WATERSHED MANAGEMENT & GREEN INFRASTRUCTURE

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PRINCIPAL CONSIDERATIONS

SOSIP's focus on Green Infrastructure can be a role model for watershed health. SOSIP recommendations articulate a general strategy for Green Infrastructure in Downtown, but note that concepts in SOSIP will need to be developed further through the collaboration of engineers, urban designers, landscape architects, merchant representatives, and others. In addition, Green Infrastructure designers should always refer to the Department of Public Works for technical standards and guidance.

Urban Runoff Challenges

When it rains, runoff can pick up contaminants from the air, rooftops, or the land prior to its discharge into storm drainpipes, creeks, and eventually the Bay. Runoff is also generated when landscaping is over irrigated or cars are washed. Considerable pollution comes from urban runoff contaminated by dripping oil pans, tires debris and other sources. Street run-off also includes metals, pesticides and litter -- especially non-biodegradable plastics. Urban runoff is now one of the greatest contributors to degraded water quality in the Bay.

Runoff rates and volumes increase proportionally with impervious surface area within a watershed. Through conventional stormwater conveyance measures, runoff is quickly collected, conveyed by storm drainpipes, and creeks to the Bay. Consequently, water converges in some locations at nearly the same time, where peak flows in some locations exceed available capacity, resulting in surface ponding and flooding. This approach fails to recognize how larger watersheds function hydrologically and ecologically, and misses opportunities to use stormwater as a valuable resource.

***Facing Page:* "Rain gardens"** *provide a place where urban runoff can flow and be filtered by plants and soil, as is illustrated by this rain garden in Portland, Oregon. Staff photo.*

Watershed Approach & Green Infrastructure Strategies

Green Infrastructure strategies to manage stormwater and watersheds are being implemented across the nation to address the challenges outlined above and many other community needs. Green strategies emphasize landscape-based green Infrastructure features designed to absorb, evaporate, store, and slow runoff, while filtering out pollutants. The general approach is to increase evapo-transpiration from plants, store water in cisterns, and encouraging infiltration where permeable soils allow it.

As runoff percolates through the vegetation, and other natural media (gravel, mulch, sand, soils) that is often associated with Green Infrastructure, pollutants are removed by physical, chemical, and biological processes. This offers pre-treatment of the runoff prior to its entrance into storm drainpipes or creeks. Additionally, Green Infrastructure can reduce peak flows downstream by detaining and diverting runoff away from existing stormwater infrastructure.

Modest Green Infrastructure features placed close to where run-off first occurs can be more functional and less expensive than using larger more centralized features downstream. Green Infrastructure reduces the need for piping, inlet

Figure g.1*. *Urban Runoff. *Urban runoff includes rainwater that washes motor oil and other pollutants off of streets and into storm sewers. Green Infrastructure can filter these pollutants and improve water quality downstream.*

Figure g.2*. *Downstream Flooding. *Green Infrastructure can retain rainwater, and become part of strategies to reduce flooding downstream.*

__Figure g.3__. __Eco-Parks.__ "Eco-parks" contain low-lying areas to receive and treat urban runoff. Eco-parks offer an opportunity to educate the public about watershed issues. They can have a natural appearance as in Portland Oregon (top & center), or a formal appearance as in Santa Barbara (below).

structures, downstream detention facilities, and other traditional engineered facilities, as well as reduce a creek's exposure to erosive flow conditions. Stormwater detention and conveyance at the surface is generally less expensive than underground solutions. Green Infrastructure also simplifies maintenance and makes many problems easier to detect.

Leveraging Co-Benefits

Beautification & Traffic Calming. Green Infrastructure also offers significant co-benefits. The Downtown can be beautified while addressing environmental concerns. Vegetation can be used to reduce pollutants and will bring more green to the Downtown, while permeable paving can replace mundane asphalt with visually appealing surfaces.

