Session Abstract

From coast to coast, regional water issues are highly variable, yet most policy and expectations are broad and generalized. This session will describe a targeted approach to addressing a watershed’s unique infrastructure, hydrology, and urban context using green infrastructure. Case studies are from Philadelphia and San Francisco.

Learning Objectives:

- Understand the historical context of federal, state, and local stormwater regulations in the U.S and how it has translated into designing the landscape.
- Identify best practices for designing landscape-integrated stormwater strategies to address specific local conditions and how to manage expectations
- Learn how two cities, San Francisco and Philadelphia, are implementing policy and practices that target each city’s unique stormwater management issues.
- Discuss as a larger group what we think needs to change, both in design and policy, to implement better green infrastructure systems.

Program Outline

1. Know your watershed
2. Regional Stormwater Issues (See Attached)
   - Combined Sewers
     - System and Treatment Plant Capacity
     - CSOs (combined sewer overflows)
   - Urban Stormwater Runoff
     - Erosion and Sedimentation in Rivers/Streams
     - Nutrient Pollution
     - Water Quality Impairment
     - Aquifer Depletion
   - Rainfall patterns
     - Drought/Water Scarcity
   - Adapting to Climate Change
2. Case Study: Philadelphia (See Attached)
3. Case Study: San Francisco (See Attached)
4. Implementation
   - Building blocks of local green infrastructure
   - Design Approaches
     - Efficient Site Design
     - Top Down and Layered Approach
     - Limits of Green Infrastructure, overflow expected.
   - Stormwater Performance
     - First measured in Pervious/Area Greened (PAG) in all areas
     - Secondarily measured by Volume (V) and designed as such in CSO areas
5. Panel Discussion with Audience Participation
Nicole Holmes, PE, is a Green Infrastructure Project Manager at Boston-based Nitsch Engineering. Her role is focused on developing green infrastructure techniques and innovative stormwater management solutions to site challenges; she specializes in working closely with design teams to integrate design solutions into the landscape and building systems. Nicole's key projects have included stormwater management design and master planning services at the University of Virginia, Yale University, Princeton University, and Harvard Business School. Her experience also includes sustainable consulting services for Philadelphia's GreenPlan, Washington D.C.'s Canal Park, and the Frick Park Environmental Center in Pittsburgh. Nicole's work also focuses on urban green infrastructure for parks and streetscapes, including her current involvement with the winning streetscape design for DC Water's Green Infrastructure Challenge. Nicole is one of the creators of Nitsch Engineering's proprietary RainUSE® Software program, a rainfall reuse simulation program that simulates scenarios to optimize rainfall capture and reuse systems. Nicole has a Bachelor's degree in Civil Engineering from Northeastern University and completed the Boston Chamber of Commerce Future Leaders Program in 2008. Nicole was selected by the American Society of Civil Engineers (ASCE) as one of the Top 20 New Faces of Engineering of 2003. Nicole is a registered professional engineer in Massachusetts, Connecticut, Pennsylvania, Rhode Island, and Virginia; she is also a LEED Accredited Professional in Building Design + Construction. Nicole is a frequent speaker at professional society and industry events on stormwater master planning and implementation, and rainwater harvesting. She is a member of the Boston Society of Landscape Architects.

As First Deputy Commissioner of the Philadelphia Water Department, Mami Hara’s responsibilities include coordination of Department policy, strategic planning, programs and management. The Philadelphia Water Department is a progressive, 2000-person water, wastewater and stormwater utility in service of over two million customers over 200 square miles. The Department’s current initiatives include implementation of one of the most ambitious municipal green infrastructure programs in the US, Green City Clean Waters; a broad based energy program; and significant increases in other investments that support sustainable water management, urban development and community health. Formerly a principal with Wallace Roberts & Todd, Mami focused upon large scale civic projects, green infrastructure and sustainability planning and led the firm’s Waterfronts and Watersheds practice. While in private practice, she contributed to the Green City Clean Waters program and led projects such as the Anacostia Waterfront Initiative, A Civic Vision for the Central Delaware, GreenPlan Philadelphia and the Upper Mississippi Master Plan. Mami has degrees in Design of the Environment from the University of Pennsylvania and Landscape Architecture from Harvard University’s Graduate School of Design. She has been an instructor with University of Pennsylvania’s School of City and Regional Planning and the Architecture Department of Temple University and is an advisor to several design advocacy and planning organizations.

