirements is left to the individual municipalities. However some MRP components are more practicably conducted under the umbrella of the ACCWP as Group Activities. These include Watershed Assessment, Monitoring and Special Studies, and elements of Public Outreach. This is because assessment results, study findings, and outreach campaigns are generally applicable to multiple jurisdictions within the county. In this same vein, other Countywide Clean Water Programs around San Francisco Bay collaborate on regional efforts through the Bay Area Stormwater Management Agencies Association (BASMAA).

WATERSHED ASSESSMENT

The focus of this component is on characterizing landscape-level attributes of watersheds and streams within Alameda County, with consideration of beneficial uses and management issues specifically tied to physical, biological, or social conditions in individual watersheds.

Using pilot watersheds throughout the county, the program has identified indicators and benchmarks for evaluating the conditions of an urban creek's beneficial uses. These indicators and benchmarks include: measurements of individual pollutants, characterization of the amount and timing of creek flows in relation to preciptiation, and surveys of diversity and composition of plant and animal communities living in creeks and adjacent riparian areas.

MONITORING AND SPECIAL STUDIES

This program component addresses pollutants and problems that tend to be uniformly distributed in urbanized areas where study and management areas are greater than the individual watershed scale. The results of the water quality monitoring and related activities are used to focus collective and individual member-agency actions that reduce pollutant loadings to protect and enhance receiving waters and to comply with regulatory requirements.

The Clean Water Program conducts or participates in are numerous on-going monitoring and special study efforts, including:

- Regional Monitoring Program for Trace Substances (RMP): collaborative effort with the San Francisco Estuary Institute (SFEI) involving collection and analysis of data on pollutants and toxicity in water, sediment, and biota of the Estuary
- Status Monitoring/Rotating Watersheds: seasonal sampling program conducted on a rotating-watershed basis to assess biological characteristics, general water quality, chlorine levels, temperature, water column toxicity, sediment-based toxicity and pollutants, pathogen indicators, and stream surveys.
- Pollutants of Concern (POC) Monitoring: assesses inputs of POCs to the Bay from local tributaries and urban runoff. It is also assesses progress toward achieving wasteload allocations for Total Maximum Daily Loads (TMDL) and helps resolve uncertainties associated with loading estimates.
- Long-Term Trends Monitoring: assesses long-term trends in pollutant concentrations and toxicity in receiving waters and sediment to evaluate if stormwater discharges are causing or contributing to toxic impacts on aquatic life.

The findings of the monitoring programs have lead to the establishment of TMDLs by the Water Board for diazinon and pesticide toxicity in urban creeks, mercury, and PCBs. The Water board also plans to establish TMDLs for other pollutants of concern such as PBDEs, Legacy Pesticides, and Selenium. The ACCWP continues to conduct and participate in targeted Pollutant of Concern studies, reduction plans, and programs to identify pollutant levels and potential sources. These include:

- Pesticide Toxicity Control: Currently the Pesticides of Concern include: 1) organo-phosphorous pesticides, 2) pyrethroids, 3) carbamates, and 4) fipronil. The Program coordinates with BASMAA, the Urban Pesticide Pollution Prevention Project, and the Urban Pesticide Committee to track data, express concerns, and request consideration of its issues in federal and state insecticide registration decisions. The Program also participates in the "Our Water, Our

World", a point-of-purchase campaign that encourages retailers to stock and promote the sale of less-toxic alternatives to pesticides. The ACCWP prints and distributes pesticide-related brochures, fact sheets, and informational guides, as well as financing the development of regional and local Advertising campaigns aimed at reducing the use of pesticides

- Sediment Bound Pollutants (Mercury, PCBs, legacy pesticides, PBDEs): The Water Board has established a TMDL for Mercury and one pending approval for PCBs. The Program conducts special Mercury & PCB monitoring programs and pilot projects to evaluate: the abatement of sources in drainages, enhancement of sediment removal and management practices, on-site treatment practices, diversion of first-flush flows to wastewater treatment facilities, and quantification of loads and loads reduced to name a few).
- Copper Controls: The Program participates in the Brake Pad Partnership, a collaborative process to reduce copper discharged from automobile brake pads.

Additional monitoring and special studies that are to be undertaken in response to the requirements of the MRP include: 1) stressor/source identification as follow-up to monitoring results, 2) Best Management Practices (BMP) effectiveness investigations, 3) geomorphic data collection for creeks, and 4) sediment delivery estimations to determine sediment volumes entering the bay from local tributaries, 5) studies on emerging pollutants such as endocrine-disrupting compounds and estrogen-like compounds, 6) and citizen monitoring and participation.

Additional City Policies Relevant to Water Quality Protection

Integrated Pest Management (IPM)

The City has maintained an Integrated Pest Management (IPM) approach since 1988 with its Revised Pest Management Policy, Resolution No. 54,319-N.S. The policy assumes that pesticides are hazardous to human and environmental health, thus non-chemical management tactics should be employed first. Use of chemicals is to be considered as a last resort and must follow the Pesticide Selection Criteria established in the resolution.

Precautionary Principle

Through its adoption of the "Precautionary Principle" by Resolution Number 62,259-N.S. in 2003, and the "Environmentally Preferable Purchasing Policy" by Resolution No 62,693-N.S.in 2004, the City reaffirmed its commitment to minimizing health risks to City staff and residents, minimizing the City's contribution to global climate change, improving air quality, and protecting surface water and groundwater quality.

Bay Friendly Landscaping

Established by Resolution Number 64,507-N.S., this policy requires new development, redevelopment, or renovation projects initiated by the City (after August 1, 2009) with greater than 10,000 sq. ft of landscaping to achieve the minimum Bay-Friendly Landscape Scorecard points into their design and implementation. Other City projects, not meeting the 10,000 sq. ft. threshold, are required to achieve the most Bay-Friendly Scorecard points as practicable. These Bay-Friendly Scorecards and associated Guidelines, developed by StopWater.org (formerly the Alameda County Waste Management Authority), promote green landscaping as a whole-systems approach designed to conserve natural resources, reduce waste, minimize water and pesticide use, and reduce stormwater run-off. Further, green landscaping also creates wildlife habitat, protects local ecosystems, promotes native plant species, and reduces maintenance needs.

RECOMMENDATIONS FOR WATER QUALITY PROTECTION ACTIVITIES

4.1 ACCWP Planning and Regulatory Compliance activities, including: Management Committee and subcommittees, Watershed Assessment Program, and Monitoring and Special Studies – continue at existing level

4.2 New Development and Redevelopment Controls – continue at existing level

4.3 Industrial/Commercial Discharge Inspections & Controls – continue at existing level

4.4 Illicit Discharge Control Activities – continue at existing level

4.4 Private Property LID Promotion - Examine Policy Option to Reduce Hydromodification and C.3 Thresholds. Explore the potential impacts (to staff resources and property owners) of reducing existing threshold requirements that trigger the use of LID and other stormwater management techniques to avoid hydromodification and increased runoff.

4.5 Trash Assessment Protocols – develop Trash Assessment Protocol guidance for volunteers. Trash collection activities are conducted by volunteer groups throughout the tear. Sometimes these events take place in the designated Hot Spots, without supervision by City staff. With the proper protocols available, non-supervised volunteer groups can collect trash data that the City can use to monitor rates of accumulation, likely sources, and volumes removed.

CHAPTER 5: CREEKS

In the WMP, “creek” is synonymous with “open channel”, “open watercourse”, “natural watercourse”, and “stream”. The term “creek” is defined in the BMC Chapter 17.08 as a watercourse that: *1) carries water from either a permanent or natural source, either intermittently or continuously, in a defined channel, continuous swale or depression, or in a culvert that was placed in the general historic location thereof; and 2) the water either merges with a larger watercourse or body of water, or is diverted into an engineered structure that does not follow the general historic course of creek. A "creek" does not include any part of an engineered structure developed for collection of storm or flood waters (e.g. a storm drainpipe) that does not follow the general historic course of a creek. A "permanent or natural source" includes a spring, artesian well, lake, estuary, or a rainfall drainage area that covers at least one-third acre (14,520 square feet).*

The protection of natural waterways and aquatic habitat is identified as a goal of the WMP. This chapter reviews: the benefits of open watercourses, the City’s regulations to protect creeks, the City’s role in Floodplain Administration, and the responsibilities of property owners with creeks and creek culverts on their property. Finally, this chapter gives an overview of general creek functions and their associated habitats.

BENEFITS OF OPEN WATERCOURSES

The City recognizes the importance and benefits of creeks, as set forth in BMC Chapter 17.08. This ordinance states that the desired condition of creeks within the City includes natural stream banks and a corridor of natural vegetation. This is to support channel stability, natural ecosystems, water quality, and physical attributes of natural watercourses. Creeks and their associated natural habitats provide myriad water resource and ecological benefits to both humans and wildlife. A summary of these benefits is provided below:

- **Stormwater/flood control –** A healthy creek corridor can detain stormflow volumes and reduce flow velocities, thereby moderating flooding and protecting downstream areas. Aquatic vegetation slows the flow of water through physical resistance while features such as bank terraces can provide additional storage capacity.
- **Water quality –** Wetlands vegetation can protect and enhance water quality by removing toxins, such as oils, herbicides, and pesticides, and excess nutrients and sediments from influent water.
- **Groundwater recharge –** By slowing the flow of water, vegetation facilitates groundwater recharge by increasing residence time, allowing water to seep into the soil and enter underlying aquifers.
- **Wildlife habitat –** Structural complexity and rejuvenation are maintained by flooding and channel movement, contributing to the diversity of wildlife species in riparian corridors. Wildlife utilizes these corridors for roosting, breeding, foraging,

and refuge. High-value riparian habitat has a dense and diverse canopy structure with varied vegetation heights creating complex microhabitats.

- **Aquatic habitat –** Roots, fallen logs, and overhanging branches from riparian vegetation create diverse habitats and cover for fish, aquatic insects, and invertebrates. Bed substrate is also used by fish for redd (spawning nest) construction.
- **Temperature –** Overhanging trees and other riparian vegetation shade streams and reduce water temperatures, particularly during the summer months when streamflow is typically lower. Elevated water temperatures can be stressful or lethal to many insects, amphibians, and fish species.
- **Erosion control and channel stability –** Riparian and aquatic vegetation can help minimize erosion and sedimentation, stabilizing stream banks with their root systems. Excessive erosion can undercut stream banks and reduce channel complexity. Channel incision can lead to reduced groundwater levels. Excessive sedimentation can reduce the capacity of the channel to carry floodwaters and can smother fish spawning and foraging areas.
- **Recreation opportunities –** Habitat restoration along creeks and wetlands can include trails and other recreation opportunities to enhance visitors' enjoyment of the area, such as bicycling, walking, jogging, and bird-watching. As an innovative example, the recently constructed Codornices Creek Restoration project between Eight and Sixth Streets incorporates an outdoor classroom feature.
- **Existence value –** Existence value refers to the value of the watershed as a natural resource, outside and irrespective of human values.
- **Water supply –** Headwater tributaries and lower stream corridors provide and convey fresh water sources for humans and wildlife, both through conveyance of runoff and exchanges with underlying aquifers.

CURRENT STATUS OF CREEKS

Open Creeks

According to the City's GIS database, there are approximately 8 miles of open creeks within Berkeley city limits (Table 5-1). About 10% (less than 1 mile) of this total length is on City-owned property. The remaining 7 miles are located on private property. The Berkeley Hills retain the majority of open watercourses within the City limits (Cerrito Creek, Blackberry Creek, Capistrano Creek, Codornices Creek, Strawberry Creek, Derby Creek (Potter Watershed), and Harwood and Vicente Creeks (Temescal Watershed).

Creeks are complex, interdependent systems where actions in one location may have significant impacts either upstream or downstream, regardless of property lines. More data is needed to further refine the WMP in regards to preserving and enhancing creeks and their associated habitats. Because the majority of open watercourses flow thorough private property, access to conduct creek and habitat condition investigations would require the permission of the property-owners.

Volunteer-based Creek Assessment Pilot Program

The City could develop a pilot program for using trained volunteers using Global Positional System (GPS) equipment to collect in-stream and creek bank features (physical conditions and habitat data) for mapping and analyses. This information can be used to improve the City's GIS maps, refine future hydraulic modeling efforts, and identify common concerns across property lines. This pilot program would start on Codornices Creek.

Creek BMP Guidance Materials

Information generated from future data collection efforts can help the City identify common problems and opportunities. It can also help tailor guidance materials the City can develop to help property owners make informed creek management decisions.

Creek Culverts

There are approximately 7.35 miles of active creek culverts within city limits (Table 5-1). About 60% (just over 4 miles) of this total length is on City-owned property, mostly where streets cross over creek corridors. The remaining 3.15 miles of culverted creeks are located on private property.

Creeks & Creek Culverts by Watershed	Citywide	Cerrito	Marin	Codornices	Schoolhouse	Strawberry	Potter	Temescal	Wildcat
Estimated Open Creek Length (ft)									
Total	42,139	5,063	6,116	15,477	1,690	7,092	2,254	4,447	0
City Property	3,010	211	508	1,873	0	298	0	120	0
Private Property	39,129	4,852	5,608	13,604	1690	6,794	2,254	4,327	0
Estimated Active Creek Culvert Length (ft)									
Total	35,059	2,220	4,284	11,435	2,309	9,501	3,037	1,848	426
City Property	19,959	924	3,066	6,083	1,287	5,796	1,676	1,127	unk
Private Property	14,674	1,297	1,218	5,351	1,022	3,705	1,360	721	unk

Table 5-1, Creeks and Creek Culverts by Watershed

Wherever an open or culverted creek traverses city-owned property, the City is bound by the same regulations as any other property-owner. If the City desires to restore a length of creek or construct a facility in or adjacent to a creek or creek culvert, it too must obtain and pay for a Creek (Culvert) Permit. The City is also responsible for obtaining any other necessary permits from regional, state, and federal agencies as appropriate (including, but not limited to the California Department of Fish and Game, the Regional Water Quality Control Board, and the US Army Corps of Engineers).

The City, like any other property owner, is also responsible for the maintenance and stewardship of those portions of the creek or creek culvert on its property. This is further discussed in Chapter 7. Whether within the public right-of-way or on other city-owned property where the creek centerline defines the City's jurisdictional boundary, maintenance responsibilities are either shared with the neighboring municipality or wholly the responsibility of one jurisdiction.

Creek Culvert Conditions Assessment Program

A Closed Circuit Television (CCTV) Investigation program, using remote camera technology and certified confined spaces personnel, is needed for physical conditions assessments of creek culverts under the right-of-way or on City property. This program would help the City identify and determine of the extent of needed repairs and to prioritize and budget for these needs. This program should strive to investigate 20% of the city-owned creek culverts annually. This would begin with the Potter and the Codornices Watersheds, to understand how needed repairs may impact the rehabilitation portion of the Capital Improvement Program in Chapter 8.

Creek Culvert Rehabilitation Program

Based on results of hydraulic modeling and CCTV investigations, the City would develop a Creek Culvert Rehabilitation Plan (CCRP). The CCRP would identify and prioritize any needed repairs.

Private Creek Culverts

Creek culverts on private property are a concern because of their age and lack of maintenance. Many property-owners are unaware that culverts are their property. The City receives numerous calls from property owners and potential buyers looking for information about creek culverts. Many creek culverts were installed by private developers to expand buildable space prior to 1929 when the City began requiring permits for their construction. The City generally does not have record of most of these private structures other than location locations on historic maps.

CITY REGULATORY ROLES

As an entity, the City of Berkeley has three primary regulatory roles related to creeks: 1) Compliance and Enforcement of MRP pollution prevention requirements, 2) Creek Protection Ordinance Compliance and Enforcement, and 3) Floodplain Administration.

MRP Compliance

Urban Creeks that are tributary to the San Francisco Bay have been designated as "impaired" by diazinon and trash by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). A Total Maximum Daily Load (TMDL) allocation, expressed in toxic units and diazinon concentrations, has been established for all urban runoff. The City has already adopted and continues to implement an Integrated Pest Management Policy (Resolution No. 54,219-N.S., 1988) that directs a less-toxic approach to pest management. The MRP also establishes trash-related Receiving

Water Limitations, requiring municipal permittees to take actions to reduce trash loads by 40% by 2014. These issues are further discussed in Chapters 4 and 7.

Open watercourses are protected by Hydromodification Management (HM) requirements mandated by the MRP and are implemented by the Planning Department. HM requirements currently target new and redevelopment projects that create and/or replace one acre or more of impervious surface. It prohibits any increased stormwater discharges from such projects that could affect creek bank and/or bed erosion, silt generation, and other potential adverse impacts to the receiving watercourse. City staff also inspect all required HM controls to ensure they are being properly operated and maintained over the life of the project. Additional discussion of MRP requirements is provided in Chapter 4.

Creek Protection Ordinance

In 1989, the City passed an ordinance which established development setbacks to maintain a riparian buffer zone. The ordinance was further revised in 2006 to reflect the recommendations of the Creeks Task Force, a City Council-created body charged with studying the existing regulations and proposing policy. The latest version includes a 30 foot setback from the centerline of an open creek for new development, although some expansion of existing buildings may occur within 25 feet of an open creek with issuance of an Administrative Use Permit. Construction within 15 feet of the centerline of a culverted creek is regulated to ensure that the project and the culvert will not have a negative impact on each other and to ensure appropriate setbacks that promote safety and allow access for maintenance and repair. The current ordinance and guidelines for compliance are available on the City's webpage: www.cityofberkeley.info/CreeksOrdinance.