Greenery and special pavers can support Downtown as a focal point for community life. Furthermore, Green Infrastructure makes environmental stewardship more visible, and should enhance Downtown's image and promote Downtown as an eco-destination. Studies suggest that "[t]he greening of Downtown will increase positive perceptions of Downtown and draw more customers. . ." (Project Evergreen, 2008, as cited in San Mateo Guidebook).

Green Infrastructure features can also be used for traffic calming, such as through the use of permeable pavements and curb extensions. Pavers create visual changes that alert motorists that they are entering a pedestrian-oriented city center. Curb extensions reduce distance for pedestrians crossing streets and also slow motor-vehicles by reducing width of street. Care should be given to select pavement materials that are suitable for persons with wheelchairs.

District-Scaled Opportunities. As a larger district, the Downtown Area straddles the Potter and Strawberry watersheds. Each watershed presents unique opportunities for retaining rainwater in cisterns, so that it can be reused for irrigation. At the surface, rainwater in the Downtown flows south and west. In principle, water that falls on Downtown might be collected and stored where it could be used for landscaping and as a back-up source of water for emergencies – a strategy employed in San Francisco.

Downtown Berkeley has relatively small parcels for development , which will make it difficult to fit large detention features on-site; meanwhile the public rights-of-way adjacent to development present opportunities for detention features and other Green Infrastructure. One possible approach would allow developers to meet regulatory stormwater requirements by paying a fee in lieu of on-site improvements. In lieu fees would be combined with other sources of financing to make public improvements on adjacent streets and within the watershed to which Downtown is connected. This approach would better leverage private capital by connecting it to the most advantageous opportunities in public parks and rights-of-way.

Improvements on public land and on private sites might be cooperatively planned for higher performance and cost effectiveness. For example, the downspouts of a privately-owned building could convey runoff to bio-retention basins on public rights-of-way, and then to below-grade storage (cisterns) for later non-potable reuse within the private building setbacks.

The scale of Downtown also presents special advantages. In Santa Fe, New Mexico, the Railyards Park has a cistern that collects runoff from hardscaped plazas; a photovoltaic powered pump then lifts this water into a water tank, which provides adequate pressure for irrigating landscaped areas. Consideration should be given to similar strategies in the Downtown Area, which is comprised of subareas similar in size to the Railyards and may offer suitable rights-of-way and open space opportunities.

Regulatory Background

The City of Berkeley is a co-permittee under the Alameda Countywide Clean Water Program's NPDES permit, as required under the Federal Clean Water Act. As a co-permittee, the City has individual program and permit responsibilities to reduce the discharge of pollutants in stormwater by: adopting effective standards; educating the public; performing street sweeping and storm drain maintenance; controlling erosion, etc. In addition, State-mandated water quality standards for urban runoff are becoming more stringent, which makes implementing appropriate runoff management and of Green Infrastructure increasingly urgent.

Context-Sensitive Design

Urban Setting. Downtown is covered largely by impermeable surfaces while simultaneously being the source of many pollutants. This circumstance makes the twin goals of reducing peak flows and treating runoff especially important. Street rights-of-way cover 40% of the Downtown Area, and are dominated by concrete and asphalt areas that drain the street. On commercial properties, gutters that drain roofs often discharge to streets. Downtown also accommodates heavy traffic and commercial activities that make Green Infrastructure critical.

Some Green Infrastructure are better suited to dense mixed-use places like Downtown, where land is used intensively be appropriate in Downtown's commercial areas, where space comes at a premium.

Converting Paved Areas. Downtown is largely covered by impervious surfaces including asphalt, concrete and buildings, but numerous opportunities for permeable surfaces and Green Infrastructure exist. Traffic analysis for Downtown has confirmed that portions of Shattuck Avenue that have 6 travel lanes can be reduced to 4 travel lanes -- without adding to traffic congestion. The segment of University Avenue from Shattuck Square to Oxford can be reduced from 4 lanes to 2 travel lanes, as can Hearst Avenue from Shattuck to Oxford. Diagonal parking and parking aisles along Shattuck might be reconfigured as parallel parking, thereby halving the asphalt per parking space from 330 to 160 square feet. Finally, Downtown has many red zones where curbs might be extended and Green Infrastructure added.