Rosey Jencks leads the Urban Watershed Management and Stormwater Planning Program at the San Francisco Public Utilities Commission where she works to integrate stormwater management and other water sensitive polices and designs into San Francisco’s landscape. She is currently the project manager for the San Francisco Public Utilities Commission’s Urban Watershed Assessment, an integrated watershed planning process to develop projects, programs and policies for rebuilding and managing the City’s urban watersheds for the next 30 years. She holds a Master’s Degree in Landscape Architecture and Environmental Planning from UC Berkeley.

Kevin Robert Perry is a recognized leader in successfully integrating stormwater management with high quality urban design. Kevin has designed over 40 green infrastructure demonstration projects within the United States. Kevin’s innovative stormwater projects meld the concepts of art, education, and ecological function. Kevin has extensive experience in the entire process for sustainable stormwater design and implementation, including pilot project identification, opportunities and constraints analysis, education and outreach for the client and general public, interagency coordination, technical design, construction administration, and operations and maintenance plan development. His work experience has helped municipalities and policy makers develop a “toolbox” of design strategies and guidelines for agencies across the United States. Kevin has given over 85 public presentations nationally and internationally and often conducts “hands on” workshops to communities interested in how green infrastructure can be integrated within the urban fabric. His projects have been featured multiple times in Landscape Architecture Magazine, Stormwater Magazine, and other publications. For the last decade Kevin Robert Perry has worked in the public, private, and academic sector advancing the application of green infrastructure within the built environment. He received a 2012 National ASLA Design of Honor Award for the SW Montgomery Green Street. Kevin Robert Perry received his Bachelor’s Degree in Landscape Architecture in 1996 at the University of California, Davis. Kevin has now come full circle and teaches advanced studio courses in green infrastructure at UC Davis Landscape Architecture Department and frequently lectures at colleges campuses throughout the United States.
Glossary

**CSO: Combined Sewer Overflow**
Combined sewer overflows are sewer systems that were designed to carry sewage and storm water in the same pipe to a sewage treatment plant. After heavy rainfall or snowmelt events, the wastewater volume is often more than the sewer system or treatment plant can handle. For this reason, combined sewer systems were designed to overflow after rain events and result in excess wastewater being discharged directly into rivers, lakes, and coastal areas. The wastewater the CSOs carry not only contains storm water but also untreated human waste and industrial waste, toxic metals and floating debris. (Source www.epa.gov)

**NPDES: National Pollutant Discharge Elimination System**
The Clean Water Act authorizes EPA and states, which are delegated the authority by EPA, to regulate point sources that discharge pollutants into waters of the United States through the National Pollutant Discharge Elimination System (NPDES) permit program. So-called “point sources” are generated from a variety of municipal and industrial operations, including treated wastewater, process water, cooling water, and stormwater runoff from drainage systems. The NPDES Storm Water Program, in place since 1990, regulates discharges from municipal separate storm sewer systems (MS4s), construction activities, industrial activities, and those designated by EPA due to water quality impacts. (Source www.epa.gov)

**MS4: Municipal Separate Storm Sewer System**
An MS4 is a conveyance or system of conveyances that is:
- Owned by a state, city, town, village, or other public entity that discharges to waters of the U.S.;
- Designed or used to collect or convey stormwater (including storm drains, pipes, ditches, etc.);
- Not a combined sewer; and
- Not part of a Publicly Owned Treatment Works (sewage treatment plant).

Polluted stormwater runoff is commonly transported through Municipal Separate Storm Sewer Systems (MS4s), from which it is often discharged untreated into local waterbodies. To prevent harmful pollutants from being washed or dumped into an MS4, operators must obtain a NPDES permit and develop a stormwater management program.
- **Phase I**, issued in 1990, requires medium and large cities or certain counties with populations of 100,000 or more to obtain NPDES permit coverage for their stormwater discharges. There are approximately 750 Phase I MS4s.
- **Phase II**, issued in 1999, requires regulated small MS4s in urbanized areas, as well as small MS4s outside the urbanized areas that are designated by the permitting authority, to obtain NPDES permit coverage for their stormwater discharges. There are approximately 6,700 Phase II MS4s.