Distinction between Creek Culverts and Storm Drains

The City provides many services to its residents such as maintaining storm drain pipes in the right-of-way and performing flood investigations related to creeks. However, creeks are the responsibility of the owner of the property within which the creek lies. A few of the major differences between creeks and storm drain pipes are:

- Most creeks and creek culverts retain the name “creek” in their name.
- The alignment of creeks and creek culverts follow closely the original path of the creek. Most storm drain pipes follow street alignments.
- Creeks and creek culverts are generally constantly fed by natural sources. Storm drain pipes are generally empty except during and immediately after rainstorms.
- Creeks provide habitat value. Storm drain pipes do not.
- Creek culverts were typically built (a) by private developers to enlarge the buildable space on private lots, or (b) by the City to allow a street to pass over a creek. Storm drain pipes are public structures under streets designed to carry stormwater runoff.

Floodplain Administration

Flood zone development in the city is regulated through implementing the requirements set forth in BMC Chapter 17.12—Flood Zone Development. This chapter was last updated by Ordinance No. 7,108—N.S. in September 2009. The requirements of BMC 17.12 make flood insurance available to homeowners, renters, and business owners in the City, through the federally backed National Flood Insurance Program (NFIP). BMC 17.12 establishes procedures for reviewing new and redevelopment projects, administering changes to the Flood Insurance Rate Map (FIRM), and processing appeals and variances.

Watercourse Flooding – Investigation & Assessment

In cases of emergency, the City is often the first responder. The City performs Watercourse Flooding – Investigation & Assessment site visits regardless of property-ownership as a matter of public safety. These investigations often seek to determine additional circumstances above and beyond natural causes leading to damages. The City may undertake enforcement activities on the responsible party if it is found that negligent maintenance or other preventable condition contributed to the damages.

CREEK RESTORATION

Creek restoration can encompass a range of objectives and activities. At minimum, restoration includes reestablishing native riparian plant communities on creek banks to naturally enhance bank stability, habitat, and water quality. Restoration can also include more intensive measures to reestablish natural channel form (cross-sectional dimensions, meander pattern, and profile) while maintaining or increasing flow capacity. This type of project is typically done to move the creek towards an equilibrium state where it is transporting both water and sediments without excessive deposition or erosion. When the physical form and vegetation are restored, the creek ecosystems are rejuvenated.

In urban settings, creek restoration reaches are often defined by upstream and downstream creek culverts which serve as fixed controls. Often times the creek reach between these control points crosses several property lines, necessitating coordination and partnerships.

The City has engaged in numerous creek restoration and stewardship projects over the years either as a project lead or project participant. This includes the 1986 daylighting of a 220’ reach of the Strawberry Creek culvert in the creation of Strawberry Creek Park, between Addison and Bancroft Streets. This project is widely considered to be the first daylighting project in the country.

Joint Watershed Goals Statement

In 1996, the City—in partnership with the cities of Albany, El Cerrito, and Richmond, and the East Bay Regional Park District, and the University of California—adopted a Joint Watershed Goals Statement, committing each entity to cooperate closely to achieve the following goals:

- Restoring creeks by removing culverts, underground pipes, and obstructions to fish and animal migration
- Restoring creek corridors and natural transportation routes with pedestrian and bicycle paths along creekside greenways; wherever possible using creekside greenways to connect neighborhoods and commercial districts east of the Interstate 80 freeway to the shoreline of San Francisco Bay and the San Francisco Bay Trail.
- Restoring a healthy freshwater supply to creeks and the bay by eliminating conditions that pollute runoff and eliminating conditions that prevent groundwater recharge
- Instilling widespread public awareness of the value of developing infrastructure along lines that promote healthier watersheds and watershed oriented open spaces where nature and community life can flourish.

Lower Codornices Creek

The City is a partner with the City of Albany and UC-Berkeley in the long-range planning, implementation, and maintenance of restoring a ½ -mile stretch of Codornices Creek from San Pablo Avenue to the UPRR railroad tracks (Third Street). Thus far the project has completed three phases, restoring the creek corridor from the railroad tracks to 8th street. In addition to restoring meanders, modified floodplain terraces, and native riparian vegetation, this effort also includes construction of a bicycle/pedestrian trail and an outdoor classroom.

Additional locations on Codornices Creek have been identified as candidate restoration sites, pending agreements with partners and property owners and securing funds to design, implement, and maintain. These sites are:

- Eastshore Hwy Rd to UPRR tracks
- Vacant Lot on Kains Avenue

WATERCOURSE FUNCTIONS & ASSOCIATED HABITATS[4]

Natural water courses are innate features of watersheds, occurring in topographical depressions where surface runoff and groundwater contribute to channel forming flows. The channel form is further dictated by a complex combination of climatic conditions, geology, and ecology. Bay Area creeks originate in elevated headland areas and flow toward the Bay plain at a rate relative to slope or gradient and the volume of surface runoff or discharge. During travel across the alluvial fan, stream velocity generally declines, water temperatures and turbidity tend to increase, and the channel bottom changes from rocky to muddy (McNaughton and Wolf 1973). At the Bay, discharge into

[4] The following descriptions of Bay Area Watercourse Functions, Associated Habitats, Common Impacts, and Linkages Between Hydrology, Geomorphology, Water Quality and Habitat are taken from Chapter 2 of the *Watershed Management/Habitat Protection and Restoration Component of the San Francisco Bay Area Integrated Regional Water Management Plan*, created in 2006 by Jones and Stokes. Some minor changes have been made to the text to be more descriptive of Berkeley conditions.

tidal marshlands forms a salinity gradient from brackish to saline, depending on the volume of discharge from streams.

Creeks can be divided into the following categories, which generally describe their function within a watershed.

- **Ephemeral:** Channel contains flow for short periods of time during a rainfall event or immediately after the event and become dry between events.

- **Intermittent:** Channel contains flowing water seasonally and is supported by direct runoff as well as sub-surface baseflow. In the dry summer months, there is no flow, but isolated pools may persist.

- **Upper Perennial:** Generally located in the zone between mid to lower watershed, there is no tidal influence and some water flows throughout the year. The substrate consists of rock, cobbles, or gravel with occasional patches of sand. Gradient and velocities are lower than in the upper watershed intermittent systems, though steeper than the lower perennial and tidal zones, and there is very little floodplain development.

- **Lower Perennial:** Found in the lower Bay watersheds approaching the tidal zone, the water velocity is slower than the upper perennial reaches. There is no tidal influence, and some water flows throughout the year. The substrate consists mainly of sand and mud. Oxygen deficits may sometimes occur. The fauna is composed mostly of species that reach their maximum abundance in still water. The floodplain is well developed.

- **Tidal:** The gradient is low and water velocity fluctuates under tidal influence. The streambed is mainly mud with occasional patches of sand. Oxygen deficits may sometimes occur. Historically, the floodplain along the tidal front was broad, but in much of the Bay Area today, these floodplains are more restricted due to levees, roadways and other human development.

- **Habitat Types:** From headwaters to confluence, open creeks create a wide variety of habitat settings. In addition to aquatic and riparian habitats, adjacent upland vegetation plays an important role in watershed ecosystems. Many bird and terrestrial species use both upland and wetland areas for different lifecycle needs, and connectivity among these areas is essential for sustaining wildlife populations.

Creeks (Riverine)

Water flows, velocity, depth, and tree shading determine the quality of riverine habitats. Due to the Mediterranean climate, nearly all Bay Area streams experience very low flows and nearly dry up at some point. Because of the intermittent nature of flows, water temperatures in mainstem riverine habitat are not constant. In general, small, shallow streams tend to follow but lag behind air temperatures, warming and cooling with the seasons as well as the day/night cycle. Creek with large areas exposed to direct sunlight are warmer than those shaded by trees, shrubs and high, steep banks. The eddying and churning of high-velocity water over riffles and falls results in greater contact with the atmosphere, and thus a high oxygen content. In polluted waters, deep holes, or low velocity flows, dissolved oxygen is lower (Smith 1974). This habitat supports 1) the water-loving flora (alders, willow, etc) which comprise the riparian zone, 2) benthic macroinvertebrate organisms (BMI) which are aquatic animals, such as the nymph stage of damsel flies and dragonflies, worms, crayfishthat generally feed on the vegetative detritus of leaf fall, 3) fish and birds, who feed on the BMI.

Codornices Creek still supports a native population of rainbow trout as well as steelhead salmon (*Oncorhynchus mykiss*) (Keir Associates, 2007) (Leidy, 2007), which is federally designated as a threatened species.

Riparian

Riparian habitat is found along rivers and streams, as well as lakes, ponds, reservoirs and other water bodies or drainages. Riparian ecosystems are generally characterized by increased structural diversity, as compared to surrounding plant communities (Manci 1989). Live oak, big leaf maple, California bay, and Fremont cottonwood are typical dominants of riparian habitats in the Bay Area. Tree cover provides hiding places for aquatic species to escape predation, increased substrate for food items and for egg attachment. Shading produces lower water temperatures which benefit many aquatic species. Tree litter contributes organic substances to the aquatic system (Brooks et al. 2003). The range of wildlife that use riparian habitat for food, cover, and reproduction includes amphibians, reptiles, birds, and mammals. Terrestrial species that benefit from the region's riparian zones include: raccoons, striped skunk, coyote, deer, gray fox, bobcats, and mountain lions. These habitats are critical for at-risk or protected species including the bald eagle, golden eagle, Swainson's hawk, Cooper's hawk, foothill yellow-legged frog, and steelhead salmon.

Tidal Wetlands

Tidal wetlands are characterized as salt or brackish marshes. Tidal wetlands extend from moist grasslands and riparian habitats downstream to intertidal sand and mud flats along the Bay margins. Salt marsh vegetation is generally found immediately adjacent to the Bay and along the margins of associated creek and slough channels where the water is relatively saline. Plant species composition is dependent on elevation, and level and frequency of inundation relative to the daily tidal cycle. The lower portions of the marsh (below mean high water) are inundated more frequently and typically support monotypic stands of California cordgrass. The mid-portion of the marsh is inundated less frequently (mean high water to mean higher high water) and is typically dominated by pickleweed, as well as Jaumea and the parasitic salt marsh dodder. The upper portions of the marsh (above mean higher high water) are inundated infrequently and support an assemblage of plant species that are adapted to drier, more saline conditions, including alkali heath, sea lavender, salt grass, marsh gum plant, and brass buttons.

Waterfowl, herons, egrets, rails, gulls, terns, and a variety of shorebird and songbird species all use tidal wetlands habitats for foraging and nesting. Tidal wetlands are also often the preferred habitat for specialized groups of insects and other invertebrates that rely on a saline environment. Wetlands are important habitat for at-risk Bay Area species including the California clapper rail, California black rail, western snowy plover, California least tern, song sparrow, salt-marsh common yellowthroat, salt-marsh harvest mouse, harbor seal, steelhead, and Chinook salmon.

Uplands Habitats

Uplands habitats consist of adjacent lands that are important to wetland and riverine ecosystems, but that are not typically inundated by surface water. Uplands habitats throughout the Bay Area typically include grasslands, oak woodland, and mixed evergreen forest. In Berkeley, the Oak-Woodland ecosystem dominates. Oak woodlands are an integral part of watershed ecosystems as they provide important foraging, roosting, and breeding habitat for many species of amphibians, reptiles, birds, and small mammals. Representative species associated with oak woodlands include southern alligator lizard, gopher snake, red-tailed hawk, California quail, acorn woodpecker, western jay scrub, California ground squirrel, and black-tailed deer (Goals Project 1999).

Common Impacts to Creeks & Associated Habitat

Flow Regime, Channel Incision and Aggradation

Flow volumes also determine the resulting amount of in-stream and riparian habitat, as creek bed material, channel morphology, and flow hydraulics affect habitat quality for aquatic species (Young 2001). Changes in the physical characteristics of in-stream and floodplain habitats can lead to associated changes in local species composition and diversity. With increased in flow volume and velocities associated with urbanization, peak storm events scour the channel bed, mobilizing and transporting bed material downstream, reducing the quality and quantity of habitat (e.g., fish spawning[5] gravels, and redds[6]).

While creeks are more commonly known for their water transport capabilities, they also transport sediment. Stream channels undergo continuous modification (plan form, slope, and cross-sectional dimensions) through processes of erosion or deposition of bank and bed materials. Watershed enhancement or restoration projects should take into account the incision and deposition characteristics of a particular creek.

Though incision (down cutting of the creek bed through stream flow erosion) can occur due to natural processes, in the Bay Area most channel incision is attributed to human land uses. High flows can result in sorting of bed sediment on riffles and point bars, as well as abrasion across the bedload surface and/or riparian and aquatic plants (Brookes 1995). Scouring of the bed and banks and around structures is accompanied by subsequent deposition of sediment elsewhere in the watershed, both of which can

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[5] Spawning refers to the reproductive process of aquatic animals (not including mammals) that release or deposit eggs and sperm**,** usually into water

[6] A Redd is a depression in the gravel of a spawning stream where a female lays her eggs.

increase maintenance costs. Channel incision often occurs where less overbank flow occurs (typically areas where the creek is disconnected from its natural floodplain). In many cases, changes in channel morphology associated with incision (i.e., smaller width to depth ratio) result in development of a narrow steep-banked channel with low species diversity and low habitat complexity.

Bed aggradation occurs in creeks, mostly in Bay plain settings where eroded materials from watershed headwaters are deposited. Downstream reaches typically aggrade due to high sediment yields carried downstream from incising reaches as well as breaks in channel slope at the alluvial fan. Aggradation can lead to reductions in channel capacity, thereby creating flood hazards in downstream reaches.

Surface Runoff and Erosion

Runoff and erosion processes are key factors affecting creek bed and bank stability, and the quality of aquatic and riparian habitat systems. Erosion can cause degradation of downstream water quality (turbidity), embeddedness of streambed substrate, reservoir sedimentation, and bank erosion and bed degradation in downstream reaches (Brooks et al. 2003).

One of the most obvious linkages in a watershed is the relationship between surface runoff and sedimentation caused by erosion. The materials that constitute a floodplain, e.g., alluvial fans, point bars, and river beds, illustrate the sediment transport process whereby flowing water picks up mineral grains of various sizes and deposits them elsewhere (Dunne and Leopold 1978). Suspended sediment is the greatest surface water non-point-source pollutant on a volumetric basis for California watersheds (Charbanneau and Kondolf 1993). Reduction of erosion and sedimentation is a key watershed management component of watersheds that support populations of anadromous fish.

Flooding and Overbank Flows

Because of their effects on channel morphology, floods of various sizes are important determinants of the structure of aquatic and riparian habitats. In the channel, flooding creates stress on the streambanks, disturbs vegetation, and dislodges bottom-dwelling fauna. This natural cycle contributes to species composition and diversity within a watershed (Young 2001). Floods recruit large woody debris to the channel and determine the frequency of major habitat disturbance in the in-stream environment. Floods also drive the water regime in many floodplain environments (although groundwater and local runoff also play a role) and hence determine the range of plant communities.

Groundwater Recharge

Aquifers generally surface at springs, seeps, and stream channels, where they release surface water to flow downstream within the channel. The flow of a creek in dry weather, and therefore the width of the nearby riparian zone, is often derived from water released from an aquifer. Groundwater recharge contributes water to an aquifer that may then provide base flows within creeks during the dry season. The flow characteristics and water quality of creeks are dependent on the processes of infiltration, percolation through the soil profile, and movement by underground flow paths through riparian areas (Holmes 2000). Recharge of groundwater is particularly important for areas that withdraw water supplies from groundwater wells (not generally applicable in Berkeley). Excessive drawdown of an aquifer for human uses can indirectly impact the condition of riparian habitats by reducing or eliminating base-flow to streams.

RECOMMENDATIONS FOR CREEKS

5.1 Floodplain Administration Duties: continue at current level of service.

5.2 Watercourse Flooding Investigations: continue at current level of service.

5.3 Preservation and Restoration of Natural Watercourses: continue at current level of service.

5.4 Creek Culvert Condition Assessment Program – Perform condition assessment investigations on 20% of City owned creek culverts annually. Thus the entire City would be covered in 5 years. The process would begin again after the 5 years, providing opportunity to prioritize replacement and rehabilitation opportunities based on need. This will also enable the City to track the rate of deterioration. Characteristics such as pipe shape, invert elevations, length, and construction materials obtained from the condition assessments will be input into the City's GIS database.

5.5 Creek Culvert Rehabilitation Program – Based on results of hydraulic modeling and CCTV investigations, the City would develop a Creek Culvert Rehabilitation Plan (CCRP). The CCRP would identify and prioritize any needed repairs.

5.6 Creek Restoration – Identify, seek partnerships, and grant funding for creek restoration and stewardship projects. Identify capital improvement funds that can be available as "matching funds" for grant programs.

