

Protecting Puget Sound from CSOs by retrofitting Urban Neighborhoods with Green Stormwater Infrastructure



Kathryn Gwilym, PE, LEED AP, MIG | SvR

John Phillips, ENV SP, King County Department of Natural Resources

Peg Staeheli, FASLA, MIG | SvR

Steve Burke, PE, MIG | SvR

Salish Sea Ecosystem Conference, Vancouver BC

April 13, 2016, 3:30-5pm, SW3F session

<http://www.kingcounty.gov/environment/wtd/Construction/Seattle/BartonCSO-GSI.aspx>

www.svrdesign.com



King County

Department of Natural Resources and Parks
Wastewater Treatment Division



Barton CSO Control with Green Stormwater Infrastructure (GSI)

- King County Wastewater Treatment Division (WTD) led project within the public right-of-way of the City of Seattle

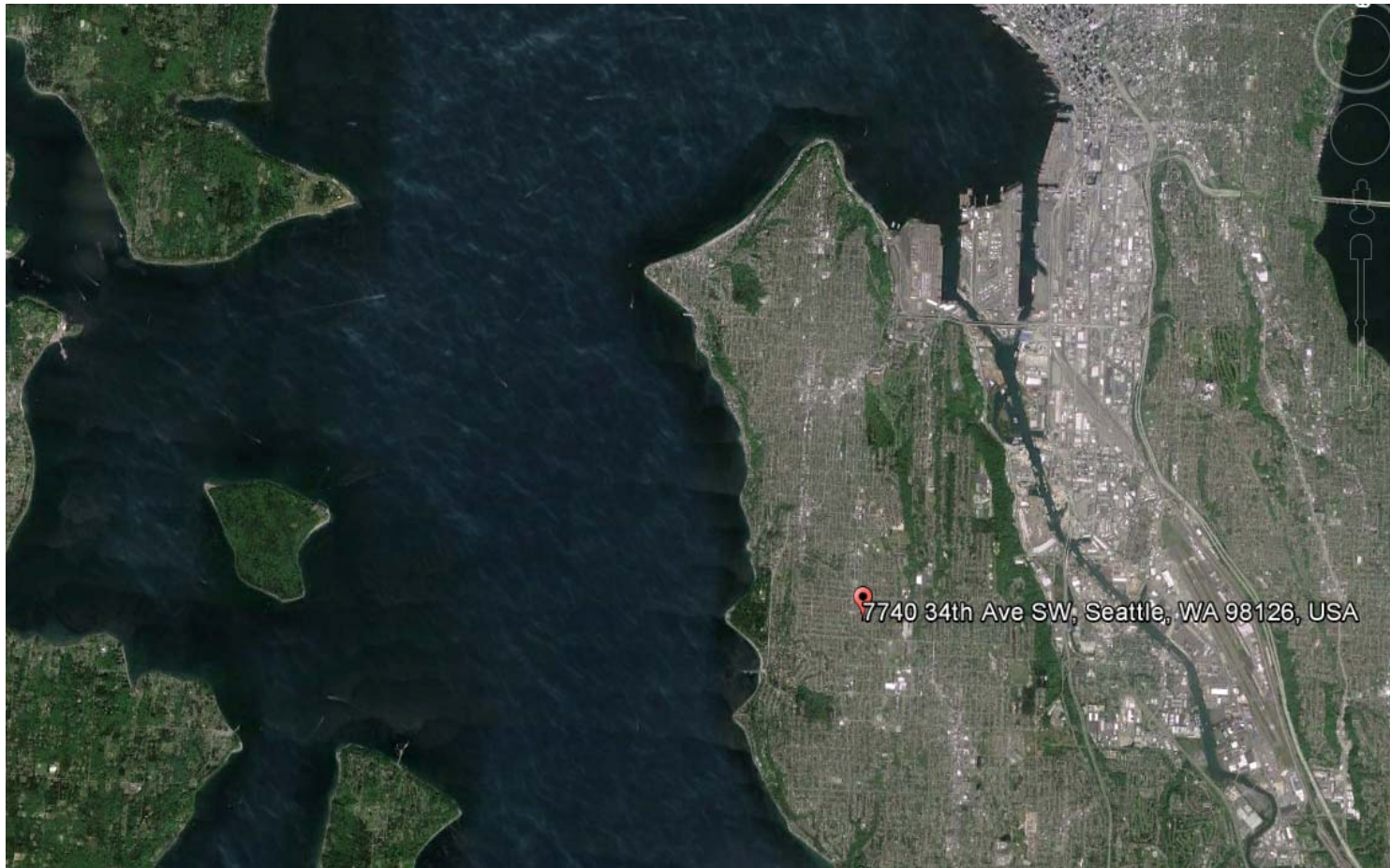


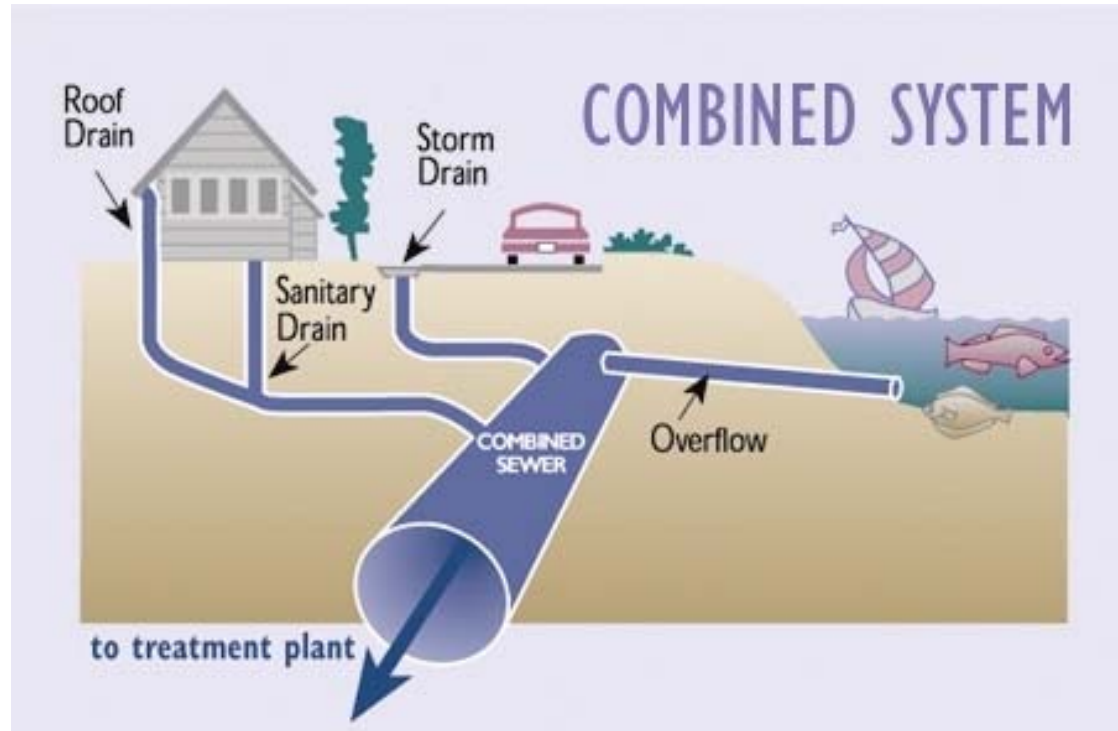
Photo from Google Earth



Regulatory Requirements

Combined Sewer Overflow (CSO)

Combined Sewer System (CSS)



- Ecology requires no more than 1 CSO event per year over a 20-year rolling average
- Consent decree: *United States of America and the State of Washington v. King County* (USDC Civil Action No. 2:13-cv-677 lodged on April 16, 2013)
- In 2008, average 4 CSOs per year, 4 MG