Generally, Phase I MS4s are covered by individual permits and Phase II MS4s are covered by a general permit. Each regulated MS4 is required to develop and implement a stormwater management program (SWMP) to reduce the contamination of stormwater runoff and prohibit illicit discharges. (source: www.epa.gov)

**TMDL: Total Maximum Daily Load**
Under section 303(d) of the Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters. These are waters that are too polluted or otherwise degraded to meet the water quality standards set by states, territories, or authorized tribes. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. A Total Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards. (Source: www.epa.gov)

**Consent Decree**
When an entity has failed to comply with federal environmental laws, states and/or the EPA may initiate an enforcement action. Enforcement actions are taken for two main reasons: first, to compel the individual, company, or organization to return to compliance; and second, to deter others from committing similar violations in the future. Enforcement can be civil, administrative, or criminal. In civil enforcement settlements, there are generally two components of relief: injunctive relief, which requires actions that will be taken to bring the defendant back into compliance; and monetary penalties, which account for any economic benefit the entity experienced as a result of delayed compliance. Monetary penalties are also calculated with gravity factors associated with violations and environmental harms, and help to both level the playing field and deter future noncompliance. Administrative settlements require measures to bring an entity back into compliance and can include penalties. Some enforcement actions are resolved by the entry of a consent decree, which is a negotiated settlement between the enforcing agency and the permittee. The consent decree can include several of the enforcement actions described above. (Source: www.epa.gov)
November 6, 2015

Regional Stormwater Considerations - Boston Case Study

Water Quality Impairment
Designing sites to absorb, filter and cleanse the rain.

Combined Sewer Overflows
Restoring gray infrastructure solutions with a hybrid approach.

Groundwater Recharge
Replenishing historic water tables with infiltration.

361,400 gallons
annual amount of rainfall conveyed to groundwater recharge from greenroof and green alley

83% reduction
annual rainfall runoff conveyed to storm drain

Climate Change
Sea level rise in coastal cities will have major impacts on regional stormwater issues.
Green City, Clean Waters

- Comply with federal and state water quality requirements: Combined Sewer Overflow (CSO) reductions
- Augment a city’s overall resilience to urban pollution + climate change
- Advance livability and public health
- Increase market attractiveness
- Reduce pollutant contributions
- Create local green economy jobs
- Recharge water supplies
- Maintain and upgrade the infrastructure network
- Advance City-wide sustainability programs
- Transform river and stream corridors
- Preserve and restore aquatic habitat
- Maximize return on every dollar spent

Driving Regulatory Agreements

- 2011 Consent Order and Agreement (COA) with the PA Department of Environmental Protection
  - Reduce CSO volume
  - Pollutant removal
  - 34.5%+ ‘Greening’
  - Proof of Concept
  - Adaptive Management

- 2012 Landmark Partnership Agreement and Administrative Order for Compliance on Consent with the US Environmental Protection Agency

Signing of Green City, Clean Waters Agreement
Green City, Clean Waters

Green Stormwater Infrastructure
$1.67 billion ($800M Present)

Wet Weather Treatment Plant Upgrades
$345 million ($200M Present)

Adaptive Management
$420 million ($200M Present)

Philadelphia characteristics: relatively poor, densely developed, excess plant capacity.

Water Quality Based Effluent Limit

<table>
<thead>
<tr>
<th>Metric</th>
<th>Units</th>
<th>Cumulative amount as at Year 25 (2036)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE / SW / SE WPCP upgrade: Design &amp; Construction</td>
<td>Percent complete</td>
<td>100%</td>
</tr>
<tr>
<td>Miles of interceptor lined</td>
<td>Miles</td>
<td>14.5</td>
</tr>
<tr>
<td>Overflow Reduction Volume</td>
<td>Million gallons per year</td>
<td>7,360</td>
</tr>
<tr>
<td>Equivalent Mass Capture TSS / BOD / Fecal Coliform</td>
<td>Percent</td>
<td>85%</td>
</tr>
<tr>
<td>Total Greened Acres</td>
<td>Greened Acres</td>
<td>9,564</td>
</tr>
</tbody>
</table>
Measurable impacts:

Consent Order Compliance

- PWD is on a course to exceed our Year 5 Green City, Clean Waters compliance target.
- By the end of FY16, we fully expect more than 1,000 greened acres in Philadelphia’s CSO and MS4 areas.
- We are creating better water and air quality, and improved human health conditions for the residents.