5.7 Volunteer GPS Creek Assessment Program – Pilot open watercourse assessment program on Codornices Creek, using trained volunteers to collect physical conditions and habitat data with Global Positional System (GPS) technology with permission of private property owners. This data can be used to further refine future hydraulic modeling efforts and identify common concerns across property lines.

5.8 Creek Guidance Materials – Provide creekside property owners with best management guidance for stewardship.

CHAPTER 6: STORM DRAIN FACILITIES

A fundamental component of watershed management planning is the consideration of the City's storm drain pipe infrastructure, which is designed to intercept, collect, and convey stormwater runoff from the public right-of-way either directly to the Bay or to nearby watercourses that ultimately discharge into the Bay. This infrastructure accepts runoff from public and private facilities (such as buildings, parking lots, and driveways) while protecting them from chronic inundation associated with wet weather. Much of the storm drain pipe infrastructure is over 80 years old and well past its useful life expectancy.

STORM DRAIN PIPES & APPURTENANCE TYPES

In assembling the WMP, staff analyzed the GIS database of the city's storm drain infrastructure components. In addition to providing a general location of these facilities, the City's GIS database is set up to store information on various characteristics of the system components such as: date constructed, material used, dimensions, and slope. Many of these data fields are empty and will require a proactive data gathering effort to backfill. Currently, the database gets updated from as-built information of construction projects, observations by City staff, as well as field information gathered by the City's surveyors and private surveyors.

The City's storm drain infrastructure inventory includes nearly 100 miles of underground pipelines, and their attendant appurtenances. These features are further described below:

- **Pipelines (nearly 100 miles):** Generally located under the public right-of-way, these are the primary conveyance conduits of the City's gravity-controlled storm drainage infrastructure. The pipe materials and shapes vary, often indicating the era in which they were built, as design standards and building materials evolved. Thus, the existing array of pipes shapes include: circular, egg, horse-shoe, and box. The range of materials used to fabricate the pipes include: vitrified clay, (reinforced) concrete, corrugated metal, ductile iron, steel, asbestos cement, plastic, polyvinyl chloride (PVC), and (high density) polyethylene (PE or HDPE). Pipe dimensions typically range from 6" to 108" diameter.

- **Manholes (1,200):** Extending from surface (street) level to the invert elevation (inside bottom) of pipelines, these shaft-structures are designed to provide convenient access for inspection, maintenance, and repair of storm drain pipelines. Manholes can also be designed to allow for multiple pipe intersections, ventilation, and pressure relief. In Berkeley, the typical manhole is constructed of brick or concrete with a cast iron cover fitting snuggly against the manhole rim-frame.

- **Curb & Gutters:** Raised concrete or stone border along a roadway (curb) and a channel (gutter) that directs runoff into an inlet or catchbasin or other stormwater conveyance

- **Inlets (515):** There are several different inlet types used to intercept and convey surface runoff into the pipelines. These include curb opening inlets, grate inlets, curb and grate (combination) inlets, which are all generally located in the curb and gutter of the public right-of-way. Inlet types and placement (often at intersections) are selected using factors that consider not only hydraulic conditions, but also likelihood of clogging, traffic considerations, and pedestrian/bicycle safety. Inlet clogging with leaf-litter and debris is the most frequent cause of localized flooding in the city.

- **Catch Basins (2,840):** These shaft-shaped structures serve as inlets to the storm drain pipelines.

- **Cross-Drains (1,450):** Shorter conduits often located at the corners of intersections to convey gutter flows beneath the corner at a 45-degree angle rather than around a 90-degree turn. Cross-drains are also used at to convey gutter flows beneath the crown of a cross street to the downstream gutter.

- **Valley Gutters (63):** These are very shallow concrete swales used to at intersections to convey gutter flows past the cross-street to the next downstream gutter. These surface-level facilities are more expensive to install, but much easier to maintain than cross-drains.

- **Wyes and Tees (962):** Wyes and tees describe the general shape of specialty pipes used to connect one underground pipe to another.

- **Outlets (238):** Outlet structures are used where storm drain pipes end at receiving waters.

STORM DRAIN PIPE FACILITIES EXISTING CONDITIONS

Moderate to heavy rainstorms can cause localized flooding in storm drain facilities. This is due to a number of contributing factors including:

- Conveyance capacity
- Tidal effects of the Bay
- Age and physical condition
- Obstructions (from leaves and debris) (see Chapter 7)
- Street gradient changes (see Chapter 7)
- Tree root damage (see Chapter 7)

Design Storm

A design storm is a mathematical representation of a precipitation event that reflects local conditions for the design of storm drain pipe infrastructure. It provides guidance for computing flows and sizing infrastructure (such as pipes, curbs & gutters, and valley gutters). Design storm criteria provide for consistency in the design of public (City) and private storm drain improvements. Design storms are defined by their duration, total rainfall depth, temporal patterns, and special characteristics (such as average spatial distribution, storm movement, and spatial development and decay).

The City of Berkeley design storm characteristics are summarized in this Table:

Recurrence Interval[7]	Total Rain Fall (in)	Duration (hr)
10-yr	2.03	6
25-yr	2.44	6

Conveyance Capacity

Conveyance capacity describes the hydraulic volume or flow that the storm drain pipe infrastructure is designed to convey without flooding. The use of a 10-year design storm is appropriate for most of the Berkeley because it is applied to drainage areas under 1,000 acres. The 25-year design storm is recommended for storm drain trunk lines that drain areas 1,000 acres or more; this applies only to the Potter Watershed (Adeline/ Woolsey to the Bay) and the Strawberry Watershed (Curtis/University to the Bay).

When precipitation from storm events cause stormwater runoff at volumes larger than the 10-year design storm, localized flooding and nuisance ponding can occur.

Hydraulic Modeling

Hydraulic models are tools used to quantify the conveyance capacity of drainage pathways within a watershed. These models are computer-generated representations of predicted flows and drainage pathways associated with various storm event sizes. While empirical evidence of flooding at certain locations is readily available, hydraulic models are able to analyze the entire drainage network within a watershed. They can be used not only to analyze existing conditions, but also to evaluate the expected hydraulic effects of potential modifications.

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[7] Storms are classified by intensity (inches of rain fall in a given time), duration (how long the storm lasts), and recurrence interval. Recurrence interval may be expressed as a "2-year" or "5-year" or "100-year" storm. This means that statistically a storm of a given duration and intensity can be expected to occur every 2, 5, or 100 years. The probability that a 100-year storm or greater can occur in any given year is 1%; a 25-year storm probability is 4%; a 10-year storm is 10%; a 5 year storm is 20%; and a 2-year storm is 50%. A 2-year storm is less severe than a 5-year storm; a 5-year storm is less severe than a 10-year storm and so on. It is possible to have a 25-year event two years in a row or even within the same year. (City of Pocatello, www.pocatello.us/se/documents/2000_SWMP/chapter-05.pdf).

The hydraulic modeling efforts conducted thus far (see Chapter 8) have led to the development of various Capital Improvement Project recommendations, which are predicted to resolve many flooding problems within the subject watersheds. Hydraulic modeling of the remaining watersheds is needed to determine the existing capacity of storm drain pipe infrastructure and develop recommended Capital Improvement Projects for each watershed.

Capital Improvement Projects (CIP) Program

The term “Capital Improvement” is often used to describe any construction-related work. However, in the context of stormdrain pipe facilities, the WMP breaks construction activities into two distinct categories: 1) Rehabilitation and 2) Capital Improvement.

1. **Rehabilitation (Rehab)** describes construction-related work to correct structural or physical defects to maintain proper functioning and extend the useful life of existing storm drain pipe infrastructure. This can include various methods and means, such as:
   - Correction of specific problems in a certain section of pipe (“Point Repairs”).
   - Reinforcement of the inside of an existing pipe with a hardened membrane (“Slip-lining”).
   - Replacement of a pipe with another pipe with the same hydraulic capacity.
2. **Capital Improvement (CI)** is any construction project that increases the hydraulic capacity of the storm drain pipe infrastructure. This can include various methods and means, such as:
   - Construction of new storm drain pipe infrastructure that expands the network.
   - Construction of pump stations or retrofit of pipes to operate under pressurized conditions to force more discharge through the same size pipes.
   - Enlargement of storm drain pipes by replacing existing pipelines with larger pipelines (“Upsizing”).
   - Construction of detention facilities, such as Green Infrastructure/storage measures.

PW Maintenance and Engineering Divisions keep a list of repair and nuisance locations. This list is updated each year. Projects are prioritized based on potential for property damage and public safety issues. Projects are implemented as funding is available.

CCTV Inspection Program

As aging stormdrain pipe infrastructure deteriorates, defects can become more pronounced. Typical defects can be divided into two categories: 1) structural and 2) physical condition. Structural issues include cracks, factures, breaks, holes, joint offsets, and sags. Physical condition-related defects include root intrusion, infiltration, debris accumulation, obstructions, and material deterioration.

A CCTV program is used to determine the extent of needed rehabilitation repairs and to prioritize and budget for these needs. The number and location of structural and physical condition-related problems within the storm drain infrastructure is largely unknown. In larger diameter pipes, only specially-trained and certified personnel are allowed into the confined spaces to perform visual condition assessments. Otherwise, remote camera technology, using CCTV, would be typically deployed to inspect the storm drain pipe infrastructure.

RECOMMENDATIONS FOR STORM DRAIN FACILITIES

6.1 CIP Program

6.1.a. Rehabilitation Program: Current Rehab projects come from the list of priority projects that have recurring localized flooding issues or present a public nuisance. Projects are implemented based on funding available. Future additional rehab projects would be based on results of hydraulic modeling and CCTV investigations.

6.1.b. CI Program: Recommended CI plans are provided for the Potter and the Codornices Watersheds (Chapter 8), which have already been hydraulically modeled. CI planning for the remaining watersheds will be done after analyzing the results of future hydraulic modeling of each watershed.

6.2 Hydraulic Modeling: As funding becomes available, develop hydraulic models for all watersheds in Berkeley to determine extent of capacity issues, identify constrictions, and evaluate potential capacity gains from pipe upsizing, realignments & modifications, and green infrastructure measures.

6.2.a. The Potter Watershed and the Codornices Watershed have already been hydraulically modeled. Uplands draining into Aquatic Park south of Channing are included in the Potter Watershed analysis.

6.2.b. Remaining Watersheds to be modeled in order of priority:

1. Strawberry
2. Schoolhouse
3. Gilman
4. Marin
5. Cerrito
6. Wildcat
7. Temescal

6.3 CCTV Inspection Program: Perform physical conditions assessment investigations on 20% of the City's storm drain pipe infrastructure annually. Thus the entire City would be covered in 5 years. The process would begin again after the 5 years, providing opportunity to prioritize replacement and rehabilitation opportunities based on need. This program will also enable the City to track the rate of deterioration. Characteristics such as pipe shape, invert elevations, length, and construction materials obtained from the condition assessments will be input into the GIS database.

The first watersheds for CCTV Inspection should be the Potter and Codornices Watersheds. Storm drain pipes that are not included in the CIP recommendations (Chapter 8) or are less than 18" in diameter in should be investigated.

CHAPTER 7: MAINTENANCE

Drainage pathways (whether natural or engineered) require routine on-going maintenance and servicing to ensure long-term function and performance. The Public Works Department's Maintenance Division is the agency most responsible for providing, operating, and maintaining the City's storm drain infrastructure and its water quality protection measures. In addition, the Parks, Recreation, and Waterfront Department is responsible for creek stewardship in City parks as well as the maintenance of street trees and medians.

PW MAINTENANCE PROGRAM OVERVIEW

Over time PW staff have become very familiar with the drainage pathways within the City right-of-way and their seasonal characteristics. This knowledge helps PW to anticipate when and where problems are likely to occur and to allocate resources accordingly. The most common concerns are localized flooding and surface ponding often due to: (1) blockages, and (2) pipeline defects. PW addresses these problems by conducting on-going debris removal operations (such as catch basin & inlet servicing and street sweeping programs) as well as performing storm drain pipe facility repairs and street/curb & gutter repairs as needed.

PW Maintenance manages its routine and seasonal work by dividing the city into 9 primary "storm maintenance" districts, and further divides these into 39 smaller sub-districts (See Appendix C – Maps, Storm Maintenance Districts Map). This helps to efficiently deploy and track the progress of assigned crews, which is especially useful prior to and throughout the wet season when areas with known drainage issues are patrolled and serviced more frequently.

PW Maintenance Major Task Categories

Clean Storm Fund revenue is the primary source of funding for PW Maintenance activities related to watershed management. Table 7-1 shows the various existing tasks conducted by the Public Works Department as an average percentage of Clean Storm Fund expenditures (according to analysis of Fund 831 expenditures from 2004 through 2011).

Maintenance Division's Watershed Management-related Tasks (Fund 831):

FUND 831 EXISTING TASKS	% of Mtnce Budget
Service Catch Basins (XX3131)	26.8
Service Inlets/Outlets (XX3137)	23.1
Storm Repairs (04AD66)	17.7
Winter Storms (10EM02) & Storm Response (10SD12)	11.7
All Storm Day (10SD11)	5.6

FUND 831 EXISTING TASKS	% of Mtnce Budget
Service Sidewalk/Tree Root Damage (09AD06)	3.0
Service Trash Racks (XX3135)	2.6
Misc. Activities (pothole repair, sand bags, leaf removal, etc)	9.5
TOTAL	**100.0%**

Table 7-1

Catch Basin and Inlet/Outlet Servicing

Catch Basin and Inlet/Outlet Servicing includes the routine inspection and removals of trash, gravel, silt, and other debris from inlets, catch basins, cross drains, and adjacent curb & gutter areas. This task provides both flood and water quality benefits and is an established performance standard of the SQMP, described in Chapter 4. The City strives to service each storm drain catch basin, cross drain, and inlet/outlet at least once per year and as needed according to local conditions. Areas prone to flooding and heavy leaf fall receive more service visits than others. Annually 85% of catch basins, cross drains, and inlets/outlets are serviced.

The jet-vactor truck (with a crew of two laborers) is equipped with a high-pressure jet flushing devise (for dislodging debris) and a vacuum hose (for removing solids and fluids). Cross-drain and Inlet/Outlet Servicing is typically conducted by the "hand-rodding" crew (one laborer) with hand tools and a utility truck.

Minor Storm Drain Facility, Curb & Gutter & Street Repairs

This task includes the repair and replacement of storm drain inlets, catch basins, pipes and manholes to correct structural deficiencies and improve drainage. This task also includes the temporary and permanent repair of damaged curb & gutters to eliminate irregularities caused by tree roots, as well as storm drain facility-related patching of potholes, trenches, failed areas, breaks and depressions. These repairs help to maintain drainage flow by preventing ponding in addition to improving public safety by providing smooth surfaces for pedestrian or vehicular travel.

Repairs are scheduled on a priority basis based on public safety factors. Determination for priority is a made by the Streets Senior Supervisor and the Supervising Civil Engineer.

Wet Weather Maintenance Programs

PW Maintenance workforce assignments are shifted just prior to the rainy season (typically at the end of October) to ensure that drainage inlets and pathways in the right-of-way throughout the city are unobstructed. Tasks include:

- Storm Patrols
- Sand Bags Program
- Additional Commercial District Storm Drain Facility Servicing
- Concentrated Leaf & Debris Clearing (All Storm Day)
- Trash Rack and Creek Culvert Inspections and Servicing

Storm Patrol

The Storm Patrol services priority areas with a propensity for localized flooding. The Storm Patrol crew proactively looks for flooding from manholes, inlets, or catch basins. This crew is also available to respond to dispatched service calls.

Sand Bags Program

A limited number free of sandbags are made available for City of Berkeley residents who are threatened by flooding. Maintenance crews fill and supply sand bags to local fire stations for citizen pick-up. A supply of sandbags is also stored at the Corporation Yard. Customers are required to present proof of Berkeley residency and fill out a form acknowledging receipt of the sandbags in order to participate in this program.

Additional Commercial District Storm Drain Facility Servicing

An additional vactor truck is assigned to clean commercial district streets on a regular basis, due to the heavy volume of debris they generate. The districts covered include San Pablo, University, Ashby, Adeline, Shattuck, and Telegraph Avenues.

Concentrated Leaf & Debris Clearing (All Storm Day)

Initiated in 2006, All Storm Day has evolved into an annual single day event typically held in late October or early November. All PW field personnel are assigned to areas throughout the city to remove leaf and debris from City curbs & gutters, inlets, and catch basins. In addition to personnel using hand tools, the City also deploys mechanical street sweepers, utility and dump trucks, and refuse collection trucks to collect and transport materials to the Transfer Station. Volunteers are also encouraged to participate in these efforts.

Trash Rack and Creek Culvert Inspections and Servicing

PW Maintenance crews conduct visual inspections of creek culvert inlets at street crossings and also inspect and service trash racks in creeks on public property. Trash racks are cleared of debris at this time and after the first storm events.

Street Sweeping Programs

Curb & gutters serve as pathways for the transport of many urban runoff pollutants that originate from the street, wash off from adjacent lands, or are deposited atmospherically. Street sweeping is a service that the City of Berkeley has always provided, initially with horse-drawn carts sprinkling dirt roads to keep dust down, and subsequently on an as-needed basis with voluntary participation by City residents.