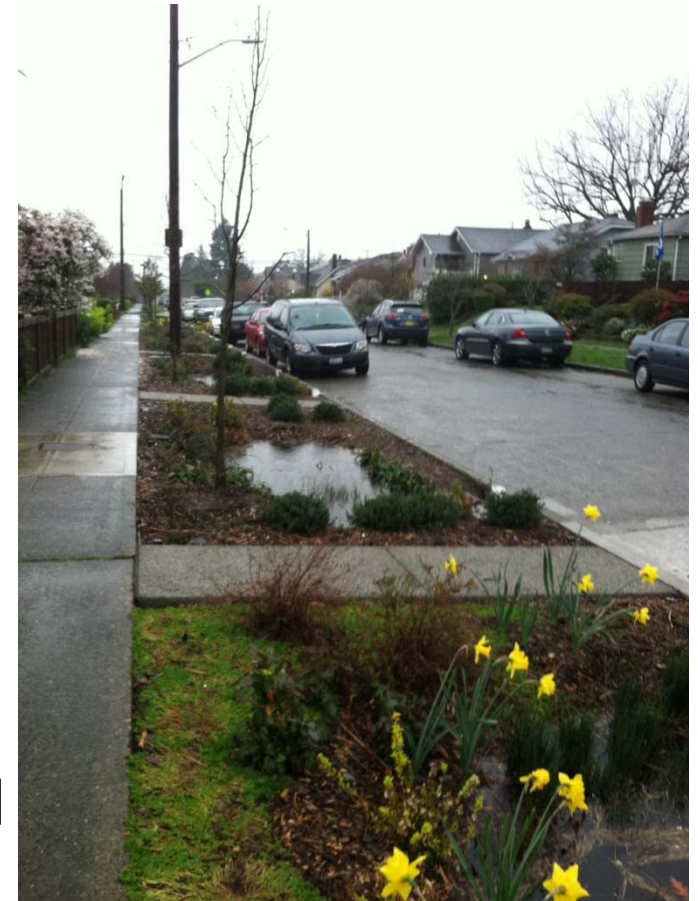
Project Team – Design & Construction

- Developer/Owner of Facility:
 - King County Wastewater Treatment Division
- Consultant Design Team
 - MIG | SvR (Prime – civil & landscape)
 - Associated Earth Sciences Inc. (Hydrogeologist/Geotechnical)
 - Aqualyze Inc (GSI & Basin modeling)
 - ILM, Bill Lucas (GSI modeling support)
 - PRR (Community outreach)
 - Sue Nicol (Arborist)
 - Pacific Geomatic Services (Surveyor)
- Permitting through Seattle Department of Transportation and Washington State Department of Ecology
- Community Involvement
- Contractor
 - Goodfellow Bros., Inc. (Prime)
 - T. Yorozu Gardening Co. (bioretention soil & plantings)
 - Aquatech Well Drilling & Pumps
- CM support - MWH



Why GSI was chosen for CSO Control by King County in 2011 for Barton CSS

- Facility Plan evaluated green & grey alternatives
- GSI allows for adaptive management over time
- Lifecycle costs less than gray infrastructure
 - Pump station cost reduction
 - Treatment plant cost reduction
 - Greenhouse emissions reduced



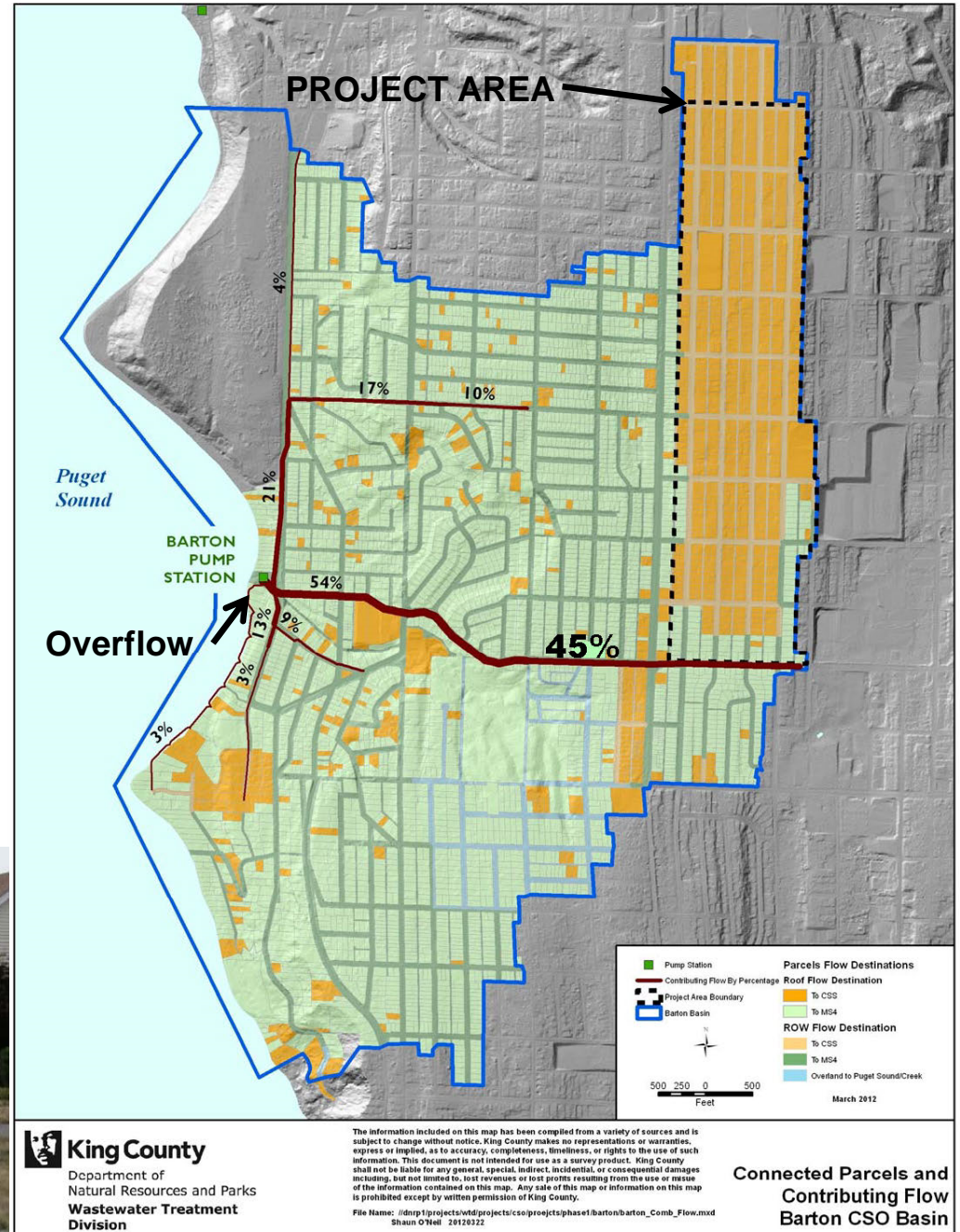
Barton CSS Basin Description

- 1,111 acres (450 ha)
- Five sub-basins
- CSS pipes convey flows to the Barton Pump station then on to West Point Treatment Plant



Why this area?

- 45% of stormwater flows entering CSS come from the project area. Streets drain to CSS.
- 72 streets in project area 151 acres (61 ha)
- Available space in street right of way planting strip



Challenges at start of Design Phase

- Approved Facility Plan scope: shallow infiltration on the blocks
- Shallow infiltration was not feasible
- On the heels of another not-so-successful roadside rain garden project
- Community fears and concerns
- New City ROW permitting process
- Federal consent decree schedule
- New technology for WTD in addressing CSOs

Seattle removes rain gardens in Ballard

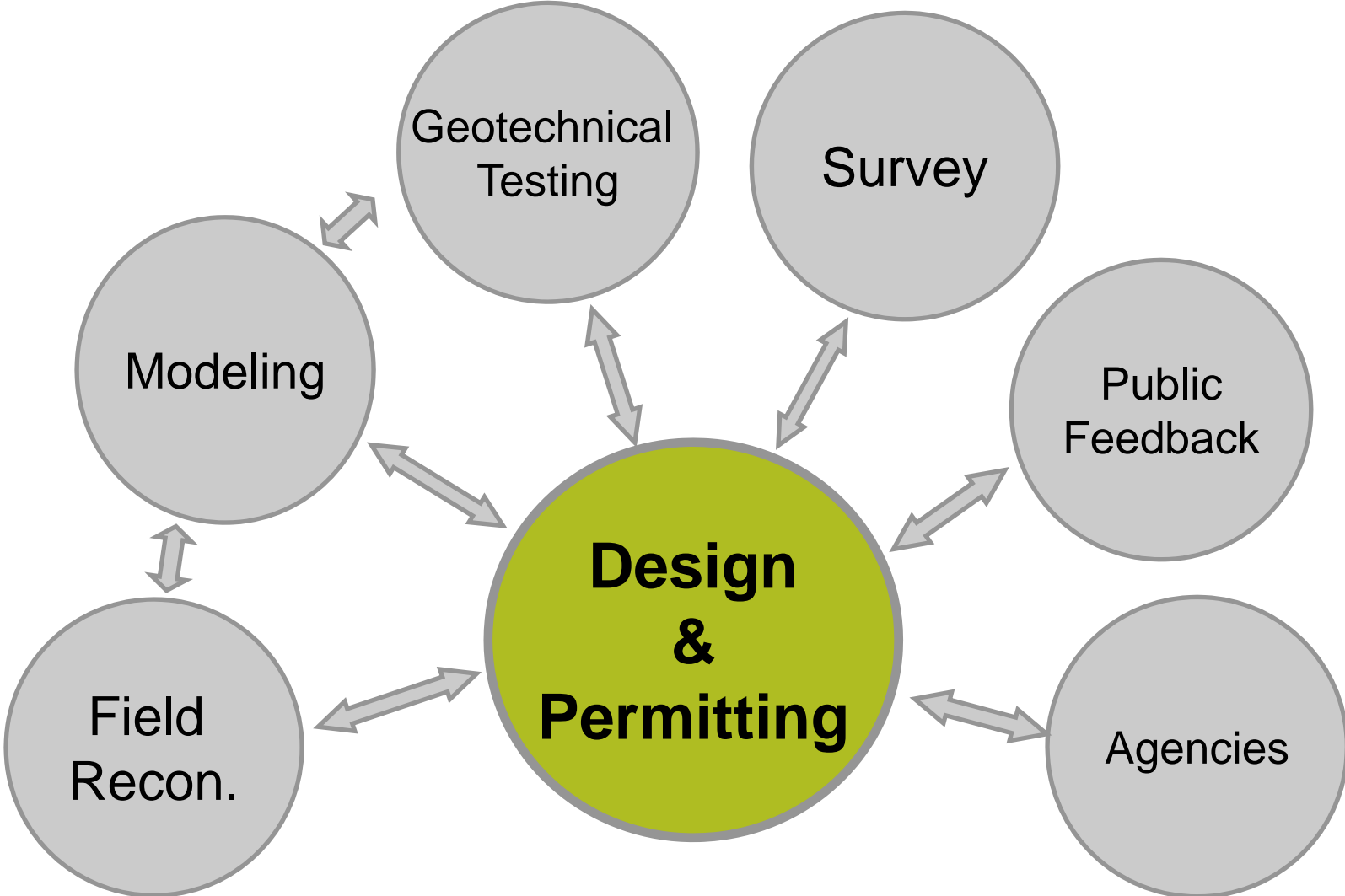
By Paula Wissel



King County Approach

- Take the time to study existing conditions
- Geotechnical & Hydrogeological Testing
- Understand street surface flows and use of flow model
- Design for individual streets and site context
- Careful and rigorous construction
- Early and on-going community involvement from planning through O&M