Clay Soils. Downtown's natural conditions need to be factored into Green Infrastructure decisions. Nearly all of Downtown is underlain by clay soils and silts, and infiltration strategies where water percolates into native soils are generally infeasible. Outflow features will often be needed in conjunction with subsurface collection – such as through below-grade

5 While environmental impacts from Downtown are significant, it is also important to recognize that impacts from high-density urban areas are less than if the same amount of develop occurred at lower densities – when measured at the scale of whole systems. EPA's "Protecting Water Resources with Higher Density Development" notes that not only to low-rise buildings cover more land than taller buildings, but low-density development also requires more impervious infrastructure like roads and parking lots. In addition, most green areas in low-density development has been created on soil that has been disturbed during development -- and is therefore compacted and far less pervious than undisturbed natural and agricultural lands.

use of permeable substrates and other features to increase detention volumes.

Slope. Consideration must also be given to Downtown's topography. Downtown slopes by 1-2% along north-south streets and 2-5% along east-west streets. Erosion can be an issue when there is drainage across slopes exceeding 1%. When water moves at the surface in the east-west direction, features, like weirs (i.e. "micro-dams") will be needed to slow water and dissipate its energy.

Climate. The Bay Area's Mediterranean climate must also be considered. A dry season extends through the summer and into the early fall, while winters can be extremely wet. Temporary irrigation and careful plant selection are critical concerns for vegetated green infrastructure measures which will not receive natural watering for a majority of the year. During the dry season, dust, pollutants, trash and debris accumulates on roads and other hard surfaces. When rain arrives, the "first flush" of the rainy season generally produces higher concentrations of contaminants – even though the volume of water from these first rain events may be modest. Year-round Street sweeping also plays an important role in reducing first flush impacts.

Utilities. The location of subsurface utilities and building services are critical for evaluating the location and appropriateness of particular facilities. In addition, the BART station mezzanine is located close to the surface between Addison and Allston. BART tracks run down the center of Shattuck and may limit some – but not all – Green Infrastructure options.