In 1987, City Council adopted Resolution No. 54-513-N.S., which established regular street sweeping scheduling and mandatory parking enforcement to ensure effectiveness of the Residential Street Sweeping Program. Street sweeping has since expanded to commercial and industrial areas as an established performance standard of the SQMP, described in Chapter 4. In addition to protecting water quality, routine street sweeping also improves community aesthetics and livability, prevents inlet blockages, and increases vehicular safety in wet weather. The City's Clean Cities program (Fund 820) supports street cleaning programs including both mechanical and hand sweeping activities.

Residential Street Sweeping Program

This program includes once a month mechanical sweeping of city streets in most residential neighborhoods. Local parking restrictions are established on certain days and times to maximize the sweeper's access to the curb/gutter area where pollutants and debris accumulate. Sweeping is performed by one mechanical sweeper operator using a mechanical street sweeper, which averages 25-35 curb miles a day.

Residential areas that are not routinely mechanically swept year-round include:

- Hillside areas, which are excluded due to steep, windy road grades, narrow streets or absence of curbs
- Opt-out areas, where residents were given the opportunity to petition out of the program and accept responsibility for cleaning the street curb area (opt-out option discontinued in 1994)
- Selected omitted streets approved by the City Manager due to noise complaints.

When access to the curb and gutter is available, mechanical street sweeping is the most cost effective way of removing leaves and debris from the City streets. The challenge to maximizing efficiency is the on-going conflict between parking and sweeping. Where parking spaces are at a premium in certain areas of the City, automobile owners often choose to pay a monthly fine, rather than move their cars and risk losing the space. Those sections of streets cannot be swept effectively.

Commercial/Industrial Street Sweeping

Commercial districts, such as San Pablo Ave, University Ave, Downtown/Shattuck, Telegraph Ave, and Adeline (So. Berkeley) are serviced by mechanical sweeping service three to five times a week. In these high trash-generating areas, the mechanical sweeper is deployed at night to minimize conflicts with business hour parking. The Commercial Street Sweeper crew (one operator and one mechanical sweeper) currently takes on additional routes every two weeks to service Industrial areas. The Industrial area street sweeping routes were reduced due to budget constraints.

Hand Sweeping

Mechanical sweeping is supplemented in commercial areas by the Clean City Program's BOSS hand-sweeping crews who service the sidewalk, gutters, and tree wells for litter pick-up on a daily basis. The hand sweeping crews are comprised of one skilled laborer and one laborer with a truck and hand tools (brooms, rakes, etc). This supplemental labor force, which can sweep around and between parked cars, is critical due to night-time parking conflicts which are more prevalent due to mixed-use zoning trends.

Mechanical Leaf Removal

Street sweeping once a month in heavy leaf fall areas is not enough during the winter season. Residential streets within heavy leaf fall areas receive additional leaf removal services nine months out of the year (August through April). Determination of "heavy leaf fall" is based on the age and maturity of the street trees, and density of vehicular traffic, Leaf removal operations are performed on a rotational basis with a leaf vacuum machine which allows sweeping around parked cars. All areas not in the routine residential street sweeping program due to steep road grades, narrow street widths, and absence of curbs receive leaf removal services 4 times per year on average.

Miscellaneous On-Going PW Maintenance Tasks

The PW Maintenance Department adheres to water pollution prevention best management practices in its servicing, washing, and fueling of City fleet vehicles and equipment; as well as the storage of hazardous and non-hazardous materials. Waste materials and chemicals from field jobs and the corporation yard are disposed of properly. The Maintenance Corporation Yard is swept weekly or as needed. Crews are trained in the proper response, containment, clean up and reporting of non-hazardous spills. These practices are established performance standards of the SQMP, described in Chapter 4.

PRW MAINTENANCE MAJOR TASK ACTIVITIES RELATED TO WMP

The Parks, Recreation, and Waterfront Department (PRW) also provides on-going watershed management-related maintenance services in the public right-of-way. This includes maintaining street medians (81 sites) and street trees (approximately 4,000) within the public right-of-way. PRW provides a level of service that includes tree pruning, young tree care (staking, irrigation, mulch, training), and root pruning for parkway strips (also known as planter strips) along sidewalks.

PRW operates and maintains City Parks and open spaces, including the upkeep, litter abatement, and vegetation management of watercourses within city parks. This work, which includes wildlife habitat restoration and protection, is conducted by landscape gardeners, landscape gardening supervisors using a variety of hand tools, mowing equipment, and utility trucks.

Like PW, the PRW also performs seasonal duties such as providing emergency response services (roughly 500 calls per year) to handle public tree hazards and right-of-way clearing. During the winter season and just prior, PRW inspects and cleans creek trash racks, ensures functioning catch basins in parks, and assists PW in clearing street drain pipe inlets and catch basins. PRW also assists PW in filling sand bags as needed.

NEW MAINTENANCE TASKS

Full Trash Capture

To comply with the new Full Trash Capture provision of the MRP (Provision C.10), the City must install and maintain full trash capture devices[8] servicing a total catchment area of 55 acres of commercial areas by July 1, 2014. These devices must handle flow from a storm that has a return frequency of one year and one hour duration (1-1 Storm), which is a typical storm event. The full trash capture devices currently being tested include retrofitting existing catch basins and inlets with various configurations of 5 mm mesh screening.

It is anticipated that subsequent MRP permit cycles will mandate further trash reduction requirements (the stated goal in current MRP is 100% trash capture by the July 1, 2022).

Green Infrastructure Maintenance

Green infrastructure measures undertaken by the City will need on-going maintenance to ensure functionality, safety, and aesthetics as appropriate. These maintenance measures can be performed by the Public Works Department or by the Parks Waterfront and Recreation Department as mutually determined and funding made available. No matter which City departments are ultimately responsible for GI maintenance, appropriate personnel will need to be trained to properly perform this role.

As described in Chapter 3, the GI approaches most appropriate for the public right-of-way and in parks are: 1) Bioretention cells, 2) permeable paving, 3) underground pipe storage (for temporary detention and possible reuse), and 4) hydrodynamic separator units. Staff have reviewed technical guidance documents from various municipalities both local and from across the country to develop estimated operations and maintenance activities associated with these recommended GI measures.

Bioretention Cells (rain gardens and vegetated swales)

Maintenance Highlights:

- Routine trash and weed removal.
- Must be pruned, mulched, and watered until plants are established. Plants take about three years to become established: Year 1 – water frequently, limit pruning

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[8] Provision C.10 of the MRP recognizes trash as a significant pollutant in urban runoff and requires the City to install Full Trash Capture (FTC) devices to serve a minimum of 55 acres within the City by July 1, 2014. FTCs are defined as devices able to control trash equal to the screening of a 5 millimeter mesh screen, and will be installed in the public right-of-way in storm drains, catch basins, and inlets. Because this is a new and unfunded mandate, the City is participating in a Bay Area-wide Trash Capture Demonstration Project funded by a $5 million allocation from the Federal American Recovery and Reinvestment Act of 2009 (ARRA) to the San Francisco Estuary Partnership. Berkeley's allocation is anticipated to provide for the purchase and installation of approximately 10 types of Water Board-approved FTC devices. This project will allow the City to pilot test the FTCs to determine which type will best serve the City's needs, meet MRP requirements, and determine associated operations and maintenance costs.

to removal of damaged limbs; Year 2 – less frequent watering, weeding necessary, limited pruning.

- If patches of bare soil emerge, plantings should be added to prevent erosion.
- Semi-annual plant maintenance is recommended including replacement of diseased or dead plants. If groups of plants fail, consider alternative species.
- Maintain mulch layer to retain moisture and control weeds. Rake mulch and soil surfaces to break crusts, which can reduce infiltration rates. Add or replace mulch as needed in spring and fall.
- Once plants are thriving, periodic trimming, thinning, and pruning may be necessary to ensure swale edge is not obscured.

The maintenance regime for bioretention cells is built around keeping the soils and plantings healthy enough for their biological processes to both breakdown and uptake pollutants. This requires initial irrigation for dry weather months, which can be built into the project as a temporary system or by weekly water truck visits during the first year after construction. Re-mulching the area every spring is recommended. Adjacent property owners and residents may want to supplement the City's routine maintenance by providing additional weed abatement and litter pick up to promote community aesthetics.

Permeable Paving

Maintenance Highlights:

- Conduct periodic visual inspections (at least once a year) to determine if surfaces are clogged with vegetation or fine soils. Correct clogged surfaces immediately.
- Street sweep with vacuum sweeper twice/annually during dry weather (after autumn leaf-fall, again in early spring).
- Inspect after at least one major storm per year.
- Surface sealing NOT allowed.
- Replenish aggregate material as needed.

The option of permeable paving may be considered for parking lanes, sidewalks, and low volume residential streets. Maintenance is primarily geared towards removing sediments from the pavement openings and joints to prevent clogging. This is best done using vacuum type street cleaning equipment rather than brooms and water spray, which may move sediment deeper into the surface openings and contribute to clogging.

A benefit of pervious joint pavers is that they can be removed and replaced to perform subsurface utility repairs. This compares favorably to asphalt, which must be cut to access subsurface facilities and patched when finished. These patches often leave the streets uneven and less aesthetically appealing. Thus, if pervious joint pavers are used, it is recommended the City stock extra pavers for replacement, if any become damaged.

Underground Stormwater Storage (detention)

Maintenance Highlights:

- Inspect street inlets, storage pipe valves and orifices (annually in the fall)
- Remove floatables and accumulated sediments that become trapped within the storage device (twice annually, before and after wet season)
- Sediments and debris can be removed mechanically or by flushing.
- Confined Space safety procedures must be followed by workers entering an underground stormwater storage facility.

The primary maintenance concerns are removal of floatables and sediments that become trapped within the system; this should be done at least on an annual basis. This work can be performed by PW using its jet-vactor truck. In-house staff may need confined space training and certification to periodically enter the pipes as-needed or an on-call service provider can be retained. Routine street sweeping and storm drain infrastructure servicing plays a major role in reducing floatables and sediment loads to underground storage devices.

Hydrodynamic Separator Units

According to vendor literature, hydrodynamic separator units are self-operating, gravity-driven devices with no moving parts. They require only the hydraulic energy available within storm water flow. These units have large sumps capacities and only need to be cleaned out with a standard vactor truck one to four times a year.

A typical inspection visit is a half hour and a servicing visit is a half hour, which calculates to 2 hours annually for each unit.

RECOMMENDATIONS FOR MAINTENANCE

7.1 Catch Basin and Inlet/Outlet Servicing: continue at current level of service.

7.2 Minor Storm Drain Facility, Curb & Gutter & Street Repairs: continue at current level of service.

7.3 Wet Weather Maintenance Program: continue at current level of service.

7.4 Miscellaneous PW Storm Maintenance Activities: continue at current level of service.

7.5 Street Sweeping Program: continue at current level of service.

7.5.a Residential Area Street Sweeping

7.5.b Commercial Area Street Sweeping

7.5.c Industrial Area Street Sweeping

7.6 PRW Maintenance Activities: continue at current level of service.

7.7 Install and Maintain New Full Trash Capture Devices: install and maintain.

7.8 Consider realignment of Storm Maintenance Districts to match watershed boundaries

7.9 Add Second Jet Vactor Crew for year-round catch basin, inlet/outlet servicing. The City is in the process of purchasing another jet-vactor truck. The existing hand-rodding crew can be replaced with a second jet vactor truck crew to increase annual production. With another jet-vactor truck in service, the crews can add pipeline cleaning as a routine element of preventative maintenance. Cleaning the lines would also facilitate recommended condition assessment inspections.

7.10 Sand Bags Program: Purchase either (1) seven small flat-bed trailers, or (2) one transportable forklift to facilitate the transport, drop-off, staging, and pick-up of sand bags. The current practice is hand loading and unloading of bags from a truck. This becomes time consuming when factoring in the replenishment of supplies and the pick-up of unused bags at the end of the winter. Additionally, putting the City of Berkeley logo on all bags would discourage the pick-up and use of free bags by private contractors, looking to save money on materials.

7.11 Concentrated Leaf & Debris Clearing (All Storm Day): Reestablish the extra weekend street sweeping assignments during the heavy leaf fall season, and refocus All Storm Day as a volunteer-oriented program supplemented by City forces. The All Storm Day event does not collect the tonnage of leaf fall and debris that was collected by the discontinued special seasonal street sweeping routes.

7.12 Street Sweeping Program: Coordinate with PW-Maintenance to evaluate and explore options for improving efficiencies. Options that could be considered are:

- Increase the residential street sweeping program to weekly instead of monthly.
- Augment the monthly residential mechanical street sweeping with eight laborers; four laborers to work with each of two street sweepers simultaneously to hand sweep the leaves from the gutter to the travel lane to be picked up by the mechanical sweeper.
- Consider the possibility of towing cars that are left parked on street during sweeping times; or purchase more maneuverable equipment that could be operated from the sidewalk to pick up leaves and debris between and under parked cars.

7.13 Develop Training Program and Maintenance Plan for Green Infrastructure Measures

CHAPTER 8: CODORNICES & POTTER WATERSHEDS HYDRAULIC MODELING FINDINGS

STRATEGY

At the initiation of the WMP process, the City allocated funding to develop hydraulic models for two watersheds. The Potter and Codornices Watersheds were selected because they represent the full range of the urban drainage spectrum in Berkeley. The Potter Watershed drains approximately 1/3 of the land area of the City through storm drain pipe infrastructure. The Codornices Watershed drains about 1/10 of the City through open watercourses and creek culverts.

Findings from these two watersheds could be extrapolated to the other watersheds, but it is preferable to continue hydraulic modeling of the remaining watersheds.

The Potter watershed is the largest in the City; it experiences localized flooding in many areas; and it contributes runoff to the Aquatic Park Lagoons. The Codornices Watershed is regionally significant as Codornices Creek is one of the least culverted creeks in the East Bay; and is one of the few with a salmonid population.

Balance Hydrologics, Inc. (Balance), a local water engineering firm, was retained to develop the two hydraulic models. The scope of work[9] included developing baseline (existing watershed conditions) hydraulic and hydrologic models to determine expected runoff volumes and quantify the existing conveyance capacity of storm drain infrastructure and other drainage pathways (watercourses and creek culverts). Various potential retrofit scenarios were then input to the models to quantify the expected flood reduction benefits of these approaches. Retrofit scenarios in the scope of work included examination of: 1) stormwater storage BMPs (rainbarrels, cisterns, permeable pavements with subsurface gravel reservoir storage), 2) biofiltration BMPs (flow through planter boxes, rain gardens, and swales), 3) combined stormwater storage BMPs and biofiltration BMPs, and 4) retrofits to storm drain pipes (diversion pipes, enlargement, and pumps). Balance also developed cost estimates for the design, permitting, and construction of the various scenarios.

[9] Balance modeling was limited to incorporating pipe sizes of 18” in diameter or greater.

POTTER WATERSHED FINDINGS

Potter Drainage Pathways

The storm drain pipe infrastructure consists of a main trunkline and a network of branches and laterals. The trunkline runs from the intersection of Adeline/Woolsey and MLK, Jr. Way to the Bay outfall.

Five branches feed into the trunk line from the north:

1. San Pablo Ave Branch
2. Russell-Mabel Branch
3. Sacramento Branch
4. Ellis-Grant Branch
5. Shattuck-Adeline-Ashby-MLK Branch

Three other branches east of Shattuck/Adeline feed either the trunk or lead into another branch:

1. Upper Woolsey Branch
2. Derby Branch
3. Parker-Dwight Branch

The remaining pipelines input into the model include lateral lines from the branches, as well as a network of storm drain pipelines west of San Pablo Ave and south of Dwight Way leading to Aquatic Park.

See Appendix C Maps: Potter Watershed Existing System Results (May 6, 2011).

Existing Conditions Results

From a 10-yr design storm, the Potter Watershed generates an estimated 236 acre feet (af)[10] of runoff. Most pipelines including the trunkline are operating at or above capacity for a 10-year storm with about 34 af of flooding predicted throughout the watershed (Table 8-1). Maximum capacity discharged to the Bay is 446 cubic feet per second (cfs).

Trunk/Branch	Total Flooding (af)	% of Total Flooding	Max. Discharge (cfs)
Main Trunk (outfall to Bay)	-	-	445.8
Main Trunk (overflow into MYB[11])	-	-	217.0
Main Trunk (inlet)	15.1	44.2%	403.8
San Pablo Branch	1.7	4.9%	73.1
Russell – Mabel Branch	0.0	0%	68.4
Sacramento Branch	0.0	0.1%	122.0
Ellis-Grant Branch	5.8	17%	120.4

[10] An acre foot equates to one square acre of water one foot deep.
[11] MYB: Model Yacht Basin, Aquatic Park

Trunk/Branch	Total Flooding (af)	% of Total Flooding	Max. Discharge (cfs)
Shattuck – Adeline – Ashby – MLK Branch	2.3	6.7%	317.6
Upper Woolsey Branch	4.0	11.8%	129.3
Derby Branch	2.8	8.1%	76.8
Parker - Dwight Branch	2.4	7.2%	154.4
TOTALS	**34.1**	**100.0%**	

Table 8-1

The modeling identified locations of predicted overflows. Many of these locations were confirmed as chronic nuisance flooding sites by PW Maintenance staff and correspond well with City experiences during the storms of February 25, 2004 and the El Nino events of the 2005-06 rainy season. Localized flooding can be expected in varying degrees within the locations in Table 8-2.