Design Process



Public Outreach During Design

- **6** community meetings
- **24** block level meetings
- **2** neighborhood surveys
- **4** association briefings
- **2** rounds of neighborhood canvassing
- **6** project update newsletters
- **10** small group neighborhood meetings
- Nearly **700** email, phone or street conversations with more than **500** residents and stakeholders.



Future (summer)



Future (winter)



What We Heard from Neighborhood

- Existing Drainage Concerns
- Pests
- Parking
- Access
- Vegetation and Trees
- Maintenance
- Minimize Construction Impacts
- **Define agency roles**
- **Be consistent with terminology**



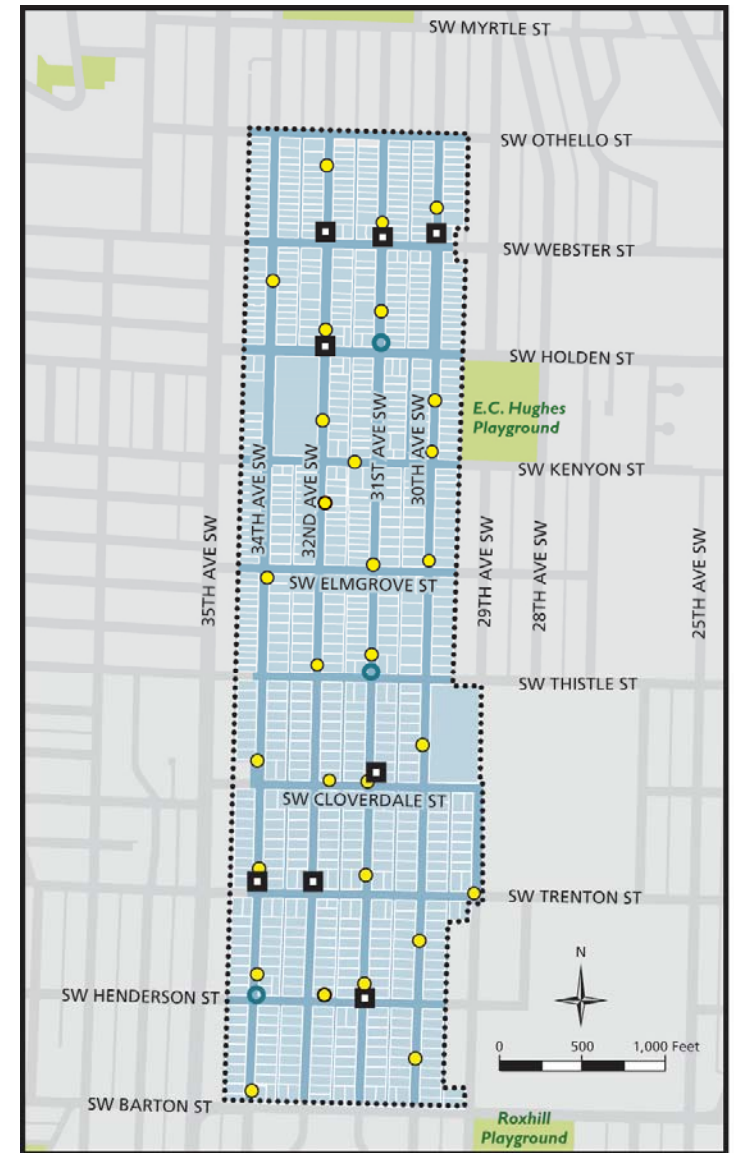
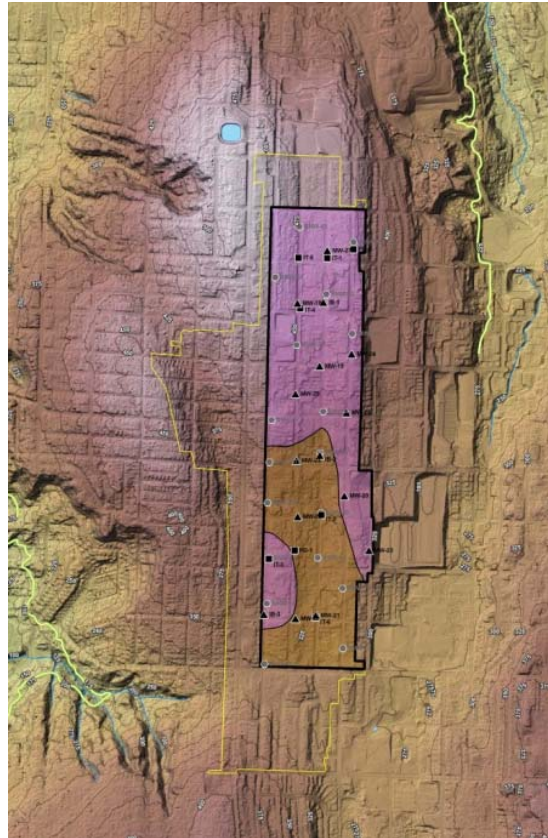
Field Reconnaissance

- Above- and Below-Ground Infrastructure and features
- Within ROW & Adjacent



Project Area Geology

- Soil layers
- How and where water flows underground
- Water table
- Deep infiltration borings
- Monitoring wells
- Infiltration test pits



Legend:

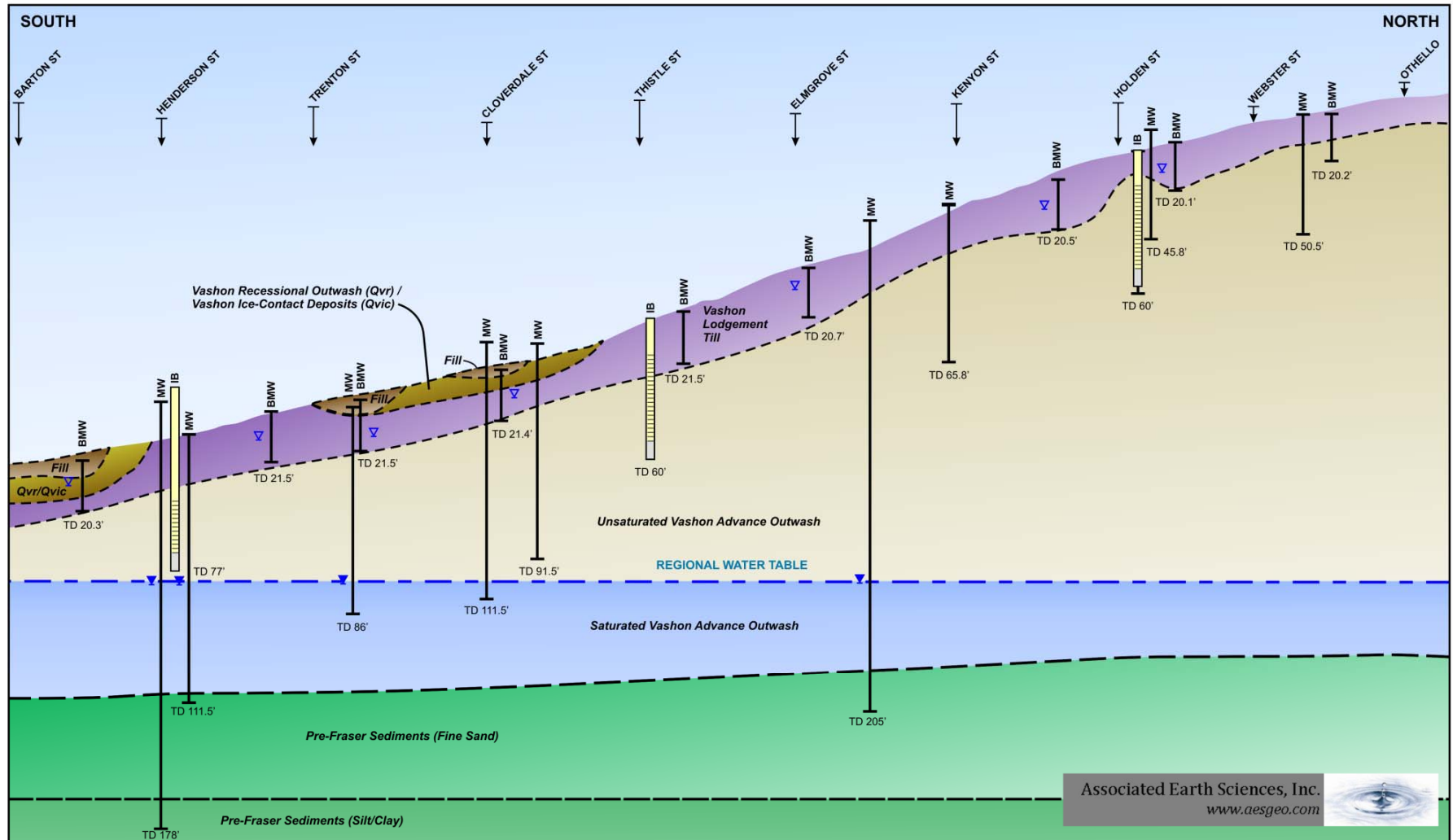
- Deep infiltration borings
- groundwater monitoring wells
- infiltration test pit sites*
- Potential bioretention swale sites
- ▭ Project area