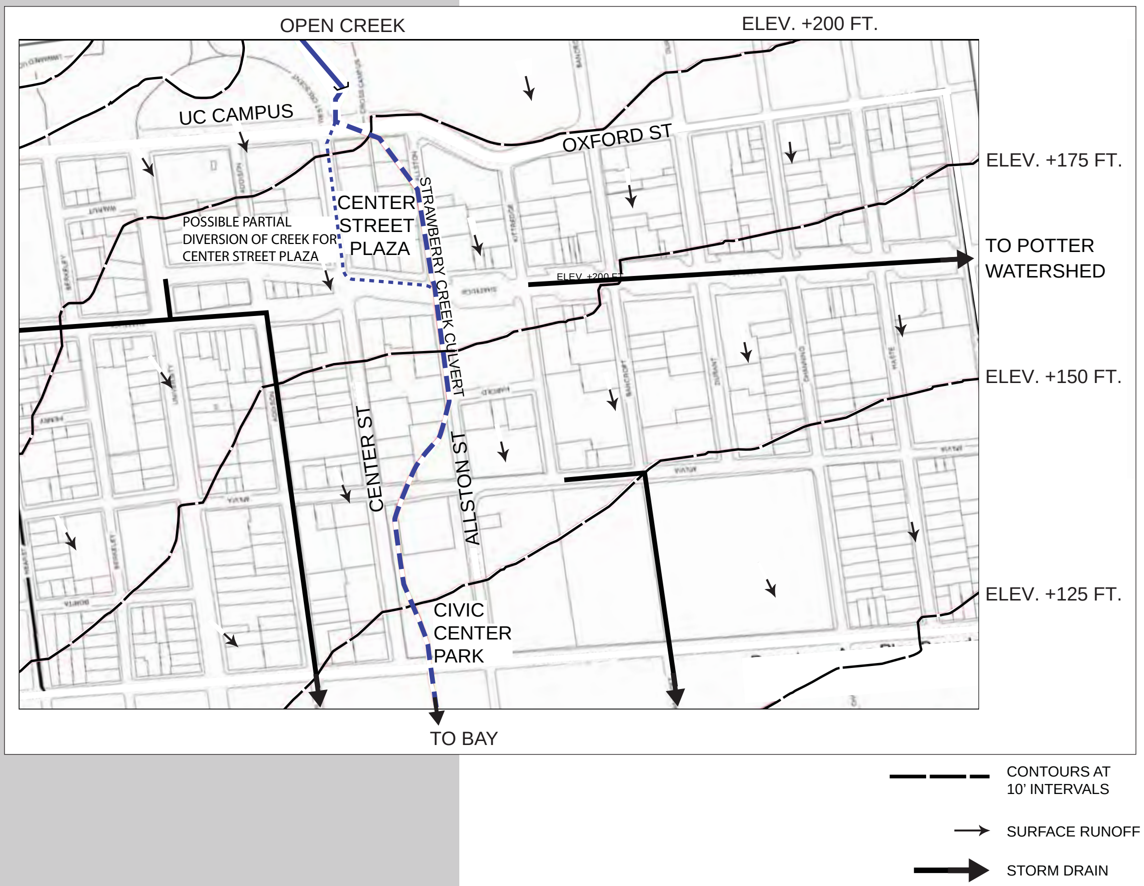

Figure g.4. Countours & Drainage (July 21, 2010).

Accessibility. Paths of travel must comply with the Americans with Disabilities Act (ADA), which will limit the type of Green Infrastructure selected in some locations, and may dictate how travel surfaces are finished.

Basements. Buildings in Downtown have basements and several buildings have basements that extend under sidewalks and possibly into public rights-of-way. The potential for disturbing basements directly or through the infiltration of water should be considered, so that possible impacts can be mitigated.

Green Infrastructure Performance & Types

Each Green Infrastructure feature performs differently and each is more-or-less suited to address one or more of the following. Figure ## depicts potential locations for Green Infrastructure, where sufficient space could be provided and topography is factored. The location, type and size of facilities should be decided during the design of major improvements in close consultation with the Department of Public Works.

Filtration & Absorption. Some Green Infrastructure measures filter or absorb pollutants contained in urban runoff, such as automotive fluids, pesticides, cleaning solutions, and metals. As runoff soaks into the site, larger contaminants like litter are left at the surface for easy collection.

Detention. Some Green Infrastructure measures temporarily hold or slowly meter the discharge of runoff which can reduce peak flows and downstream flooding. These Green Infrastructure include “rain gardens” that hold a few inches of water above grade, bio-retention trenches that hold water below grade, and properly-engineered permeable pavements and structural soils.

Retention & Infiltration. Retention measures divert water from the storm drain pipelines and creeks by impounding runoff rather than conveying it. Infiltration facilitates retention by having diverted water sink into the ground. Infiltration is limited to locations that are underlain by soils that have some permeability and are not over-compacted. The clay soils that underlay most of Downtown are impermeable, and would require expensive engineering to attain modest infiltration. Consequently, infiltration features are generally not recommended by the SOSIP.

Evapotranspiration. Significant amounts of water can be diverted through evaporation associated with landscaping and porous surfaces. Tree canopies also capture water on leaves, and some of this evaporates before reaching the ground. Vegetation also absorb and transpire large quantities of water, and some trees intercept and absorb hundreds of gallons of water a day. Through this process, pollutants in urban run-off can be absorbed, and reduce downstream flows.

Local Conveyance. Conveyance features may be used to gather and direct run-off to Green Infrastructure. Conveyance features, such as pipes, may be used to direct water to bio-retention basins or rain gardens, which may present a more cost-effective option than extensive use of permeable paving. Channels, and shallow gutters and runnels, reduce the need for pipes and can help reduce costs. In addition, some conveyance features slow runoff, such as textured pavement. Conversely, detention features become conveyance features when they overflow during the heaviest rains.