Street Name	Cross Streets
San Pablo Avenue	between Ward and Murray
California Street	between Woolsey and Harmon
Woolsey Street	between California and Adeline; at Dana
Ashby Avenue	between California and King
Martin Luther King, Jr. Way	between Russell and Woolsey
Parker Street	between Seventh and Fourth
Fulton Street	at Derby
Ellsworth Street	between Blake and Parker
Telegraph Avenue	between Ashby and Woolsey; at Stuart
College Avenue	at Dwight

Table 8-2

Tidal effects from the Bay compound the Potter Watershed flooding problems as far upland as Adeline/Woolsey. This is due to the water surface of the Bay effectively reducing the discharge ability of the storm drain trunk line. Thus 10-year frequency storms in combination with high tides will cause flooding in the Potter watershed.

Options Analyzed

To provide desired level of flood protection, the storm drain trunk line must handle the 25-year design storm runoff and all other branches and laterals must handle the 10-year design storm runoff with minimal flooding. There are several approaches the City considered to achieve these goals.

Traditional Pipe Upsizing

One consideration for improving pipe line capacity is the traditional approach of upsizing the entire network of pipes such that each pipe is sized and shaped to efficiently convey the appropriate design storm runoff. In this scenario, roughly 35,000 lineal feet of storm drain pipeline would be replaced with larger diameter pipes.

However, if all upstream pipes were upsized, then the main trunkline would need to be massively enlarged to accommodate the additional flow volumes. Most of the existing 9-foot diameter egg-shaped trunk would need to be replaced with a much larger box-shaped trunk, ranging from 7-feet x 20-feet (H x W) to 10-feet x 10-feet for an estimated cost of $33M.

The upsizing of the remaining branch pipelines would cost an estimated $19.75M. The total estimated cost of this approach (not including resolution of tidal effects, Aquatic Park pipeline replacement, or water quality protection measures) is $52.75M.

It should be noted that regardless of what overall approach the City takes to reduce flooding, a significant amount of pipe upsizing will be necessary, including the main trunk and at site specific locations where existing pipes constrict flow.

Resolution of SF Bay Tidal Effects

Six options were developed to resolve the tidal effects. All options are listed in Table 8-3 with their description and their pros and cons. The two options the City is considering are Option 1: discharges stormwater directly to SF Bay (preferred option); and Option 5: discharges most stormwater directly to SF Bay and only discharges to Aquatic Park Lagoon on high flow levels (no additional stormwater into Aquatic Park).

	Option	Description	Pros	Cons
1	**Pressure pipe outflow to Bay for entire Q10** Capacity to Bay = 1,400 cfs Flow to Aquatic Park = 0 cfs **$17,238,000**	1. Pressure pipe = single 11-ft diameter or twin 8-ft diameter; 1,525 ft total length 2. Rebuild existing outfall to Bay, add new outfall if twin pipe option is used 3. New large collector box with trash rack at upstream end	1. No stormwater flows from Potter Watershed to Aquatic Park. 2. Inclusion of trash rack would allow meeting trash TMDL for all Potter watershed.	1. Costly construction, including tunneling under I-80 and UPRR. 2. Lengthy permitting process of new outfall to Bay. 3. Very lengthy closure of I-80 on-ramp from Shellmound (~2 mos)
2	**Existing outfall plus storage in combined Radio Tower Pond and Model Yacht Basin** **N/A (infeasible)**	1. Maintain existing Potter trunk and outfall downstream of MYB 2. Construct diversion structure with trash rack and automated control gates to allow flow to MYB + ML only when excess storage needed 3. Increase trunk line size from above UPRR to new diversion structure	1. Potential major cost savings with reduced infrastructure 2. No new Bay outfall, much simpler permitting 3. Limited I-80 on-ramp closure	**1. Infeasible, not enough storage in RTP + MYB** 2. Stormwater still flows to Aquatic Park in large events

	Option	Description	Pros	Cons
3	**Pump station with no storage to supplement existing outfall** Capacity to Bay = 1,400 cfs Flow to Aquatic Park = 0 cfs **$39,000,000**	1. Construct pump station to handle flow that cannot be conveyed by existing outfall (latter left in place) 2. Construct new force main outfall to Bay for pump station outflow 3. Provide trash rack at pump for all flow	1. No stormwater flows from Potter to Aquatic Park. 2. Inclusion of trash rack would allow meeting trash TMDL for all Potter watershed.	1. Costly construction, including tunneling under I-80 and UPRR. 2. Lengthy permitting process of new outfall to Bay. 3. Lengthy closure of I-80 on-ramp from Shellmound (~2 mos) 4. Relative high ongoing O&M costs
4	**Existing outfall plus storage in MYB+Main Lagoon** Capacity to Bay = 400 cfs Flow to Aquatic Park = 1,000 cfs **$6,405,000**	1. Maintain existing Potter trunk and outfall downstream of MYB 2. Construct new diversion structure with trash rack and automated control gates to allow flow to MYB + Main Lagoon only when excess storage needed 3. Increase trunk line size from above UPRR to New diversion structure	1. Potential major cost savings with reduced infrastructure 2. No new Bay outfall, much simpler permitting 3. No stormwater flows to Aquatic Park for small events (e.g. < 2-year storm) 4. Inclusion of trash rack would allow meeting trash TMDL for all Potter watershed. 5. Limited I-80 on-ramp closure	1. Stormwater still flows to Aquatic Park in large events, possibly more storm water in largest events depending on upstream system upgrades 2. Tunneling required under UPRR.
5	**Smaller pressure pipe plus storage in Main Lagoon** Capacity to Bay = 1,000 cfs Flow to Aquatic Park = 400 cfs **$14,788,000**	1. Maintain existing Potter trunk and outfall downstream of end Potter 2. Construct new 9-ft diameter pressure pipe directly to Bay to handle all initial discharge 3. Construct new diversion structure with trash rack at end of Potter, only flows above pressure pipe capacity flow down existing trunk	1. Almost no stormwater flows of any kind from Potter to Aquatic Park, could be none with green infrastructure in upper watershed 2. Inclusion of trash rack would allow meeting trash TMDL for all Potter watershed 3. With minor modification could have stormwater only go to RTP, not Main Lagoon	1. Costly construction, including tunneling under I-80 and UPRR. 2. Lengthy permitting process of new outfall to Bay. 3. Very lengthy closure of I-80 on-ramp from Shellmound (~2 mos)

	Option	Description	Pros	Cons
6	**Smaller pressure pipe plus smaller pump station** Capacity to Bay = 1,400 cfs Flow to Aquatic Park = 0 cfs **$35,700,000**	1. Maintain existing Potter trunk and outfall downstream of end Potter 2. Construct new 8-ft diameter pressure pipe directly to Bay to handle all initial discharge 3. Construct pump station to handle any larger flows 4. Construct force main from pump station to Bay routed inside existing trunk line	1. No stormwater flows of any kind from Potter to Aquatic Park. 2. Inclusion of trash rack would allow meeting trash TMDL for all Potter watershed.	1. Costly construction, including tunneling under I-80 and UPRR. 2. Lengthy permitting process of new outfall to Bay. 3. Lengthy closure of I-80 on-ramp from Shellmound (~2 mos) 4. Relatively high O&M 5. Capacity gained with pump station offset in part by lost capacity in existing trunk due to routing of force main.

Table 8-3

With the exception of Option #6, each of the options includes a new trunk line junction near the UPRR right-of-way that would be designed to accept discharges from a realignment existing storm drainpipes that currently drain into the park from Heinz, Grayson, Carleton, and Parker Streets.

Option 1: Pressure pipe outflow to Bay for entire Q10 – $17.3M: This option includes 1,525-feet of either a single 11-foot diameter pipe or twin 8' diameter pipes, rebuilding the existing outfall to the Bay and potentially adding another (for the twin pipe option); and installing a collector box with a trash rack at the upstream end. No stormwater would be discharged to Aquatic Park.

Option 5: Smaller pressure pipe plus storage in Main Lagoon - $14.8M: This option includes the construction of a new diversion structure with a trash rack at the end of Potter St. and a new 9-foot diameter pressure pipe from the diversion structure to the Bay. The existing lower Potter trunk and outfalls to the MYB would remain. Pressure pipe capacity to the Bay would be approximately 1000cfs with excess flows diverted to the existing lower trunk. Excess flows diverted to Aquatic Park can be further reduced by the installation of storage unit in the upper watershed.

Green Infrastructure

Green Infrastructure options were input into the model to determine the viability of reducing hydraulic loading to the storm drain pipe infrastructure using bio-retention measures and large volume storage units. The concept is to strategically locate surface-level bio-retention measures (rain gardens and swales) within the planter strip area of sidewalks, within red zone curb-extensions, and in street medians as feasible. Permeable paving can be used in sidewalk areas, parking lanes, and residential streets where site conditions limit the area available for bio-retention. These GI features would drain into large underground storage pipes, which would fill during storm events and discharge metered flows into the existing storm drain pipelines through small orifices (Figures 8-1 and 8-2, Green Street Cross-Section & Plan View).

The assumed storage unit was represented in the model as a 6-feet diameter by 300-feet long pipe. Any configuration of GI and underground storage would need to approximate this volume to realize the level of flow-reduction benefits predicted by the modeling.

Modeling results indicate that the GI approach is much more effective in locations east of Adeline/Shattuck, and there are diminishing returns on investment beyond 54 units. However, 54 GI/Storage units in the upper watershed would result in incremental flood reductions throughout the watershed.

This cost estimate factors in site preparation, street demolition and disposal, materials and installation of the GI unit, and street replacement. Total estimated cost for 54 units is $31.3M.

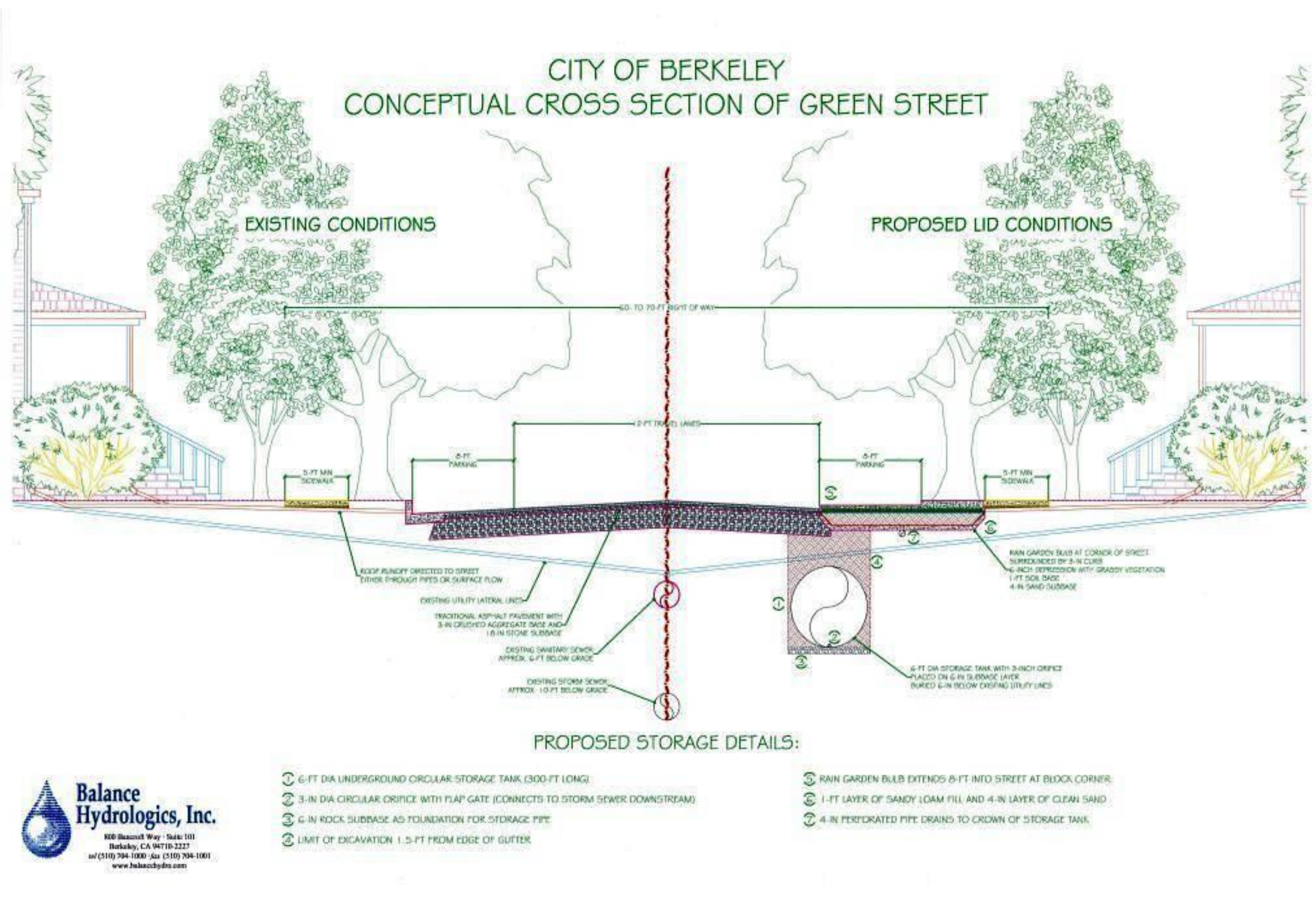

Figure 8-1, Conceptual Cross Section of Typical Green Infrastructure

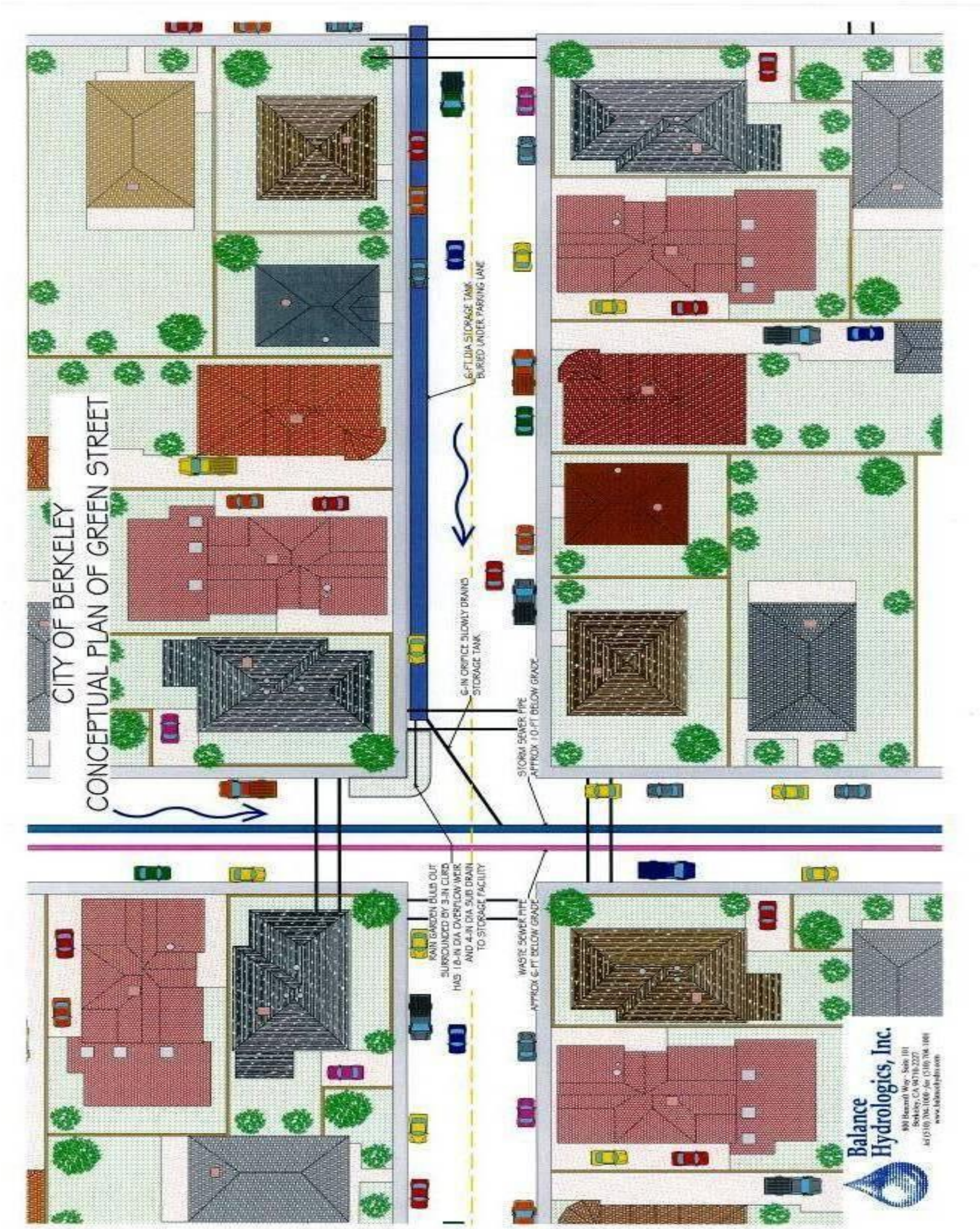

Figure 8-2, Conceptual Plan View of Typical Green Infrastructure

CODORNICES WATERSHED FINDINGS

Codornices Drainage Pathways

The Codornices Watershed includes land from both the City of Berkeley and the City of Albany. Codornices Creek is the primary drainage avenue, consisting of both open channels (approx. 15,500-feet in length) and culverted creek segments (approx. 11,450-feet in length). The creek discharges to the Bay just north of Buchanan St. in Albany. The creek represents the boundary between the cities of Berkeley and Albany from just west of Monterey Ave to Eastshore Highway.