<table>
<thead>
<tr>
<th>Year</th>
<th>Greened Acres</th>
<th>Square Miles</th>
<th>% Impervious cover removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>750</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>10</td>
<td>2,100</td>
<td>3</td>
<td>8%</td>
</tr>
<tr>
<td>15</td>
<td>3,800</td>
<td>6</td>
<td>14%</td>
</tr>
<tr>
<td>20</td>
<td>6,400</td>
<td>10</td>
<td>23%</td>
</tr>
<tr>
<td>25</td>
<td>9,600</td>
<td>15</td>
<td>34%</td>
</tr>
</tbody>
</table>

Key points

GCCW is currently establishing:
- A national precedent for cleaner water
- Visible progress in Philadelphia
- Partnerships
- Multiple implementation programs

GCCW will drive:
- Urban enhancements
- Climate change planning
- 21st century utility
- Water industry hub

Implementation in the first five years

Building on publicly owned land:
- PWD Facilities
- Parks and Recreation Centers
- Schoolyards
- Streets
- Vacant lands
- Campuses

Regulating and incentivizing GSI on private land:
- RainCheck for green homes
- Stormwater regulations for new development
- Incentives to retrofit property

Building partnerships:
- City agencies
- Community groups
- 3rd-party project implementers
- Funders
Visible Progress in Philadelphia

- Green infrastructure is becoming as common as manholes!
- Already there are 100's of private installations
- There are over 500 public projects in design or completed
- Coming Soon: 25 porous streets

Visible Progress

Temple University area

Green Streets
Green Schools
Green Parking
Green Parks
Green Homes
Vacant Land
Green Public Facilities
Green Alleys, Driveways, & Walkways
Green Industry, Business, Commerce & Institutions
Public projects

Green Schools  Green Streets  Green Parks

<table>
<thead>
<tr>
<th>Program</th>
<th>Complete</th>
<th>In Progress</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Open Space</td>
<td>29</td>
<td>139</td>
<td>168</td>
</tr>
<tr>
<td>Parking</td>
<td>4</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Streets</td>
<td>132</td>
<td>211</td>
<td>343</td>
</tr>
<tr>
<td>Vacant Land</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>171</td>
<td>362</td>
<td>533</td>
</tr>
</tbody>
</table>

Development regulations

Local Business: PWD Stormwater Pioneer

Development: Granary Green Roof

Business-Friendly Improvements
- Faster project approvals
- Clear application resources
- Accessible information
**Incentivizing private retrofits**

<table>
<thead>
<tr>
<th>SMIP Awards</th>
<th>$24.8 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projects Awarded</td>
<td>40</td>
</tr>
<tr>
<td>Greened Acres</td>
<td>298</td>
</tr>
<tr>
<td>Cost Per Acre</td>
<td>$83,000</td>
</tr>
</tbody>
</table>

**Scope and scale of partnerships**

**City Depts. & Public Agencies**
- Parks and Recreation
- Streets
- Planning Commission
- OHCD
- PRA
- Libraries
- PHA
- PIDC
- PRA
- PPA
- Public Property
- MOS
- MOTU
- SEPTA
- School District of Philadelphia

**Committees & Work Groups**
- Flooding Task Force
- Climate Change Working Group
- Green Streets Committee (Streets, PWD, MOTU, PennDOT, SEPTA, Commerce)
- Natural Lands Team
- Food Policy Advisory Council Vacant Land Subcommittee
- Brownfields Funding Working Group
- Joint Plumbing Committee
- Scrap Yard Task Force
- GeoXchange