Green Stormwater Infrastructure (GSI) in the Sunrise Heights and Westwood neighborhoods for controlling combined sewer overflows (CSOs) in Barton Basin.

*Approximate locations of sites within the public right-of-way.

Map & photo shown provided by Associated Earth Sciences, Inc.

CROSS-SECTION OF MONITORING WELLS TO TEST SOILS AT DIFFERENT DEPTHS THROUGHOUT THE PROJECT AREA



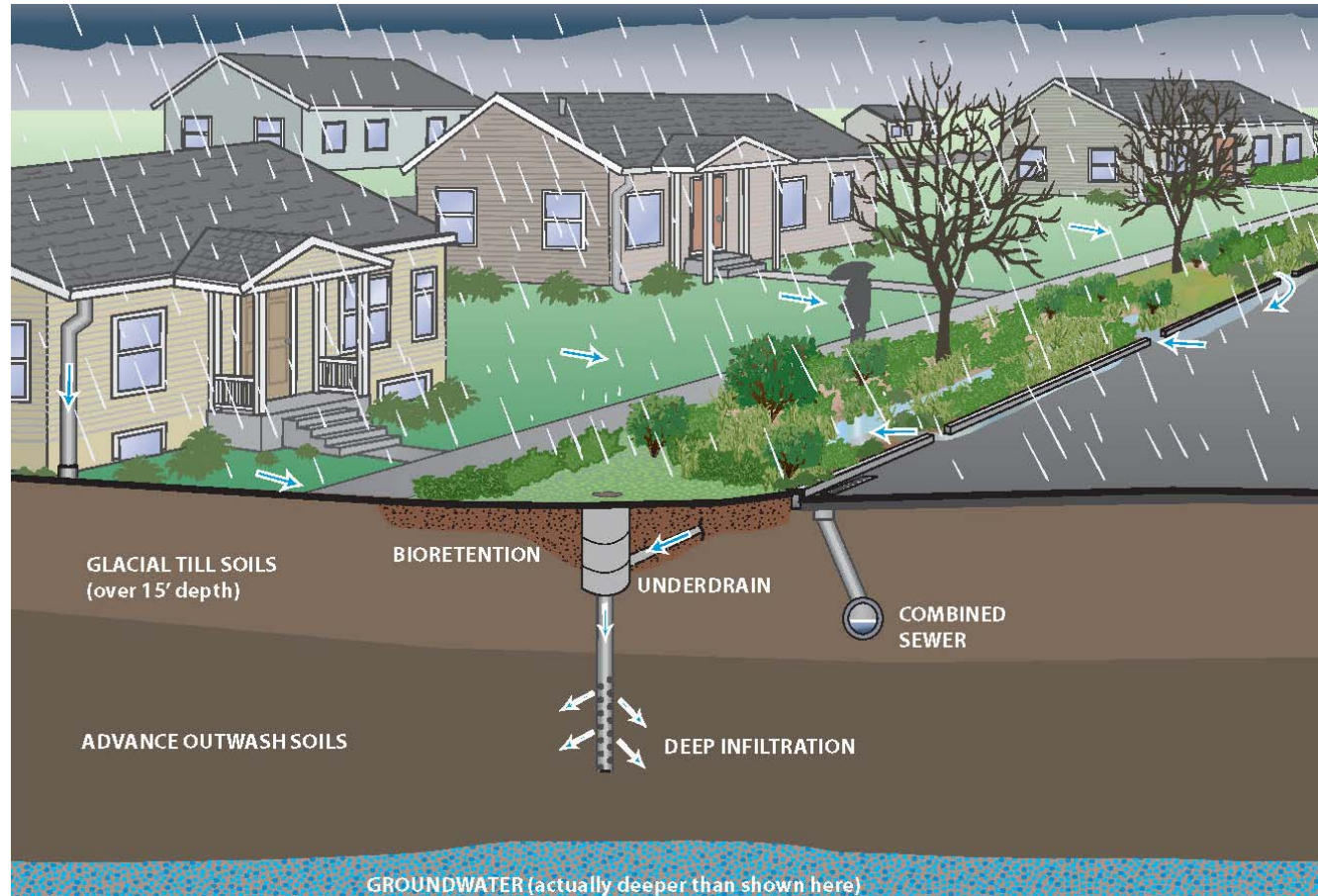
Associated Earth Sciences, Inc.
www.aesgeo.com

LEGEND:
 BMW - GROUNDWATER MONITORING WELLS TO MEASURE SHALLOW GROUNDWATER LEVELS (20 FT. DEEP)
 MW - GROUNDWATER MONITORING WELLS TO MEASURE DEEP GROUNDWATER LEVELS (45-205 FT.)
 IB - DEEP INFILTRATION BORINGS TO FIND OUT THE RATE WATER FLOWS THROUGH THE UNSATURATED VASHON SOIL LAYER (BEIGE LAYER)
 ▽ - WATER LEVELS, AS MEASURED BY WELLS
 TD - TOTAL DEPTH OF WELL UNDERGROUND

NOTE: SLOPE SHOWN IS NOT TO SCALE (STEEPER THAN ACTUAL)

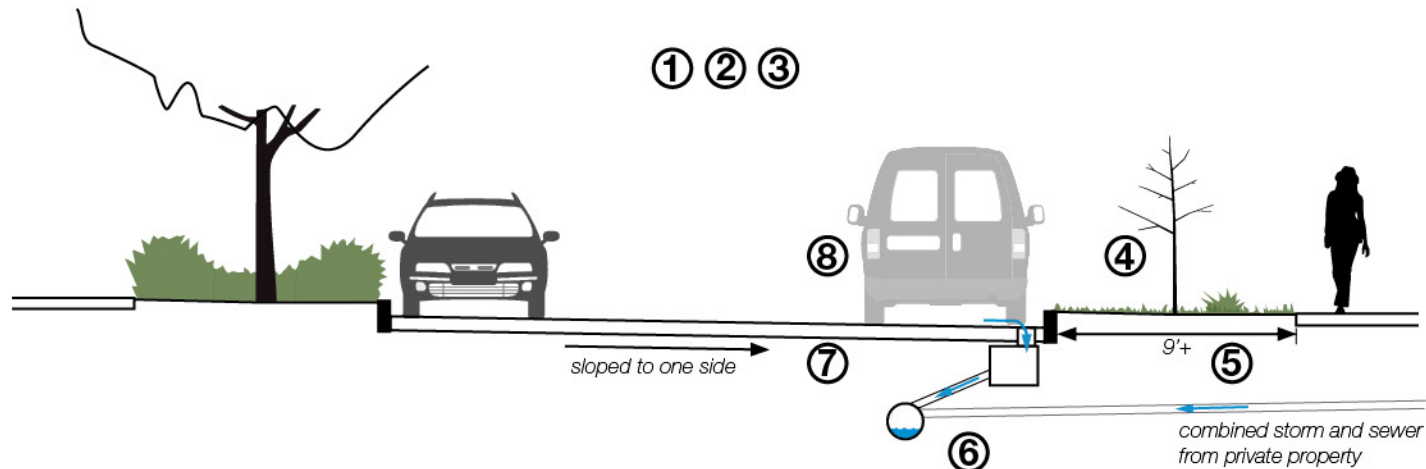
GSI with Deep Infiltration Design Elements for Barton

- Bioretention swales
- Underdrains
- Underground Injection Control (UIC) screen wells