In the upper watershed, there is a confluence of three branches of Codornices Creek at Codornices Park, immediately east of Euclid Street. Except for one other (mostly culverted) branch joining the creek at Josephine and Hopkins, Codornices Creek remains a single channel from Codornices Park to the Bay. The City operates several recreational parks and other open space areas where the channel is open; however, the majority of open channel is located on private properties[12]. The City maintains creek culverts where the creek passes under the public right-of-way. The City also operates and maintains an additional 40,100 feet of storm drain pipelines within the watershed.

See Appendix C Maps: Codornices Watershed Existing Conditions Map (May 23, 2011)

Existing Conditions Results

Most open creek sections and creek culverts located upstream of Codornices Park appear to have adequate capacity for the 10-year storm. Downstream of this, hydraulic capacity conditions vary on a reach by reach basis with capacity constraints becoming more prevalent east of Henry Street. For the 10-year storm, roughly 42 acre feet of flooding is predicted at various locations. The existing flow capacity of the Eastshore Hwy creek culvert, where the creek exits the City, is 195 cfs.

Within the watershed, storm drain pipe infrastructure shares similar hydraulic capacity conditions as the creek. Most storm drain pipes are adequately sized for the 10-year design storm above Codornices Park. However, the Euclid line is at or above capacity, as are some sections of the Shasta Road line.

Within City limits, the area with the highest propensity to flood is along Second Street where the street essentially serves as a release point or floodway, for the undersized Interstate 80 Highway (I-80) creek culvert (owned by Caltrans). Approximately 75% of the 42 acre feet of predicted flooding escapes the creek corridor at Second Street. This model result is confirmed by chronic flooding experienced at this site.

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[12] Balance Hydrologics was able to build the hydraulic model and calibrate it despite limited access to the creek due to private property constraints. Balance supplemented the City's GIS data with past information gathered for the City's Creek Task Force as well as with data from other previous work in the watershed. They maintain a flow gaging station under the BART tracks at Santa Fe Ave and also operate several rain gages in the watershed. The model can be further refined as additional data about the open channels and creek culvert conditions are obtained.

Localized flooding can be expected in varying degrees (including surface ponding at street sags) within the locations in Table 8-4.

Street Name	Cross Streets
Second Street	Creek corridor to Gilman
Rail Road tracks	Creek corridor to Gilman and to Albany
Gilman Street	between Sixth and Second
Codornices Creek	at Sixth, at most street crossings east of San Pablo, at Glen
Ninth Street	between Harrison and Creek Corridor
Monterey Ave	between Posen and Hopkins
Hopkins Street	at Carlotta
The Alameda	between Napa and Yolo
Sonoma Ave	between Fresno and Hopkins
Spruce Street	Eunice to Creek corridor
Euclid Ave	Cragmont to Codornices Park
Cragmont	Euclid to Regal
Various locations	LaLoma, Glendale, Campus Drive, Queens, Shasta Road

Table 8-4

Options Analyzed

Reducing peak runoff flows and volumes throughout the watershed will reduce bank erosion and in-stream habitat-scouring, as well as reduce flood hazards. From a flood management perspective, the Codornices Watershed's most severe problem is in the lower watershed, beginning at the railroad right-of-way.

Traditional Upsizing

Storm Drain Pipelines

The modeling identified the capacities and current hydraulic loads expected for each pipe segment greater than 18" in diameter. This approach alone offers no water quality benefits and may contribute to downstream flooding conditions and in-stream erosion. The cost to upsize these storm drain pipes such that there is no associated surface ponding is roughly $4M.

Creek Culverts

Wholesale removal or enlargement of creek culverts have effects on the upstream and downstream reaches of the open creek, which would need to be further analyzed. This type of fundamental change to the creek corridor might also affect the Flood Insurance Rate Maps and potentially increase premiums for those covered by the National Flood Insurance Program. Currently, the FEMA designated 100-yr flood zone follows the creek corridor from the Bay to the intersection of Sonoma-Hopkins-Josephine Streets.

The upsizing of city-owned culverts operating at or above capacity at street crossings west of Euclid Street (Codornices Park) to Eighth Street is estimated to cost $1.2M

Open Channel

The traditional approach to modifying a creek to provide flood control service is to remove meanders and contain flows in a widened trapezoidal channel (sized to convey the 50- or 100-yr storm) with minimal vegetation to reduce friction. This single objective approach is not desirable for protecting riparian ecosystems.

Restoring creek segments by sizing the active channel to transport the 2-year storm and providing a modified floodplain terrace is a strategy being planned and implemented between San Pablo Ave and the UPRR right-of-way. This approach is an option for the City in select locations, where the City owns the land and there is adequate space for restoration. The costs for this multi-objective approach can vary widely, however it is to grant funding, especially from state programs.

Lower Watershed Measures

At a 10-year design storm Codornices Creek overflows its banks at Second Street, where the street dead-ends at the creek corridor. The street is the low point in the surrounding landscape and was likely originally designed as a floodway. Roughly 31 acre feet of water escape the channel in this area, flowing towards Harrison and Gilman Streets.

Exacerbating the chronic flooding condition, are the sizing of the Caltrans creek culverts at San Pablo Avenue and under HWY I-80. The upstream San Pablo Ave creek culvert capacity is approximately 420 cfs, while the downstream capacity of the I-80 creek culvert is 195 cfs. The difference between the two creek culvert capacities requires the excess flow either be stored or re-routed to another drainage pathway to reduce or eliminate flooding. The modeling results indicate that localized flooding in the lower watershed cannot be completely eliminated without an additional capacity under I-80.

There are a number of measures the City studied to reduce the flooding in this area. These measures include:

- ***Berm @ Second Street:*** Constructing a low berm along the south side of the creek corridor between the Compressed Natural Gas Filling Station at the end of Second to Eastshore Highway. The berm elevations would contain higher volumes of flow within the creek corridor, forcing more flow through the I-80 culvert. The berm would be designed to keep Second Street as the breakout point for overflow. The berm would reduce the flood volume on Second Street from 28.98 af to 12.69 af[13] for a 10-yr storm. Estimated cost: $114,000.

- ***Re-Route Excess Flows to Village Creek:*** There is a by-pass structure and channel located on the north bank of the creek just upstream of Fifth Street. The

[13] All modeling result scenarios assume prior installation of large volume GI/storage units in Codornices Park and Henry Street.

by-pass channel, which currently operates at less than 50% capacity during the 10-year storm, conveys flow to Village Creek in Albany. Village Creek discharges into Codornices Creek on the west side of I-80 between the highway and Golden Gate Fields Race Track. As a stand-alone option, the activation of the Village Creek by-pass would reduce flooding on Second Street from 28.98 af to 24.86 af. Because the by-pass is already in-place, there is no capital cost associated with this option. Coordination with and permission from the City of Albany and possibly the University of California would be needed.

- ***Berm and Re-Route Excess Flows to Village Creek:*** Incorporating both options provides further flood volume reductions. In this case the overflow volume on Second Street would be reduced from 28.98 to 7.24 af.

- ***Upsize Conveyance Capacity under Hwy I-80***: The modeling results indicate that localized flooding in the lower watershed cannot be completely eliminated without an additional culvert under I-80. If the Caltrans Codornices Creek Culvert under I-80 cannot be expanded, remaining flows on Second Street may be routed to the Gilman trunk line as capacity permits. From an engineering and cost perspective, it would be easier and less expensive to install another pipeline to the Bay on Gilman Ave. Any option would require coordination and approvals by Caltrans

Green Infrastructure

Unlike Potter, the Codornices Watershed is quite narrow, with the greatest lengths of storm drain piping in the steepened hillside areas (east of Shattuck). Staff determined that the use of large volume under-street storage of runoff in the public right-of-way in this topography would be too risky. According to the California Geological Survey Hazard Study Map, the areas east of Shattuck Avenue in the Codornices Watershed are in seismic hazard zones for earthquake fault lines and landslides. However, there are opportunity areas in parklands in the upper watershed, which are appropriate for GI Storage. Retrofitting the City right-of-way with green infrastructure measures such as bioretention cells, hydrodynamic separator units, and permeable paving without large volume storage is feasible in most areas.

Park Storage

There are 10 city parks located in the Codornices Watershed. The Codornices Creek runs through (or under) portions of Glendale-LaLoma Park, Codornices Park, the Rose Garden, Live Oak Park, King School Park, and the Harrison Park. Glendale-LaLoma, and Live Oak Park have limited space available for storage. The larger sites, such as Codornices Park, King School Park, and Harrison Park, have the most potential to store large volumes of creek flow either at surface level or underground in cisterns while preserving existing recreational uses.

Both Codornices and King Parks have the space needed for subsurface level detention, where large storage pipes or cisterns can be installed underground and recreational features replaced at surface level. The Harrison Park site is appropriate for surface level detention, where the fields could be lowered to allow storm overflow from the channel to pond in the fields, which are usually closed to the public during wet weather to minimize turf damage.

Right-of-Way Retrofits

Unlike Potter, GI features would not need to drain into large underground storage pipes because the subbasins draining into the creek are so small in the Codornices Watershed.

One particularly promising site for the use of GI storage similar to the Potter Watershed approach (large volume under-ground storage pipes metering flow) is at Henry Street between Eunice and Berryman. The topography is much shallower than areas to the east, the street is very wide, and there are existing inlets discharging directly to the creek. The concept is to collect stormwater runoff from the Euclid storm drain branch (above Codornices Park) and redirect down Eunice Street in a new 2.5' storm drain pipe. This line would discharge into storage barrels (equivalent to four 8'-diameter, 550' long pipes). These pipes would meter discharge to the creek. Rain gardens, swales, permeable paver as appropriate would treat the runoff prior to its discharge into the storage pipe. Estimated Cost: $4.5 million.

DESCRIPTION OF CAPITAL IMPROVEMENTS FOR POTTER WATERSHED

1. Combination of Traditional Pipe Upsizing & Green Infrastructure: Hydraulic modeling results show that the City can effectively manage the 25-year storm for the main trunk line and the 10-year storm for all other pipes by using a combination of approaches. By striking the right balance of GI storage units (54) east of Adeline and retrofitting the trunk line from Adeline/Shattuck to the railroad tracks, the total length of storm drain pipe upsizing throughout the watershed can be reduced from 35,000' to 21,000'. This approach would also reduce the degree of upsizing needed for many of the pipe segments, which represents a significant cost savings. In addition to the main trunk line, remaining specific pipe segments recommended for replacement are identified in Balance's report, Appendix D. This report also identifies opportune locations for the proposed GI units, whose feasibility and performance are dependent on appropriate site conditions (such as topography and proximity to existing storm drain pipelines). Estimated cost is $49.24M, not including the realignment of Aquatic Park storm drainpipes and resolution of tidal effects.

2. Tidal Effect Resolution: The preferred tailwater resolution option is *Option #5, Smaller Pressure Pipe and Storage in the Main Lagoon*. The pressure pipe would push 44% more flow through the pipe to the Bay than is currently possible. For a 10-yr storm, 70% of the runoff volume would discharge directly to the Bay, while the remaining would be temporarily stored in the Main Lagoon or (with minor modification) to the Radio Tower Pond. Only large storm events would require the use of Aquatic Park for storage, which may translate to its use only a few times a year. With the addition of a trash rack, no trash should enter the Lagoon or Bay through the modified pipeline. The installation of GI units in the upper watershed would remove additional non-point source pollutants and further reduce overflows into Aquatic Park. Estimated cost is $14.8M.

3. Aquatic Park Storm Drain Pipes: This storm drain pipe infrastructure operates at or above capacity during the 10-yr storm and surcharges frequently within the park. A new alignment parallel with the UPPR railroad tracks feeding directly to the proposed trunk line improvements would reduce stormwater flows into the lagoon. The estimated cost to relocate and upsize select associated laterals is $3.75M.

See Appendix C Maps Potter Watershed SWMM Nodes and Pipe Capacities – Traditional Q10 Retrofit Results (May 6, 2011).

See Appendix C Maps: Potter Watershed Green Retrofit System Results Map (April 27, 2011)

DESCRIPTION OF CAPITAL IMPROVEMENTS FOR CODORNICES WATERSHED

1. **Traditional Pipe Upsizing**: The model identified various storm drain pipeline segments operating above capacity for a 10-year design storm. The Shasta and Cragmont-Euclid branches in the upper watershed require approximately 3,400-feet of storm drain pipe upsizing to better convey the 10-yr design storm. Upsizing these storm drain pipelines will cost an estimated $1.6M.

2. **Codornices Park Storage**: Modeling results indicate that large volume detention can reduce flow volumes and velocities within the creek corridor. This can be accomplished by offloading peak flows from the existing creek culverts within Codornices Park through the installation of 8 in-line storage pipes, each 5-feet in diameter (Figure 8-3). Three storage pipes 224-feet long would capture high flows from the North Fork culvert; while five storage pipes 95-feet long would capture high flows from the South Fork culvert. The proposed pipes would be located under existing basketball courts, lawn area, and pathways. These amenities would be replaced atop the buried pipes. Including the replacement cost of the basketball court and other recreational amenities, the estimated cost is $1.725M.

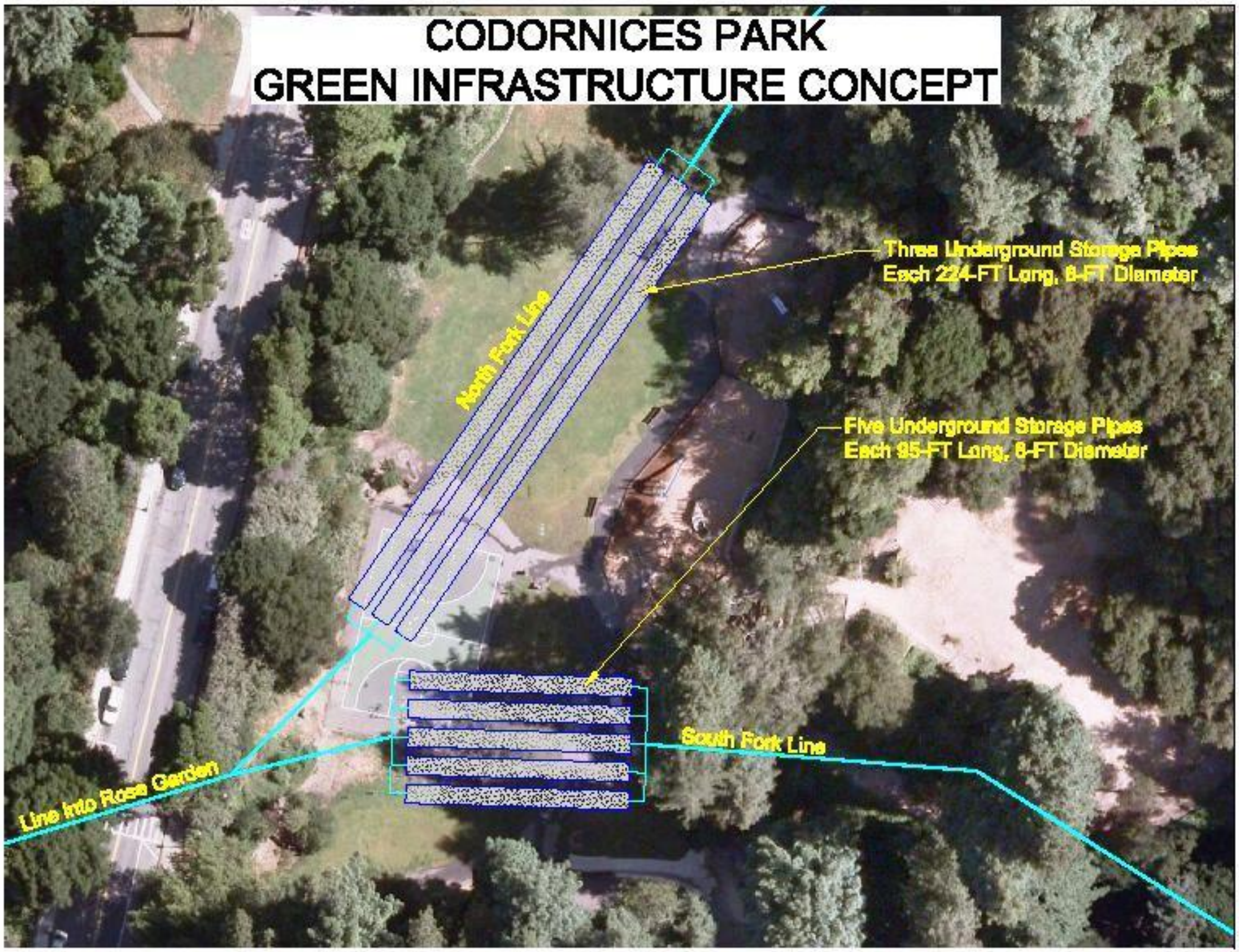

Figure 8-3, Conceptual Green Infrastructure Storage Units in Codornices Park

3. **New Eunice Pipeline with GI Storage under Henry**: This plan routes storm water collected by the Cragmont-Euclid storm drain pipeline branch into a new 30" diameter pipeline running down Eunice Street. This new storm drain pipe would turn south at Henry and discharge into four storage pipes (equivalent to 8' diameter by 550' long each) under Henry between Eunice and Berryman St. These pipes would discharge directly into the Codornices Creek culvert below Henry. Re-routing the stormwater at Eunice further relieves hydraulic loading on the open watercourse below Euclid. This approach in conjunction with the Codornices Park storage retrofits would decrease maximum discharge by 71 cfs. Estimated cost: $4.5M.