**Partnerships with other city agencies**

**Example: Parks and Recreation**
- Green 2015, Neighborhood Parks
- Recreation Facilities
- School District Lots
- Litter and Floatables control
- Wissahickon Creek restorations, improvements
- Waterways Restoration Team collaboration
- Fairmount Waterworks site improvements
- Bartram’s Gardens
- Environmental Educators
- Natural Lands and Forestation
- East Park Reservoir and Audubon Sanctuary
- Cobbs and Tacony Creek Restorations
- FDR Park, Centennial/Concourse Lakes, Pleasant Hill
- Peter’s Island and Schuylkill River drives
- Schuylkill and Delaware River Trails
Community partnerships

Soak It Up
Adoption

Rebuilding Together Philadelphia

Community enhancements
PowerCorpsPHL and Green Jobs

Green City, Clean Waters is integral to our city’s planning for climate change

Center for Clean Air Policy, Adapted from Penney, 2008
URBAN WATERSHED MANAGEMENT PROGRAM OBJECTIVES

- Develop long-term plans, policies, and standards using an integrated watershed planning approach to optimize collection system performance, improve business practices, and spur innovation across the Enterprise.
- Use green infrastructure to:
  - Protect water quality
  - Protect the collection system and increase its capacity
  - Help satisfy non-potable water demands
  - Reduce the amount of power & chemicals needed to manage stormwater
  - Revitalize natural watershed functions
  - Provide community benefits

URBAN WATERSHED ASSESSMENT OPPORTUNITIES PROCESS

LOS NEEDS

SUITYABILITY

CONCEPTS

Mami Hara, AICP, ASLA

National CSO Control Policy of 1994

- Expedite Compliance with the Clean Water Act
- Must attain WQS
- Use – Swimming, Aquatic Life, Ind. & Ag. supply
- Criteria – Numeric and Narrative
- Anti-degradation policy
- Control Discharges from CSOs
- NPDES Permitting Process
- Authorization to Discharge to Waterways

Wet Weather Water Quality Act of 2000

- Compliance with federal and state water quality requirements:
  - Combined Sewer Overflows (CSO)
  - Urban Stormwater Runoff / MS4 Phase I + II
- Water Quality Impairment
- Nutrient Pollution

Program Considerations

- Existing treatment plant capacity
- Capacity and other characteristics of the collection system and potential to increases in volume to plants or regional controls
- Local soils: infiltration rates and characteristics
- Precipitation patterns and volumes
- Affordability
- Density of development and impervious cover
- Flooding
- Adapting to Climate Change
- Erosion and Sedimentation in Rivers/Streams

Rosey Jencks

San Francisco Case Study

November 6, 2015
Services We Provide

URBAN WATERSHED MANAGEMENT PROGRAM ELEMENTS

- Watershed Planning
- Regulation
- Policy & Process Development
- Watershed Stewardship Programs
- Outreach & Education
- Capital Project Delivery Process

STORMWATER MANAGEMENT ORDINANCE

ADOPTED 2010

THRESHOLD Applies to projects disturbing 5,000 s.f. or more of the ground surface

STRATEGY Requires projects to achieve performance measures outlined in the Stormwater Design Guidelines & maintain facilities in perpetuity

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Rosey Jencks
ASLA National Conference
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Mami Hara, AICP, ASLA

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Program Considerations

• Number of SCPs Reviewed: 202
• Number of Final Approved SCPs: 72

BENEFITS OF THE STORMWATER MANAGEMENT ORDINANCE
 Over 1700 acres of DMA managed when projects are complete
 26 million gal of stormwater removed annually from CSS
 19.6 million gal potable offset annually
 Increased watershed function, habitat, buffering of the collection system,
  private partners bearing some of the stormwater management costs
 Wet weather rate
 Green infrastructure incentive programs
 Maintenance planning & policy development
 Citywide permeable pavement policy
 Non-potable Water Ordinance
 Green infrastructure capital project delivery process

RE-THINK BUILDING DESIGN & RE-IMAGINE HOW WATER IS USED
National CSO Control Policy of 1994

- Expedite Compliance with the Clean Water Act – Must attain WQS
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Policy Development & Process Improvement