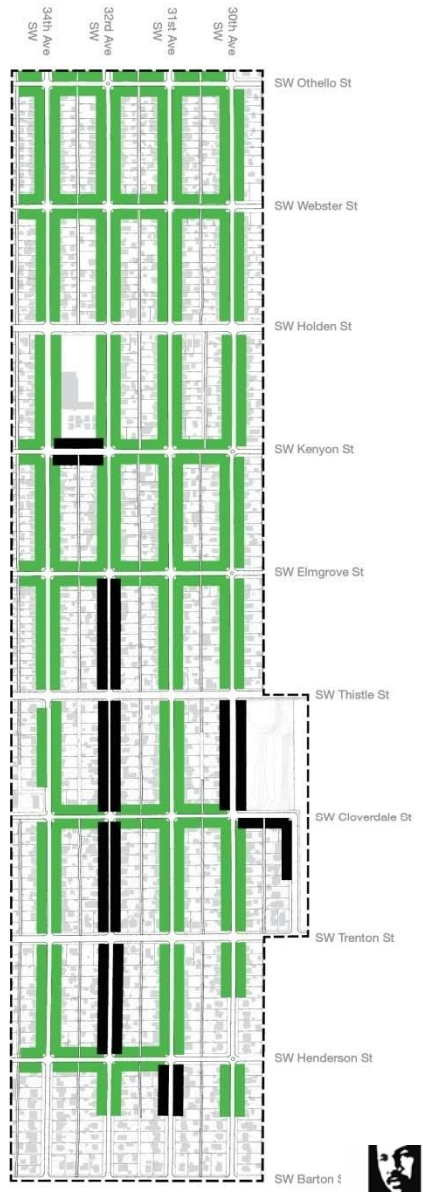
Describing Street Selection to the Public

- Factors below helped select the most effective streets in the project area for bioretention in the right-of-way
- Selection criteria are guides, not set in stone

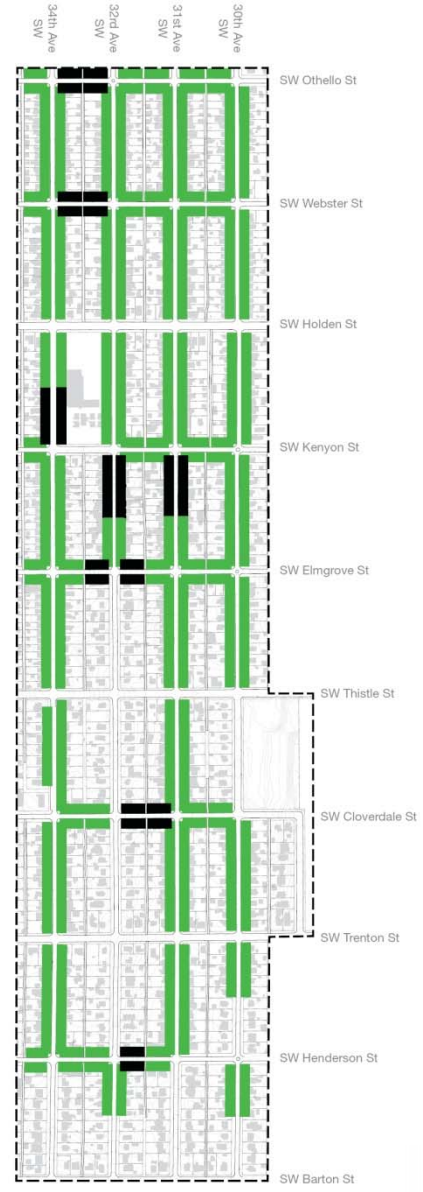
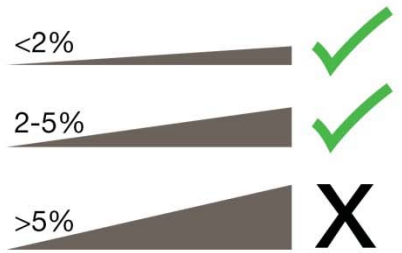


- | | |
|-----------------------------------|--|
| ① Residential streets | ⑤ Wider planter strips (9' or greater) |
| ② Flatter roads (under 5% grade) | ⑥ Minimal public & private utility conflicts |
| ③ Minimal driveways | ⑦ Cross slope of road |
| ④ Open areas without mature trees | ⑧ Minimal impact to on-street parking |

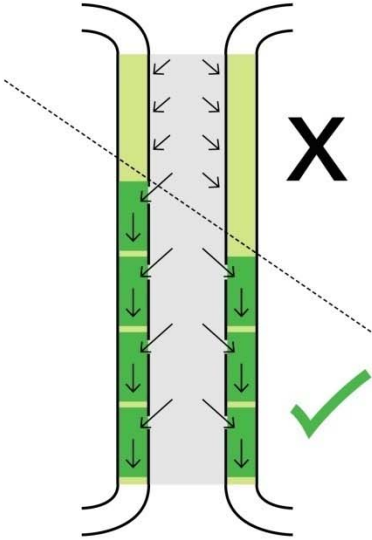
Street Selection: Wide Planter Strips



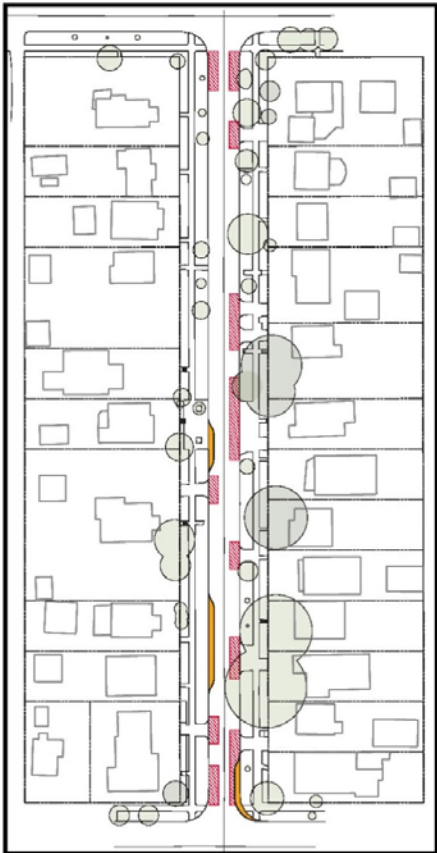
Street Selection: Flatter Streets



Street Selection: Lower Portion of Blocks

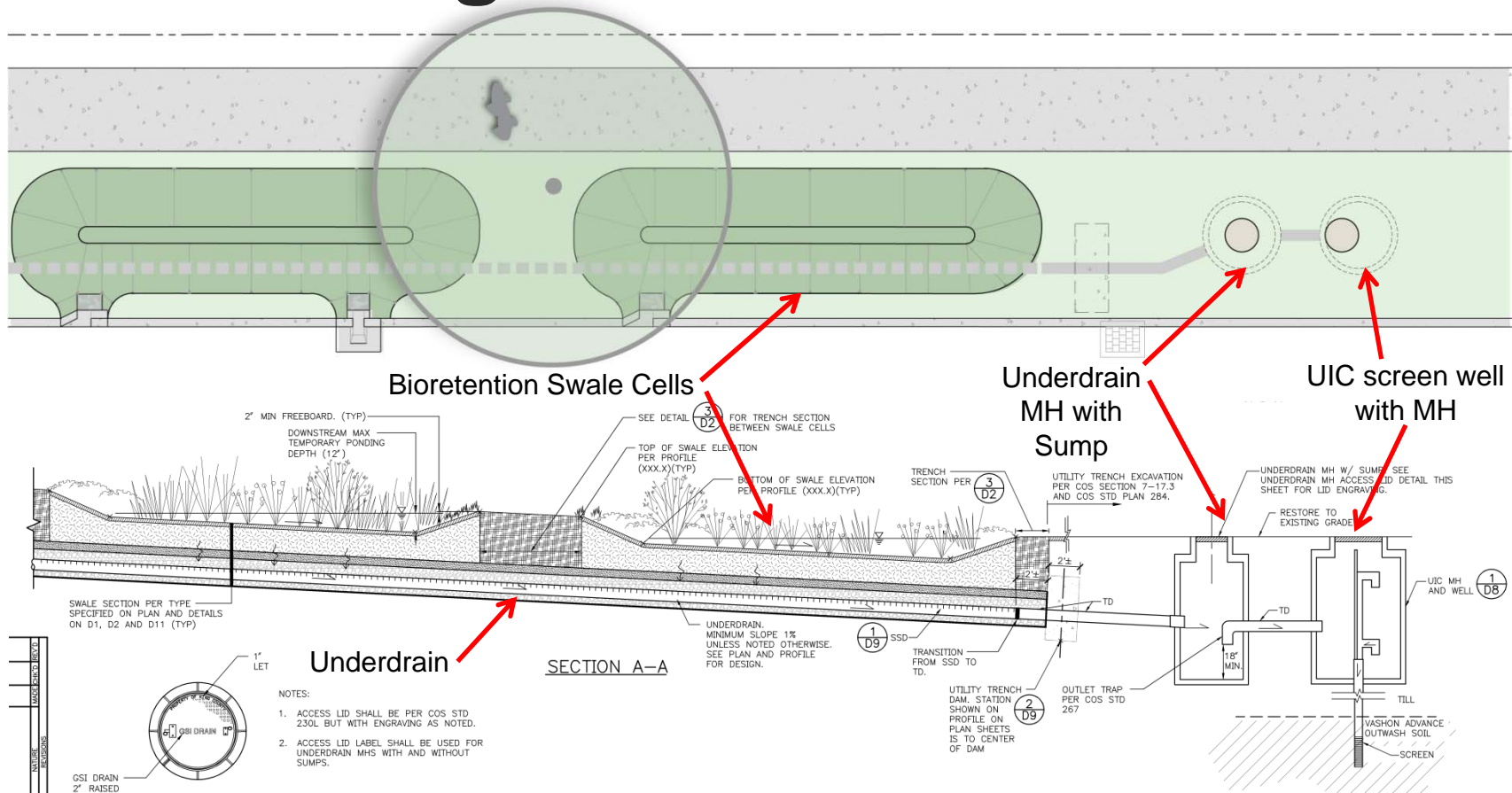


Site Considerations: Where to Locate GSI



- Each street is unique
 - Locations of trees (556 trees reviewed)
 - Above & below ground utilities
 - Parking patterns
 - Accessibility
 - Driveway access
 - Cross Slope