4. **Green Infrastructure (No additional storage features)**: Surface-level GI measures such as rain gardens, bioswales, permeable paving, and hydrodynamic separator units can be installed at opportunity sites throughout the watershed. Opportunity sites would be defined by site conditions (proximity to existing drainage inlets, slope constraints, and space available with minimal loss of on-street parking).

Promising GI sites or areas for further investigation include:

- Eunice Street, between Euclid and Shattuck (as component of new Eunice storm drain pipeline project)
- Euclid Ave, between Codornices Park and Rose Garden
- Josephine Street, at Hopkins
- Hopkins Street, between Colusa and Beverly
- Commercial Areas, such as Northbrae, Westbrae, and San Pablo Ave
- Tenth Street, at Codornices Creek
- Eighth Street, at Codornices Creek

Estimated Cost: unknown. Further analysis needed to determine best GI approach at opportunity sites.

See Appendix C Maps: Codornices Watershed Green Infrastructure Possibilities Map

5. **Berm at Second Street**: This plan installs a low berm around the downstream reach of the creek between 2nd Street and Eastshore Hwy Rd. This would force more flow into the Eastshore Hwy culvert without contributing to additional flooding on the north (City of Albany) side of the creek, downstream of the railroad right-of-way. The berm would be designed to have 2nd St. continue to be the release point for breakout flows from the channel. It would add overflow volumes to the railroad right-of-way drainage ditches, on both sides of the tracks, which are currently operating below full capacity during the 10-yr design storm. Estimated cost: $114K

   This berm would be compatible with the future long-term restoration concept for the creek corridor between the railroad tracks and Eastshore Highway.

6. **Village Creek By-Pass**: It is recommended that the City pursue an agreement with the City of Albany and the University of California to lower the weir elevation of the Village Creek By-Pass structure on Codornices Creek just upstream. Working in conjunction with the proposed berm at Second Street, this diversion structure could further reduce Second Street flooding. The resulting flow reductions on Codornices Creek would benefit downstream property-owners, such as private businesses and their customers, the City's transfer station and Compressed Natural Gas Filling Station facilities, the railroad companies, and Caltrans. Estimated cost: N/A (structure already in-place).

7. **Increase Conveyance Capacity Under Highway I-80**: It is strongly recommended that the City pursue an agreement with Caltrans to increase the capacity of the existing Codornices Creek culvert under I-80. The simple logic is that the existing capacity for Caltrans' upstream culvert at San Pablo Ave allows twice the flow as its I-80 culvert a ½ mile downstream. If upsizing or installing a new Codornices Creek culvert under I-80 is not feasible, the City should pursue an agreement with Caltrans that it increase the Gilman storm drain pipeline capacity under Hwy I-80 as necessary to accommodate breakout flows from Codornices Creek at Second

Street. Estimated Cost: Unknown (likely expenses would include legal fees and CIP cost to install storm drain pipe(s) from Codornices Watershed to Gilman Watershed).

8. **Channel and Floodplain Restoration**: It is recommended that the City continue to partner with the City of Albany and the University of California to restore the open watercourse and its associated floodplains from San Pablo Ave to the railroad tracks. Thus far, the creek reaches between Eighth Street and the railroad tracks have been restored.

   In addition to the creek corridor from San Pablo to the railroad tracks, the City of Berkeley and Albany are working on a restoration plan for the reach between the railroad tracks and Eastshore Hwy Rd.

   Estimated cost: unknown (more planning is required among the project partners).

See Appendix C Maps: Codornices Watershed Green Retrofit Results Map

RECOMMENDATIONS FOR CI PRIORITIES

8.1 Potter Watershed CI Priority List

Rank	Existing Shape & Diameter (in)	Circular Pipe Retrofit Diameter (in)	Length (ft)	CIP Cost	Project Description
1	NA	108 48	5,100	$17,532,222	Install trunkline pressure pipe from RR to bay outfall, includes relocation of transit line
2	Egg, 108	108-120	2,460	$4,333,160	Trunkline upsizing RR to San Pablo Ave
3	Egg, 108	108	2,260	$3,817,710	Trunkline upsizing San Pablo to Sacramento
4	Box, Egg, Circular, 84-108	84-96	3,200	$4,568,070	Trunkline upsizing Sacramento to Adeline
	TOTAL TRUNK		**13,020**	**$30,251,162**	
5	NA	NA	NA	$1,158,000	2 GI/Storage Units - Piedmont (Forest to Derby)
6	NA	NA	NA	$1,158,000	2 GI/Storage Units - Piedmont (Durant to Channing)
7	NA	NA	NA	$1,158,000	2 GI/Storage Units - College (Channing to Dwight)
7	Box, 20	36	514	$243,360	SD pipe Upsizing (concurrent w/GI)
	Total #7			**$1,401,360**	
9	NA	NA	NA	$1,158,000	2 GI/Storage Units - Woolsey (Eton)
10	NA	NA	NA	$1,158,000	2 GI/Storage Units - College (Parker to Derby)
11	Egg, 52-54	54	512	$458,000	SD Pipe Upsizing, San Pablo (Russell to Ashby)
12	NA	NA	NA	$1,158,000	2 GI/Storage Units - Ashby (Benevue)
13	NA	NA	NA	$1,158,000	2 GI/Storage Units - Bancroft (Bowditch)
14	NA	NA	NA	$1,158,000	2 GI/Storage Units - Bowditch (Channing-Haste)
15	NA	NA	NA	$1,158,000	2 GI/Storage Units - Shattuck (Bancroft to Kittredge)
16	NA	NA	NA	$1,158,000	2 GI/Storage Units - Derby (Telegraph to Regent)
17	Circular, 42-48	54	985	$821,332	SD pipe upsizing, Sacto (Parker to Russell)
18	Egg, Circular, 108-15	96-24	171	$592,000	SD pipe upsizing, Ashby (Prince to Sacto)
19	NA	NA	NA	$1,158,000	2 GI/Storage Units - Piedmont (Forest to Derby)
19	Circular, 27	30	1,066	$503,620	SD pipe upsizing, Derby (College to Regent)

Rank	Existing Shape & Diameter (in)	Circular Pipe Retrofit Diameter (in)	Length (ft)	CIP Cost	Project Description
	Total #19			**$1,661,620**	
21	NA	NA	NA	$1,158,000	2 GI/Storage Units - Webster (College)
22	NA	NA	NA	$1,158,000	2 GI/Storage Units - Telegraph (Regent)
23	Circular, 45-48	48-54	1,530	$1,286,090	SD pipe upsizing, Grant (Parker to Russell)
24	NA	NA	NA	$1,158,000	2 GI/Storage Units - Ellsworth (Channing)
25	NA	NA	NA	$1,158,000	2 GI/Storage Units - Shattuck (Channing)
26	Circular, 21	24	230	$89,570	SD pipe upsizing, MLK (Bancroft) - BHS
27	Egg, 78	72	260	$273,780	SD pipe upsizing, Adeline (Russell twd Ashby)
27	NA	NA	NA	$1,158,000	2 GI/Storage Units, Adeline (Oregon)
27	NA	NA	NA	$1,158,000	2 GI/Storage Units, Adeline (Asbhy)
	Total # 27			**$2,589,780**	
30	NA	NA	NA	$1,158,000	2 GI/Storage Units - Shattuck (Blake)
31	NA	NA	NA	$1,158,000	2 GI/Storage Units - Ellsworth (Dwight)
32	Egg, 54	48	1,280	$993,720	SD pipe upsizing, Parker (Ellsworth to Shattuck)
33	NA	NA	NA	$1,158,000	2 GI/Storage Units - Ashby (Telegraph)
34	NA	NA	NA	$1,158,000	2 GI/Storage Units - Woolsey (Dana)
35	Egg, 45	42	1,175	$777,400	SD pipe upsizing, Woolsey (Telegraph to Wheeler)
35	NA	NA	NA	$1,158,000	2 GI/Storage Unit - Wheeler (Prince to Woolsey)
	Total #35			**$1,935,400**	
37	NA	NA	NA	$579,000	1 GI/Storage Units - Woolsey (Tremont)
38	NA	NA	NA	$1,158,000	2 GI/Storage Unit - Dwight (Prospect)
38	Circular, 24	30	154	$72,670	SD pipe upsizing, Prospect (Dwight)
	Total #38			**$1,230,670**	
40	NA	NA	NA	$1,737,000	3 GI/Storage Units - Derby (Warring)
40	Circular, 21	30	322	$152,100	SD pipe upsizing, Derby (Warring)
	Total #40			**$1,889,100**	
42	NA	NA	NA	$1,158,000	2 GI/Storage Units - Stuart (College - Cherry)
42	Circular, 21	27	491	$216,320	SD pipe upsizing, College (Stuart - Russell)
	Total #42			**$1,374,320**	
44	NA	NA	NA	$1,158,000	2GI/Storage Units - Telegraph (Stuart)

8.2 Codornices Watershed CI Priority List

Rank	Existing Shape & Diameter	Circular Pipe Retrofit Diameter (in)	Length (ft)	CIP Cost	Project Descritption
1	NA	NA	NA	$1,730,000	GI/Storage at Codornices Park
1	Circular, 10	18	44	$13,100	SD Retrofit, in Codornices Park
	Total #1			$1,743,100	
3	NA	NA	NA	$113,621	Second Street Berm
4	NA	NA	NA	$0	Village By-Pass: City of Albany, UC-Berkeley
5	NA	NA	NA	$4,194,183	GI/Storage at Henry
5	NA	30	3200	$2,023,261	New SD pipeline, Eunice (Euclid - Henry)
	Total #5			**$6,217,444**	

Rank	Existing Shape & Diameter	Circular Pipe Retrofit Diameter (in)	Length (ft)	CIP Cost	Project Descritption
7	Circular, 18	24	205	$82,700	SD Retrofit, Hopkins (Monterey to Creek)
7	Circular, 15-24	24-30	1030	$445,700	SD Retrofit, Monterey (Posen to Creek)
	Total #7			**$528,400**	
9	Circular, 18	24	195	$78,400	SD Retrofit, Carlotta (Hopkins to Creek)
10	Circular, 21	27	407	$62,600	SD Retrofit, The Alameda (Napa to Hopkins/Creek)
11	Circular, 18	24	256	$103,200	SD Retrofit, Spruce (Eunice to Creek)
12	Circular, 24	30	1507	$677,000	SD Retrofit, Euclid (1114 Euclid to Eunice)
13	Circular, 18-24	24-30	1630	$694,500	SD Retrofit, 982 Regal, Cragmont, Euclid (to 1114 Euclid)
14	Circular, 21	30	42	$20,500	SD Retrofit, 1177-1179 Keith
15	Circular, 10	18	108	$32,100	SD Retrofit, 2949-2934 Shasta

8.3 Estimated CIP Costs – All Watersheds

Estimated costs for CIP in all Watersheds (based on extrapolations from Codornices and Potter Watersheds Hydraulic Modeling findings and cost estimates): $207.5M

- Potter: $65M
- Schoolhouse: $19.5M
- Gilman: $10M
- Wildcat: $10M
- Strawberry: $45M
- Codornices: $18M
- Cerrito: $15M
- Marin: $15M
- Temescal: $10M

CHAPTER 9: WMP REVENUE SCENARIOS & IMPLEMENTATION LEVELS

This chapter provides an overview of the revenue sources currently used to support the City's WMP-Storm program and the activities that can be supported at this time with the available funding. Also discussed are compliance issues and service reductions that will be required if the City doesn't increase the level of funding to support the program.

There are several options the City can explore to address the funding shortfalls and avoid service reductions. These funding options and the program levels that can be implemented with each funding level range from performing the minimum levels of activities to remain in compliance with MRP to increasing the storm drain facility capacity, improving water quality and providing necessary rehabilitation. The 4 options are discussed in more detail below.

At the end of each preceding chapter recommendations are made for both existing and new activities that comprise the Watershed Management Plan. These recommendations are numbered by priority. Within each of the following funding levels, recommendations that would be implemented by that funding are listed under that level's Operations and Maintenance or CIP heading. As funding increases, additional recommendations can be implemented, and these **additional recommendations for each level are indicated by bold text**.

EXISTING PROGRAM REVENUES- $2.8 Million

The City's annual expenses for WMP-Clean Storm activities are approximately $2.8 million, not including capital improvement expenditures. Revenue supporting the program at this time includes the Clean Storm Fee, an annual allocation of approximately $200,000 from UC Berkeley's long range development plan (LRDP) used for capital repairs, and a 1-time subsidy from the General Fund through FY 2013.

Clean Storm Water Fee

The City's annual WMP-Clean Storm program is funded by revenue generated by the Clean Stormwater Fee (CSF). The CSF generates $1.9 million in annual revenue, a figure that has remained flat since 1991. Every owner of real property that contributes stormwater runoff from their property in the City of Berkeley and makes use of and is served by the City's storm drain infrastructure is required to pay the CSF. Each owner's burden on and benefit from the storm drain infrastructure is related to impervious surface area on the real property. Impervious surface area is land that cannot absorb water and thus contributes significantly more stormwater runoff to this infrastructure than if the land had been left undeveloped in its natural state.

The Clean Stormwater Fund, **BMC 7.76,** imposes fees on each real property solely for the purpose of raising revenue necessary to improve the quality of stormwater discharged from the City-owned stormwater conveyance infrastructure. The annual fee for owners of parcels in all land use categories is calculated based on the formula: [(parcel size x runoff factor)/(RU)] x [rate per RU]. Runoff factors for various Land Use Categories are provided in the BMC, while the standard runoff rate (RU) is established by City Council resolution. The current RU is $50.00.

Clean Stormwater Fund revenues can only be expended for clean stormwater activities and no other purpose. By definition of the ordinance, clean stormwater activities include programs required under the ACCWP and the MRP; operation and maintenance of the City's stormwater drainage infrastructure; capital improvements to repair, rehabilitate, or replace components of the stormwater drainage infrastructure; any other activities related to the foregoing; and the administration of the ordinance.

Any future increases to the CSF would require voter approval from property owners and compliance with Proposition 218 requirements.

Additional Funding Sources

The CSF and the funding from UC Berkeley equals approximately $2.1 million. Nevertheless, the annual expenditures exceed program revenues by $700,000. In order to address this recurring annual shortfall, beginning in FY 2011, the City significantly reduced expenses by cutting clean stormwater maintenance activities by 60 percent. With an aging system, reduced maintenance activities and little to no capital improvements, the City still needed to allocate a total of $700,000 in General Funds to provide wet weather response and limited maintenance ($500,000) and perform minimal capital improvements ($200,000). This subsidy will end in FY 2013.

FUNDING LEVEL 1 – Clean Stormwater Fee Revenue + LRDP ($2.1M)

The CSF for the average single family home is approximately $50 per year. Existing revenues available to the WMP Clean Storm program limit the City's abilities to conduct proactive maintenance and condition assessments, undertake needed infrastructure repairs and meet updated MRP requirements. With the existing level of annual funding and the loss of the General Fund subsidy in 2014, the WMP- Clean Storm Program will need to decrease the service level of operations and maintenance. This also means the City can only address emergency capital repairs as they occur.

Discontinuation of the $500,000 General Fund subsidy for maintenance in FY 2014 coincides with the MRP's unfunded mandate for Permittees to begin implementation of full trash capture measures. In FY 2014, the City must reach the 40% trash reduction goal. Under current revenues, the City cannot continue its present level of maintenance and achieve the full trash capture requirement. The 1-time installation cost for the trash capture devices is projected to be $320,000 with ongoing maintenance estimated at $100,000 per year. This will increase the City's expenses by $320,000 in FY 2014 and $100,000 annually in FY 2015 and forward.

Combined with the new costs to comply with the trash capture mandate ($100,000) and the loss of the GF subsidy for maintenance ($500,000) and capital improvements

($200,000), the City will need to reduce $800,000 in ongoing costs in order to align expenses with the available annual revenues. This will reduce maintenance & operations further resulting in less frequent servicing of inlets, outlets, and catch basins. This will also reduce the City's overall effectiveness in preventing both stormwater pollution and localized flooding. Capital repairs will also be reduced to the $200,000 in available funding from the LRDP.