- Wet weather rate
- Green infrastructure incentive programs
- Maintenance planning & policy development
- Citywide permeable pavement policy
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- Green infrastructure capital project delivery process

Buildings Produce Water

Wastewater from toilets, dishwashers, kitchen sinks, and utility sinks
Wastewater from clothes washers, bathtubs, showers, and bathroom sinks
Precipitation collected from roofs and above-grade surfaces
Precipitation collected at or below grade
Nuisance groundwater from dewatering operations
SFPUC Residential Programs

- Rainwater Harvesting Program
- Graywater Program

SFPUC Technical & Financial Assistance

- www.sfwater.org/np
- On-site Non-potable Guidebook
- Non-potable Water Calculator
- Grant program
- Project review meetings

Exploratorium

- Source: Rainwater & Bay Water
- End Uses: Toilet and Urinal Flushing & Heating and Cooling System
On-site Non-potable Water Use at Innovative SFPUC Headquarters

Rainwater Harvesting System
- 25,000 gallon cistern
- Reuse for irrigation
- 25 Micron Filtration
- UV (optional)

Living Machine
- Collects and treats building’s wastewater
- Reuse for toilet flushing
- 5,000 gpd capacity

San Francisco Non-potable Projects

- 33 Projects since program inception
- SFPUC Collects data on costs, drivers, potable water offsets, and end use applications

St. Anthony’s Building

- Source: Rainwater
- End Use: Toilet & Urinal Flushing

San Francisco Case Study

November 6, 2015

Rosey Jencks
San Francisco Public Safety Building

- Sources: Graywater, Rainwater, Condensate Drainage
- End Uses: Toilet Flushing, Cooling Tower Make-up and Irrigation
- Savings: 1.5 MGY

Transbay Transit Center

- Sources: Rainwater & Graywater
- End Uses: Toilet & Urinal Flushing and Irrigation
- Status: Under Construction
- Savings: 3.5 MGY

GREEN INFRASTRUCTURE PARTNERSHIPS

SSIP Incentive Programs

- Sustainable Roof Program
  - Green and Blue Roofs
  - Targets Non-PUC Rooftops greater than 1600 sf
- Watershed Improvement Grant Program
  - Combination of Stormwater Management Tools
  - Targets Non-Residential Impervious over 0.5 Acres
- Residential Stormwater Program
  - Combination of Stormwater Management Tools
  - Targets Residential Impervious over 1,000 sq ft
- Stormwater Audit Program (Technical Services)

WATERSHED STEWARDSHIP GRANT PROGRAM

- Funds sidewalk landscaping, rainwater harvesting, & green infrastructure projects in the public realm
- Engages community & provides opportunities for education & outreach
- Over $1.6 million granted
**Transbay Transit Center**

- Sources: Rainwater & Graywater
- End Uses: Toilet & Urinal Flushing and Irrigation
- Status: Under Construction
- Savings: 3.5 MGY

**GREEN INFRASTRUCTURE PARTNERSHIPS**

Capital Projects & Incentives

- Stormwater Schoolyard Adidas
  - Pilot will inform SSP Incentive Programs, GI Capital Program
  - Generates data about processes, resources, and costs for SFUSD properties to implement GI to meet stormwater performance goals
  - Status: School selected, master planning to begin Fall 2015, MOA under development

**OUTREACH & EDUCATION**

- [Image]
- [Image]
- [Image]
ASLA National Conference
November 6, 2015
Mami Hara, AICP, ASLA

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Program Considerations

EARLY IMPLEMENTATION PROJECT LOCATIONS

BETTER STREETS PLAN PROJECT – CESAR CHAVEZ

ANY QUESTIONS?

Rosey Jencks
rjencks@sfwater.org
GREEN INFRASTRUCTURE PROJECT CONCEPTS

Mission & Valencia Greenstorm
River Beach Green Street Concept
Upper Yosemite Creek Daylighting

PROJECTED GREEN INFRASTRUCTURE BENEFITS

In the CSS, at a development rate of 1% per year over 20 years with the SMO effective, we expect:

- 150 Mgal/yr reduction in CSD volume
- 10% - 20% reduction in flood volume during the 5-year, 3-hour storm