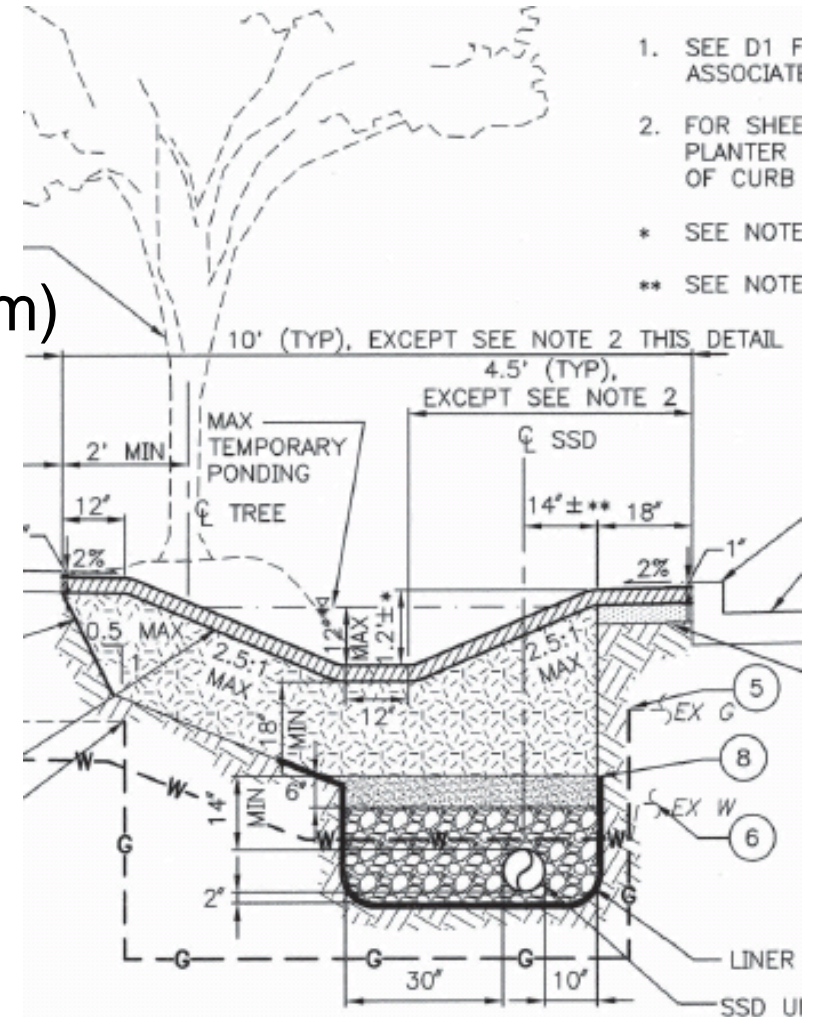
GSI Design



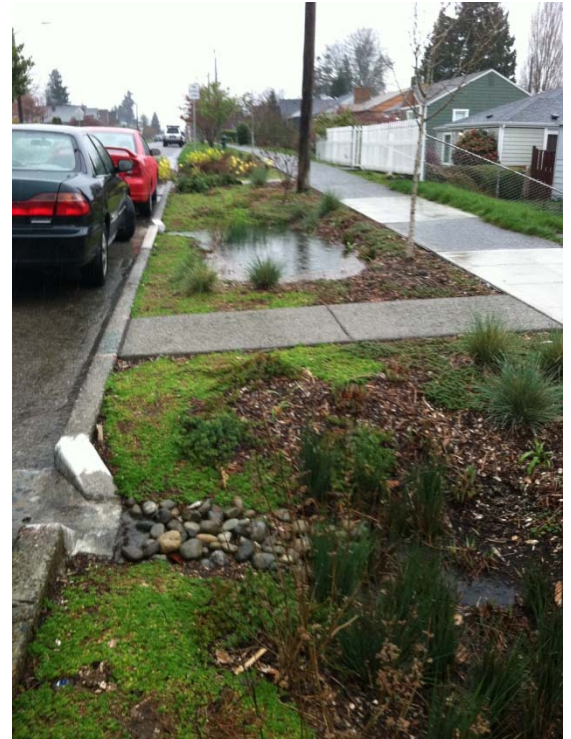
- Maximum temporary ponding depth – 12 inches (~30 cm)
- Swales drain within 24 hours
- Access & Drainage: Bottom length ~15 - 30 feet (4.5 – 9 m)
Top Length ~25 - 40 feet (7.6 – 12.1 m)

GSI Design – more details

- Swale side slopes 2.5:1
- Minimum bottom width 12 in (30 cm)
- Planting Infrastructure
- 18 in (46 cm) bioretention soil
- 6 in (15 cm) sand
- Filter drain rock & underdrain
- Partial & fully lined sections