Watershed planning and enforcement activities will be reduced to only activities that maintain the City's regulatory compliance, further development of the watershed-specific management plans, investigation of grant opportunities, and coordination of watershed issues will be minimal. No additional hydraulic modeling of the remaining watersheds will be completed and activities related to creeks and creek culverts will not be implemented.

The following WMP recommendations are activities that would be performed with the funding resulting from the Clean Storm Fee and the LRDP funds, $2.1 million. They do not represent the implementation of any new recommendation and some will be reduced and or eliminated in FY 2014 without new revenue.

Operations & Maintenance

Chapter 1:
1.1 Inter-Departmental Coordination
1.2 WMP Public Meetings & Presentations (eliminated in 2014)
1.3 WWP Website (eliminated in 2014)

Chapter 2:
2.1 Global Climate Change Monitoring

Chapter 3:
3.1 San Pablo Stormwater Spine Project (Grant Funded)
3.2 LID/GI Coordination Opportunities with Other Public Works Programs (eliminated in 2014)

Chapter 4:
4.1 ACCWP Planning and Regulatory Compliance (Required compliance level)
4.2 New Development and Redevelopment Activities (Required compliance level)
4.3 Industrial/Commercial Discharge Inspections Activities (Required compliance level)
4.4 Private Property LID Promotion Activities (Required compliance level)

Chapter 5:
5.1 Floodplain Administration Duties (Limited but As Needed)
5.2 Watercourse Flooding Investigations (Limited but as needed)
5.3 Preservation and Restoration of Natural Watercourses Ordinance

Chapter 7:
7.1 Catch Basin and Inlet/Outlet Servicing (50% Service Level Drops in FY 2014)
7.2 Minor Storm Drain Facility Repairs (50% Service Level Drops in FY 2014)

7.3 Wet Weather Maintenance Program (50% Service Level Drops in FY 2014)
7.4 Misc. PW Storm Maintenance Activities
7.5 Street Sweeping Program (Funded by Refuse Fund)
7.6 PRW Maintenance Activities (Funded by Parks)
7.7 New Full Trash Capture Devices (New in 2014- Mandated Compliance)

Capital Improvements Program (CIP)

The City has budgeted roughly $400,000 for capital improvements to the Clean Storm program in both FY 2012 and FY 2013. This includes an annual $200,000 subsidy from the General Fund as well as $200,000 received from the annual UC Berkeley allotment. Under this current funding scenario, the City can only address emergency repairs, but will be unable to implement any capital improvement recommendations of the WMP, including green infrastructure and other capacity improvements.

Funding Level 1 Recommendations:

Chapter 6:
6.1.a. Rehabilitation Program (Current- Limited to Funding Available)

FUNDING LEVEL 2 – Minimum Regulatory Compliance Level Clean Stormwater Fee ($1.9M) & Special Tax ($2.25M) *

The Minimum Regulatory Compliance Level maintains the existing CSF rates and adds a Special Tax that would generate an additional $2.2 million beginning in FY 2013 with an annual Consumer Price Index increase. At this level of funding, maintenance is restored to FY 2010 levels, allows the City to begin immediate implementation of WMP recommendations, not currently performed and maintains compliance including the MRP's required full trash capture mandate by 2014. With both the CSF and the Special tax, the average single family residence will pay about $104 per year.

Watershed Planning and Enforcement
Under this scenario, the City will continue all of its Watershed Planning and Enforcement activities and development of additional watershed-specific management plans, as findings from new data gathering efforts are analyzed.

Hydraulic modeling of the remaining watersheds could begin in 2013 and be completed by 2015 (Strawberry, Schoolhouse, and Gilman – first batch; Marin, Cerrito, Wildcat, and Temescal – second batch), so that the existing conditions and green infrastructure retrofit plans can be determined and prioritized.

* Within each of these funding levels, recommendations that would be implemented by that funding are listed under that level's Operations and Maintenance or CIP heading. As funding increases, additional recommendations can be implemented, and these **additional recommendations for each level are indicated by bold text**.

Pursuit of other Citywide WMP recommendations (such as interdepartmental coordination with the Parks, Recreation & Waterfront and Planning departments and divisional coordination with Public Works Streets and Sanitary Sewers) would be initiated. Coordination with other stakeholders, east of railroad tracks (City of Albany, CalTrans, EBMUD, Target, and UPRR) would also begin in pursuit of mutually beneficial long-term flood management strategy.

Storm Drain Infrastructure Management
FEMA Flood Plain Administration duties and investigation of watercourse flooding would continue and direct management of creek reaches on City property would continue. A combination of in-house and consultant-based CCTV inspection activities will conduct proactive condition assessments on 1/5 of city-owned creek culverts every year, starting in 2013. The goal would be to complete investigation of all city-owned creek culverts every five years. The program would begin piloting a volunteer GPS monitoring/assessment program of watercourses in 2012, starting with Codornices Creek. This activity will help identify potential creek and habitat enhancement opportunities on City-owned lands, and generate additional information for watershed characterization and planning.

The City will use a portion of program revenue as a source of matching funds often required for state or federal grant programs.

Approval of a special tax requires voter approval.

Funding Level 2 Recommendations:

Operations & Maintenance

Chapter 1:
1.1 Inter-Departmental Coordination
1.2 WMP Public Meetings & Presentations
1.3 WMP Website

Chapter 2:
2.1 Global Climate Change Monitoring

Chapter 3:
3.1 San Pablo Stormwater Spine Project (Grant Funded)
3.2 LID/GI Coordination Opportunities with Other Public Works Programs (Limited)
3.3 Technical Guidance of LID BMPs

Chapter 4:
4.1 ACCWP Planning and Regulatory Compliance
4.2 New Development and Redevelopment Activities
4.3 Industrial/Commercial Discharge Inspections Activities
4.4 Illicit Discharge Control Activities
4.5 Private Property LID Promotion Activities
4.6 Trash Assessment Protocols

Chapter 5:
5.1 Floodplain Administration Duties (Limited but As Needed)
5.2 Watercourse Flooding Investigations (Limited but as needed)
5.3 Preservation and Restoration of Natural Watercourses Ordinance
5.4 Creek Culvert Condition Assessment Program (Limited)

Chapter 7:
7.7 New Full Trash Capture Devices
7.1 Catch Basin and Inlet/Outlet Servicing (Service Level Drops in FY 2013)
7.2 Minor Storm Drain Facility Repairs (Service Level Drops in FY 2013
7.3 Wet Weather Maintenance Program
7.4 Misc. PW Storm Maintenance Activities
7.5 Street Sweeping Program (Funded by 820)
7.6 PRW Maintenance Activities (Not Funded by 831)

Capital Improvements Program

Under this scenario, the annual Clean Storm CIP budget increases to $2 million, beginning in 2013. This budget will be used to address needed storm drain infrastructure repairs ($1 million) and to implement WMP recommended projects ($1 million). Site-specific repairs to the storm drain infrastructure should offer immediate local drainage improvements; however the costs of the WMP-recommended projects will require the City to set-aside a portion of CIP funds each year until enough revenue is amassed to take on a big-ticket project, such as the lower trunk line of the Potter Watershed.

Funding Level 2 Recommendations:

Chapter 6:
6.1.a. Rehabilitation Program (Limited to Funding Available)
6.1.b CI Program (Based on 8.1 Potter Watershed CI Priority List and 8.2 – Codornices Watershed CI Priority List) (Limited to Funding Availability)

FUNDING LEVEL 3 – Limited Green Infrastructure Level Clean Stormwater Fee ($1.9M) & Bond Measure ($30M) Special Tax ($2.7M)

The Limited Green Infrastructure Level maintains the existing CSF and adds a $30 million bond that would allow for immediate planning and construction of portions of the Codornices and Potter watersheds priority list. This level also includes a Special Tax with an annual Consumer Price Index increase generating $2.7 million annually for maintenance, rehabilitation of creek culverts and storm drains. At this level of funding, the City would perform all of the necessary maintenance, maintain regulatory compliance and with the addition of staff resources, design and implement the capital improvements at an accelerated rate. This level of funding provides for immediate capital improvements in portions of the watershed, but the remainder of the necessary capital improvements will take a much longer time than supported by Funding Level 4. The average annual cost to the single family residence is $174 (this includes both the special tax and debt service on the bond).

A General Obligation Bond and the special tax both require voter approval.

Operations & Maintenance

Funding Level 3 Recommendations:

Chapter 1:
1.1 Inter-Departmental Coordination
1.2 WMP Public Meetings & Presentations
1.3 MWP Website
1.4 Potter & Codornices Watershed – Public Meetings
1.5. Partnership Opportunities
1.6 Other Watersheds –Goals/Modeling/Priorities

Chapter 2:
2.1 Global Climate Change Monitoring

Chapter 3:
3.1 San Pablo Stormwater Spine Project (Grant Funded)
3.2 LID/GI Coordination Opportunities with Other Public Works Programs
3.3 Technical Guidance of LID BMPs
3.4 Investigate "In-Lieu" Pilot Program for LID

Chapter 4:
4.1 ACCWP Planning and Regulatory Compliance
4.2 New Development and Redevelopment Activities
4.3 Industrial/Commercial Discharge Inspections Activities
4.4 Illicit Discharge Control Activities
4.5 Private Property LID Promotion Activities
4.6 Trash Assessment Protocols

Chapter 5:
5.1 Floodplain Administration Duties (Limited but As Needed)
5.2 Watercourse Flooding Investigations (Limited but As needed)
5.3 Preservation and Restoration of Natural Watercourses Ordinance
5.4 Creek Culvert Condition Assessment Program (Limited)
5.6 Creek Restoration
5.7 Volunteer PGS Creek Assessment Program
5.8 Creek Guidance Materials

Chapter 6:
6.2 Hydraulic Modeling (Balance of Watersheds)
6.3 CCTV Inspection Program

Chapter 7:
7.7 New Full Trash Capture Devices
7.8 Realignment of Storm Drain Cleaning District (Investigation)
7.9 Investigate and Analyze Second Jet Vactor Truck
7.10 Investigate and Analyze Sand Bag Program Improvements
7.11 Investigate and Analyze Concentrated Leaf & Debris Clearing – Implement Improvements as Appropriate
7.12 Investigate and Analyze Street Sweeping Program – Report on Findings
7.13 Training Program and Maintenance Plan for GI
7.1 Catch Basin and Inlet/Outlet Servicing (Service Level Drops in FY 2013)
7.2 Minor Storm Drain Facility Repairs (Service Level Drops in FY 2013
7.3 Wet Weather Maintenance Program
7.4 Misc. PW Storm Maintenance Activities
7.5 Street Sweeping Program (Funded by 820)
7.6 PRW Maintenance Activities (Not Funded by 831)

Capital Improvements Program

In this scenario, funding from the bond is immediately available to begin implementing the CIP with no reserves needed. Design activities would start in 2013. This includes design of Green Infrastructure projects for the Potter and Codornices Watersheds, with construction activities beginning in 2014. At the same time design and permitting processes would begin for projects addressing the trunkline retrofits for the Potter Watershed; and the Second Street flooding issues in the Codornices Watershed. Once outside permits are obtained, project construction can begin. The outside agency permitting process is estimated to take 18 to 24 months. Creek Culvert and Storm Drain Rehabilitation Program projects would be funded at the $2M level.

Funding Level 3 Recommendations:

Chapter 5:
5.5 Creek Rehabilitation Program (Combined and Prioritized with 6.1.a)

Chapter 6:
6.1.a. Rehabilitation Program (Based on Funding)
6.1.b CI Program (Based on 8.1 Potter Watershed CI Priority List and 8.2 – Codornices Watershed CI Priority List)

FUNDING LEVEL 4 – Complete Green Infrastructure Level
Clean Stormwater Fee ($1.9M) & Special Tax ($7.7M)

The Complete Green Infrastructure Level maintains the existing CSF and adds a Special Tax that will generate $7.7 million annually with an annual Consumer Price Index increase. Combined with the CSF, this funding level would generate $9.6 million annually and would keep the City in regulatory compliance, maintains watershed planning and enforcement and adds additional staff resources to take a proactive approach to designing and constructing capital improvements. This Funding Level allows for a phased approach to capital improvements throughout the watersheds and in comparison to Funding Level 3, allows for completion of all improvements in a more timely manner. The average single family residence would pay about $238 per year.

Operations & Maintenance

Funding Level 4 Recommendations:

Chapter 1:
1.1 Inter-Departmental Coordination
1.2 WMP Public Meetings & Presentations
1.3 WMP Website
1.4 Potter & Codornices Watershed – Public Meetings
1.5. Partnership Opportunities
1.6 Other Watersheds – Goals/Modeling/Priorities

Chapter 2:
2.1 Global Climate Change Monitoring

Chapter 3:
3.1 San Pablo Stormwater Spine Project (Grant Funded)
3.2 LID/GI Coordination Opportunities with Other Public Works Programs
3.3 Technical Guidance of LID BMPs
3.4 Investigate "In-Lieu" Pilot Program for LID

Chapter 4:
4.1 ACCWP Planning and Regulatory Compliance
4.2 New Development and Redevelopment Activities
4.3 Industrial/Commercial Discharge Inspections Activities
4.4 Illicit Discharge Control Activities
4.5 Private Property LID Promotion Activities
4.6 Trash Assessment Protocols

Chapter 5:
5.1 Floodplain Administration Duties (Limited but As Needed)
5.2 Watercourse Flooding Investigations (Limited but As needed)
5.3 Preservation and Restoration of Natural Watercourses Ordinance
5.4 Creek Culvert Condition Assessment Program (Limited)
5.6 Creek Restoration
5.7 Volunteer PGS Creek Assessment Program
5.8 Creek Guidance Materials

Chapter 6:
6.2 Hydraulic Modeling (Balance of Watersheds)
6.3 CCTV Inspection Program

Chapter 7:
7.7 New Full Trash Capture Devices
7.8 Realignment of Storm Drain Cleaning District (Investigation)
7.9 Investigate and Analyze Second Jet Vactor Truck
7.10 Investigate and Analyze Sand Bag Program Improvements
7.11 Investigate and Analyze Concentrated Leaf & Debris Clearing – Implement Improvements as Appropriate
7.12 Investigate and Analyze Street Sweeping Program – Report on Findings
7.13 Training Program and Maintenance Plan for GI
7.1 Catch Basin and Inlet/Outlet Servicing (Service Level Drops In FY 2013)
7.2 Minor Storm Drain Facility Repairs (Service Level Drops in FY 2013
7.3 Wet Weather Maintenance Program
7.4 Misc. PW Storm Maintenance Activities
7.5 Street Sweeping Program (Funded by 820)
7.6 PRW Maintenance Activities (Not Funded by 831)

Capital Improvements Program

In 2013, in-house planning and design capacity will accelerate CIP implementation. The annual budget for CIP will be stable at about $5.5 million. As with the Scenario 2 the City will use $1 million per year to address immediate needed repairs, starting in 2013. However, with the Sustainable Green Infrastructure Level, $4.5 million per year can be accrued to undertake big-ticket projects in phases. With the increased revenue to build a sizable CIP set aside, the City will be able to implement projects much faster than under the Minimum Regulatory Compliance Level. Thus, the water quality, flood management and environmental benefits will be realized sooner.

In 2013, staff will begin designing Potter and Codornices tailwater improvements, while setting aside $4.5 million each year for future repairs. In 2014, with the CIP reserve from 2013 and $4.5 million of new revenue in FY 2014, the City will use the $9 million to begin construction of Potter Watershed trunkline retrofits. Staff will also begin designing the next phase of trunkline improvements or the Codornices priority project for 2016 implementation with the CIP reserve from 2015 and new revenue in 2016. During this time, green infrastructure planning and design will start for Codornices Park and for sites east of Shattuck in the Codornices and Potter Watersheds respectively.

Funding Level 4 Recommendations:

Chapter 5:
5.5 Creek Rehabilitation Program (Combined and Prioritized with 6.1.a)

Chapter 6:
6.1.a. Rehabilitation Program (Based on Funding)
6.1.b CI Program (Based on 8.1 Potter Watershed CI Priority List and 8.2 – Codornices Watershed CI Priority List)

APPENDICES

A: Existing City Plans and Polices Related to Watershed Management

B: Public Meeting – January 10, 2010

B –1: Agenda

B – 2: Presentation

B – 3: Public Comments

MAPS:

C – 1: City of Berkeley Drainage Map

C – 2: Storm Maintenance Districts Map

C – 3: Potter Watershed Existing System Results Map

C – 4: Codornices Watershed Existing Conditions Map

C – 5: Potter Watershed SWMM Nodes and Pipe Capacities – Traditional Q10 Retrofit Results Map

C – 6: Potter Watershed Green Retrofit System Results

C – 7: Codornices Watershed Green Infrastructure Possibilities Map

C – 8: Codornices Watershed Green Retrofit Results Map

D: Draft Potter and Codornices Watersheds Hydrology and Hydraulics Report (DRAFT – July 26, 2011)

E: Acronyms & Abbreviations

F: Bibliography