Figure g.5. Rain Gardens. *Urban run-off can drain into rain gardens, small flow-through planters that filter pollutants and retain water. Rain gardens can be located along curbs (top & center) or incorporated into plazas (below).*

Features on Private Parcels. Effective watershed management also requires participation from the private sector, including locating green infrastructure features on private development. These features can include on-site landscaping and green roofs. While the SOSIP focuses on public improvements, the SOSIP also describes a comprehensive district-wide approach that should be considered as development standards and design guidelines are revised.

POLICIES AND ACTIONS

Policy 4.1, Green Infrastructure Priorities. Green Infrastructure features should promote the health and function of watersheds within which they are sited. Green Infrastructure should be considered whenever street or open space improvements may be made, but should also be coordinated to leverage benefits.

a. Green Infrastructure should be incorporated into all major subarea projects, and should be considered throughout the Downtown Area as part of landscaping and traffic calming improvements.

b. Consider which types of Green Infrastructure investments and locations might best leverage benefits within the Strawberry and Potter watersheds.

c. A diagram of potential Green Infrastructure features is included in a Green Infrastructure Concept diagram, as depicted in Figure g.9.

Policy 4.2, Function & Location. Green Infrastructure improvements should be coordinated to optimize benefits. The specific functional needs of a location should be addressed by the particular Green Infrastructure selected. Functional types for streets and open space include: filtration & absorption, detention, retention & infiltration, evapotranspiration, and conveyance. Also consult with the Department of Public Works as detailed design and engineering is undertaken.

Green Infrastructure approaches that are suitable for Downtown are described below. Guidelines outline key factors for considering the design of specific features relationships. Consult with the Department of Public Works as detailed design and engineering is undertaken.

Bio-Retention Features (including rain gardens & tree basins). Bio-retention features hold water and slow its flow, while also using soil and vegetation to absorb pollutants, transpire water, and, where possible, encourage infiltration. Bio-retention features basins do not require large areas. Bio-retention basins can be modest at the surface because they can attain an appropriate size through additional depth. As a consequence, bio-retention basins can be contained with relative ease within curb extensions and in other curbside locations – such as when excessive asphalt is replaced by wider sidewalks and other features. If the cross-slope of a street directs water towards a median, the median may present a bio-retention opportunity. Bio-retention features may not be appropriate near some basements and utilities. Bio-retention features must be designed to avoid the creation of mosquito habitat.

While typical soils become compacted when bearing loads, structural soils maintain small voids that allow water, air and roots to penetrate. Structural soils create a load-bearing matrix by using coarse gravel and stabilizing agents. Consequently, structural soils add stormwater storage capacity. While structural soils usually add to upfront installation costs, these costs are offset by increasing tree survival, reducing pavement upheaval, and enhancing downstream performance.

Bio-Filtration Features (e.g. shallow swales and flow-through planters). Bio-filtration features use soil and plants to remove pollutants and sediments, but generally convey stormwater rather than retain it. Bio-filtration features convey water and are designed to detain only small amounts of water. Bio-filtration features do not need to be deep and are therefore well suited for locations with below-grade utilities and near basements. Bio-filtration features can be used to "pre-treat" runoff before it reaches bio-retention basins that might otherwise be compromised by sediments. Long narrow areas offer ideal locations for swales, and may include portions of the Center Street and Ohlone Greenway subareas. Bio-filtration features must be designed to avoid the creation of mosquito habitat.

Permeable Paving. Permeable paving has voids that allow water to infiltrate. Over most soils, permeable paving is accompanied by an underlying reservoir of gravel and stone, with filter fabric to prevent the reservoir from silting up.

Permeable paving may be applied to areas with no vehicle traffic or traffic at low speeds, such as parking stalls, sidewalks, "shared streets," and plazas. When permeable paving is to be used in association with below-grade retention, avoid locations with underground utilities and near basements. Select paving that provides a smooth surface for persons with wheelchairs.