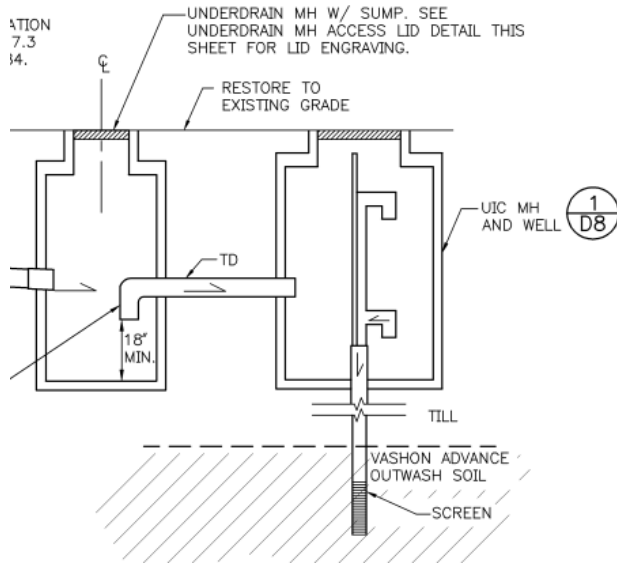


GSI Design – Curb Cuts & Presettling

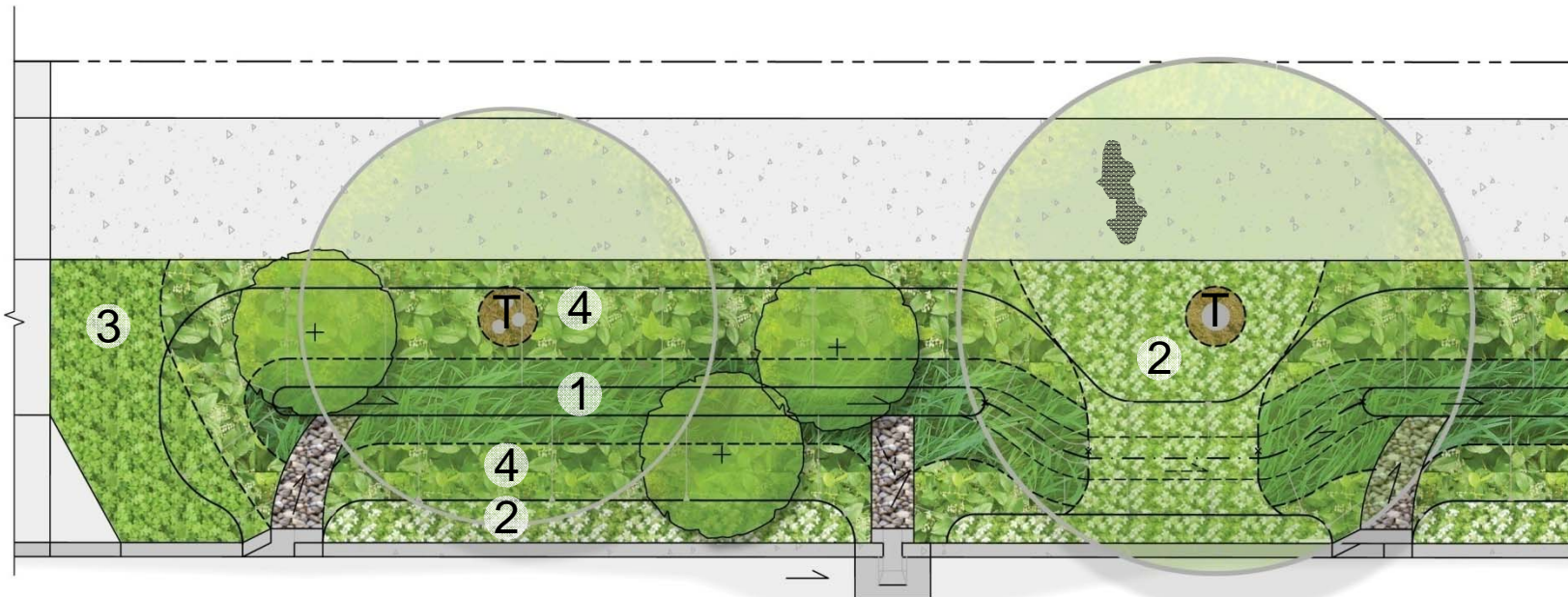








GSI Design - UIC Screen Well & MH

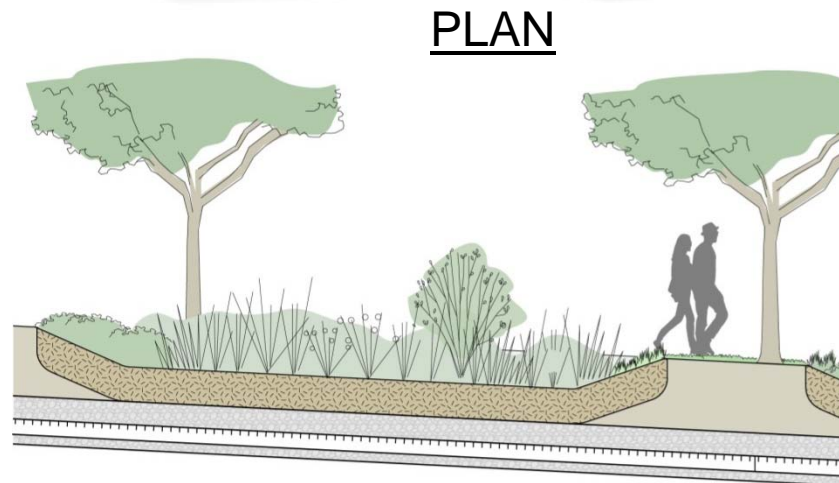
- One per block (~660 feet, 200m)
- Design depth varied at each location due to soil conditions
- Total Depth 65 – 100 feet (~19.7 - 30.3m)
- Well Screen 20 – 40 feet (~6 - 12m) of 8 inch (~20 cm) diameter



Bioretention: Planting Overview



<u>ZONE</u>	<u>PLANT TYPE</u>
 1	Emergents
 2	Steppables
 3	Groundcovers
 4	Low Shrubs
 4	Accent Shrubs / Small Trees
 T	2, 4 Tree



SECTION

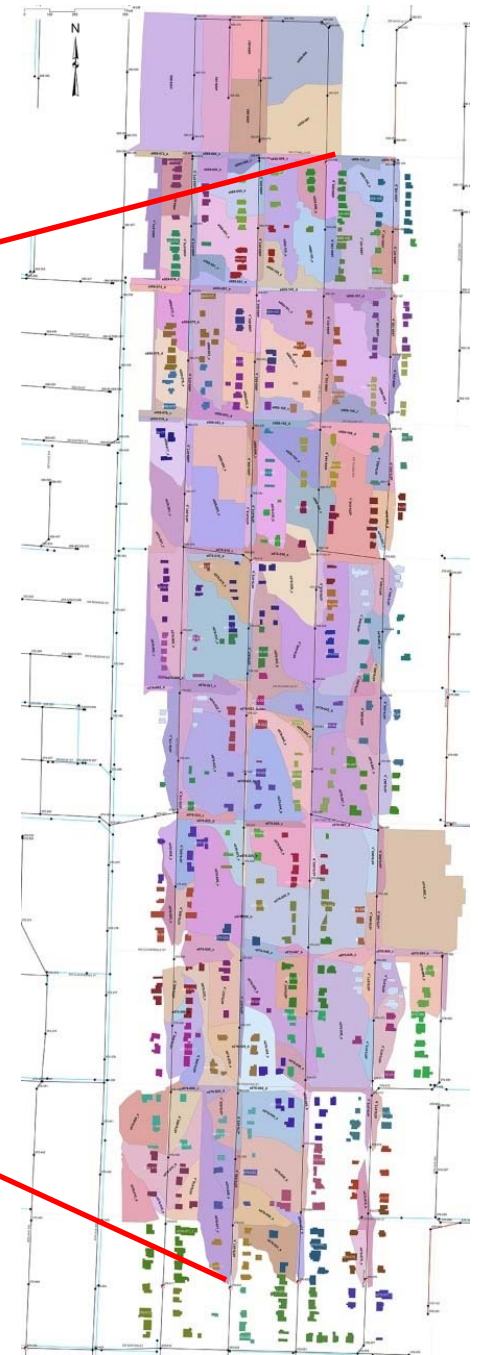
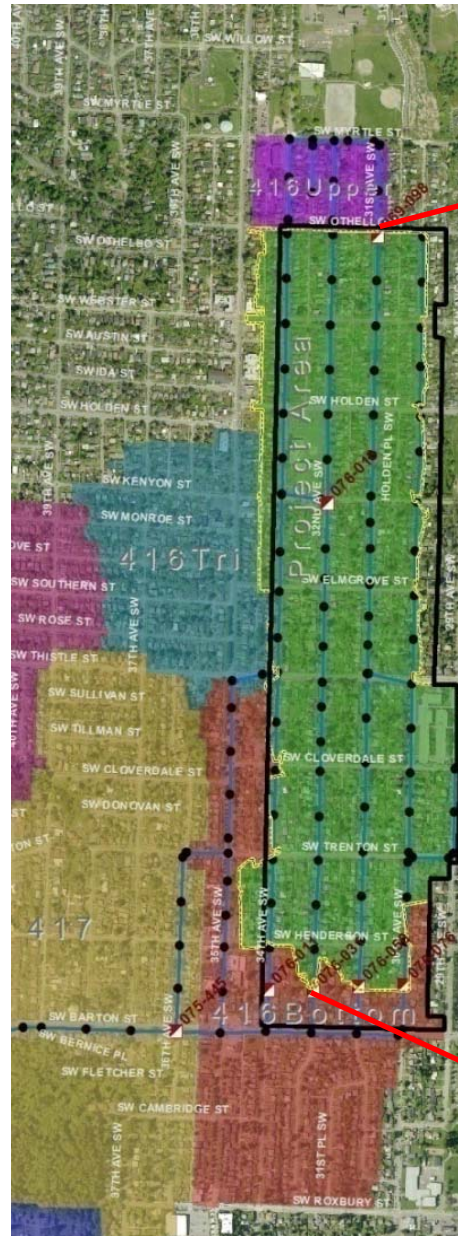
Plant Palettes – Designed for the Varying Existing Street Character

Street Character Image	Type of Street	Street Character Description	Recommended Plant Palette	Plant Character
	Open	None to few physical object/boundaries Views	Framed 	<ul style="list-style-type: none"> • Dark green foliage • Broadleaf evergreens • Cool and hot colored flowers
	Enclosed	Tall walls, fences and vegetation	Airy 	<ul style="list-style-type: none"> • Light foliage • Medium sized leaves • Light colored flowers
	Semi-Open	Low walls, fences and vegetation	Blended 	<ul style="list-style-type: none"> • Medium dark green foliage • Needle-leaf evergreens • Warm colored flowers
	Bulbs & Intersections	No Parking Zones	Bulb & Intersection 	<ul style="list-style-type: none"> • Bright foliage • Medium sized leaves • Vibrant colored flowers • Low for visibility

Modeling

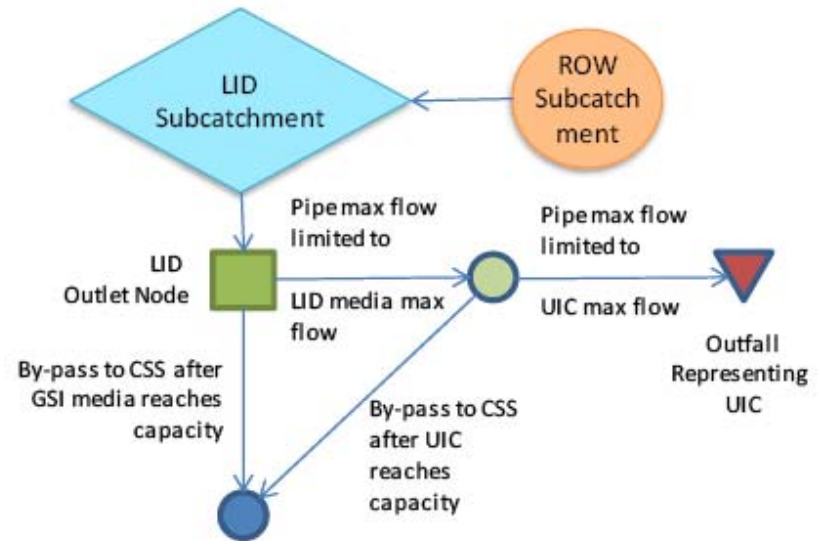
- Subcatchment delineation
- Barton Pump Station upgrade 33mgd
- Continuous Model (EPA SWMM) over last 30 years
- COS Bioretention Soil Design Infiltration Rate of 6 in/hr (15 cm/hr)
- Flow monitoring of CSS
- Rain gauge in project area
- 151 acres in Project Area