Channels & Runnels. Channels and runnels are concrete or stone lined conveyance features that run along the surface. While they are not themselves Green Infrastructure, channels and runnels reduce the need for – and sometimes the size of – drains and subsurface pipes. They also make rainwater more visible and can be attractive visual elements. Runnels are shallow and accommodate modest flows, while channels are deeper and accommodate larger flows. Channels and runnels typically gather sheeting water and direct it to Green Infrastructure features, storm drains, or creeks. Runnels are a common feature in plazas, but also narrow streets and lanes. Channels can be seen frequently as part of curb extensions projects; channels allow runoff to drain properly through curb extension areas to maintain sufficient slope.

Water Storage (e.g., cisterns & "rain catchers"). Above-ground tanks and below-ground cisterns can be used to collect water from building downspouts and urban runoff that is sufficiently clean. Storage features can release collected water slowly. They can also be used to irrigate landscaped beds. Stored water can also play a vital role during disasters, when conventional water lines may be compromised. In San Francisco, below-grade cisterns that were installed in the early 20th century are still part of the city's emergency planning. Opportunities for storing water and using it for irrigation should be explored with all Major Projects. The City should cooperate with institutional and private property owners who are interested in diverting rainwater into cisterns, and the City should consider proposals for locating cisterns within public parks and rights-of-way if the water that would be stored would irrigate public landscaping.

Policy 4.3, District-Level Opportunities. Green Infrastructure and watershed management should be addressed at the scale of the Downtown Area and might extend into

Figure g.6*. *Tree Basins. *Bio-retention features can accompany new trees, but special engineering and tree survival concerns must be addressed.*

Figure g.7*. *Landscaped Swales. *Swales gather and convey rainwater. Small "check dams" can be used to hold water in small ponds and release it slowly.*

surrounding areas in recognition of watershed boundaries. A district-scaled approach should be used to leverage benefits more fully.

a. Further develop a master plan for Green Infrastructure Features as conceptualized in Figure g.9. Coordinate improvements address unique challenges resulting from relatively small parcels and high-intensity development.

b. Consider ways that rainwater could be stored and used to irrigate landscaping, for flushing toilets, or for use during emergencies as San Francisco has done. Because it is situated at a lower elevation, consider storage facilities in or near the Park Blocks.

c. Highlight the use of Green Infrastructure to reveal natural processes and communicate Berkeley's commitment toward sustainability. Use interpretive signage can to teach basic environmental principles and dispel misconceptions regarding Green Infrastructure. Consider demonstration projects to advance best practices in urban settings.

d. Private development standards and design guidelines should be refined to reinforce district-scaled strategies. Consider ways to encourage green roofs and other on-site infrastructure features. Allow fees to be paid in lieu of some requirements so that private funds can be used to construct improvements on public land, thereby leveraging additional benefits. (Developer fees are further discussed in chapter on Financing Plan.)

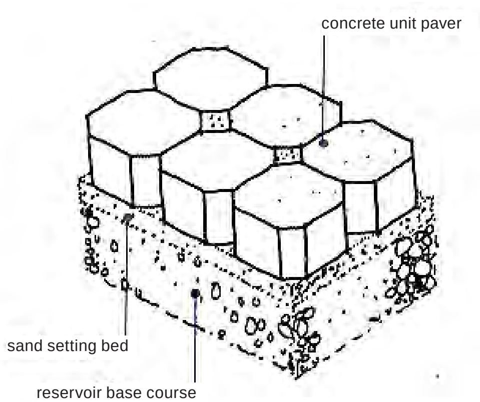

__Figure g.8__. __Permeable Paving.__ Permeable paving lets water through, to be gathered in below-grade basins or to infiltrate into the ground. Permeable paving must be accompanied by below-grade engineering.

Potential features

Rain Garden/ Swale Opportunity

Permeable Paving Opportunity

Pipe Connections

Outflow From Area

Figure g.9. Green Infrastructure Concept. *The diagram shown illustrates how SOSIP improvements could incorporate Green Infrastructure, possibly as part of an integrated strategy across multi-block areas.*