Figures provided by Aqualyze



Modeling

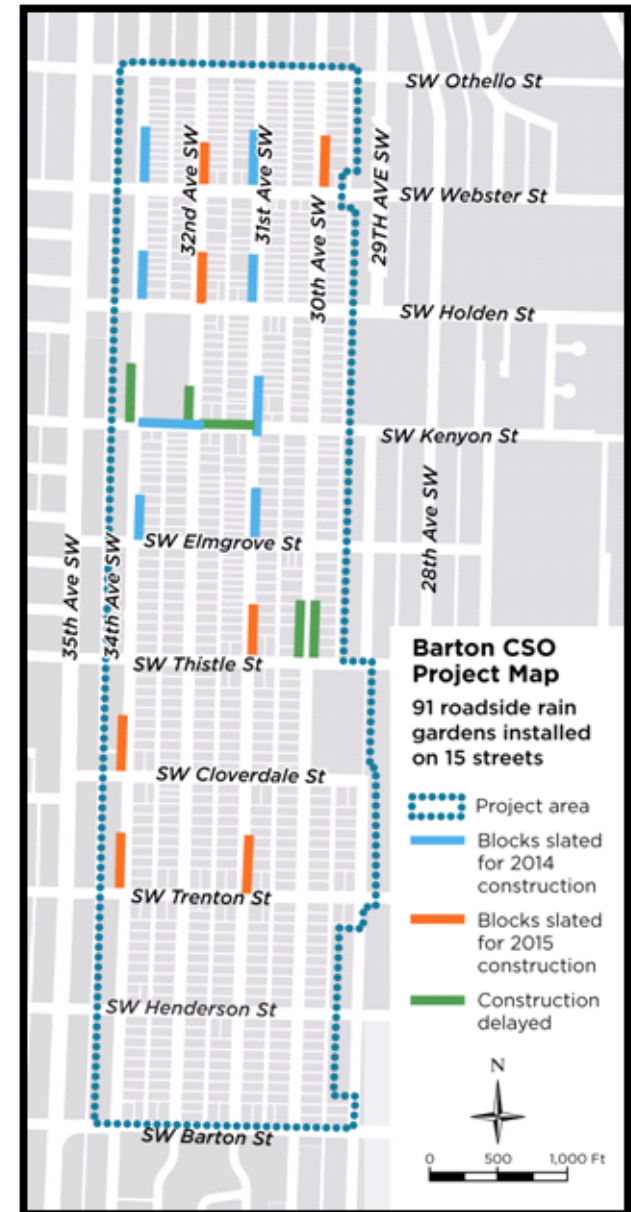
- 15 streets with GSI
- ROW Area = 11.6 acres (4.7 ha)
- Parcel Area (including disconnected downspouts) = 20.2 acres (8.1 ha)
- Parcels 43%+/- Impervious
- ROW 64% +/- Impervious



Top figure from Aqualyze. Routing of flows.

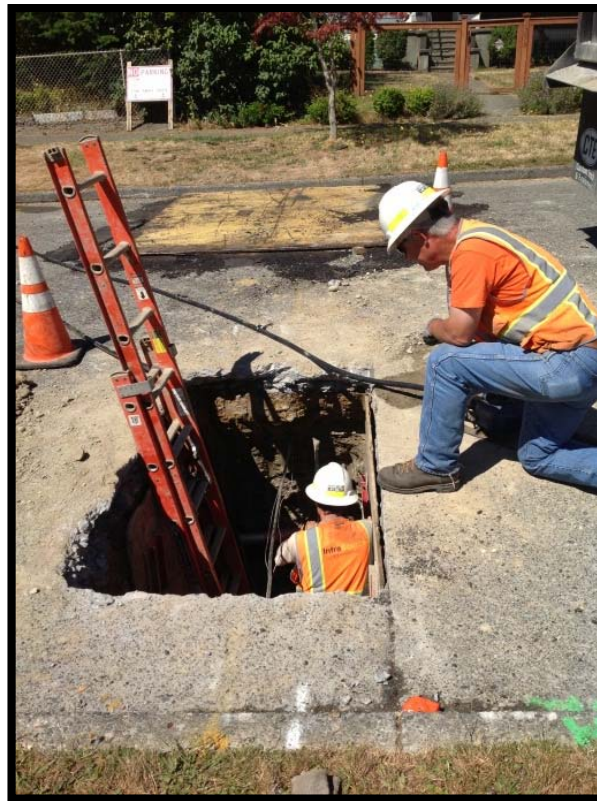
Procurement, Cost & Construction

- Public Competitive Bid
- Engineer's Estimate \$5.06 Million
- Low responsive responsible bidder \$5.10 Million
- Milestones & Constraints in Contract
 - Two construction seasons 2014 & 2015 (8 and 7)
- Lump Sum bid with select unit prices for items more likely to change (e.g. depth of well screen)



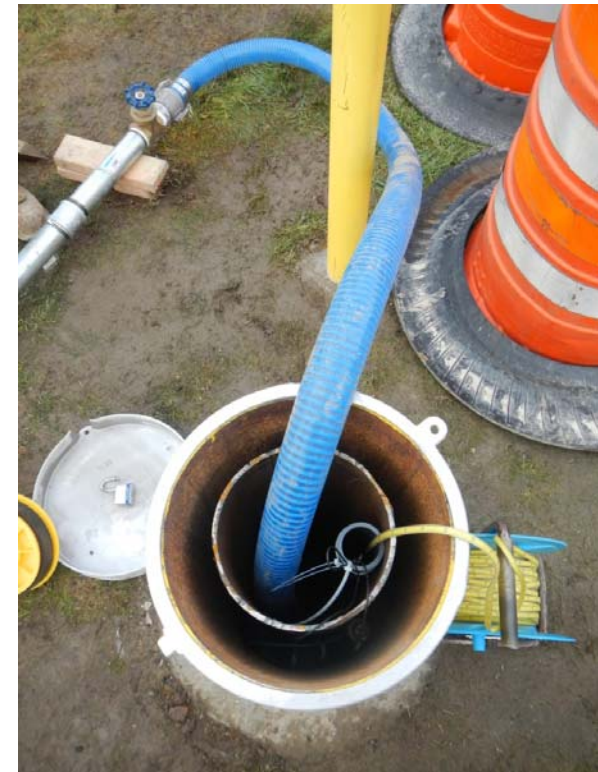
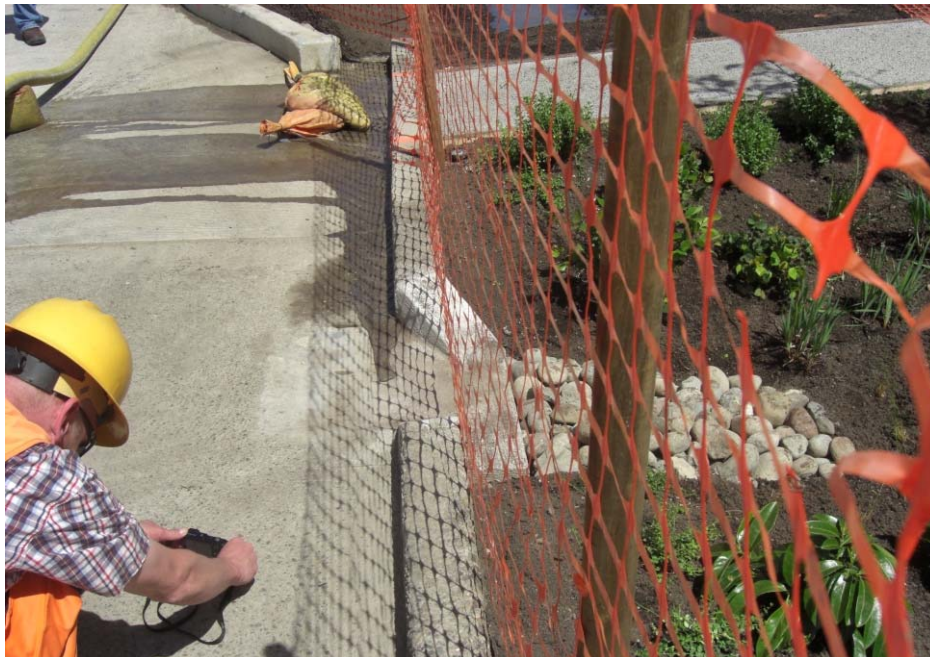
Pre-Construction

- Gas relocates done before main contract
- Tree removal
- Construction Staff Training



Construction

- Checklists for Inspectors
- Mockups
- Flow Tests
- Community Outreach



Construction – Bioretention



- Ongoing testing of soil
- Grading mock-up
- Minimize foot traffic
- Curb cuts blocked
- Increase time for wells off line

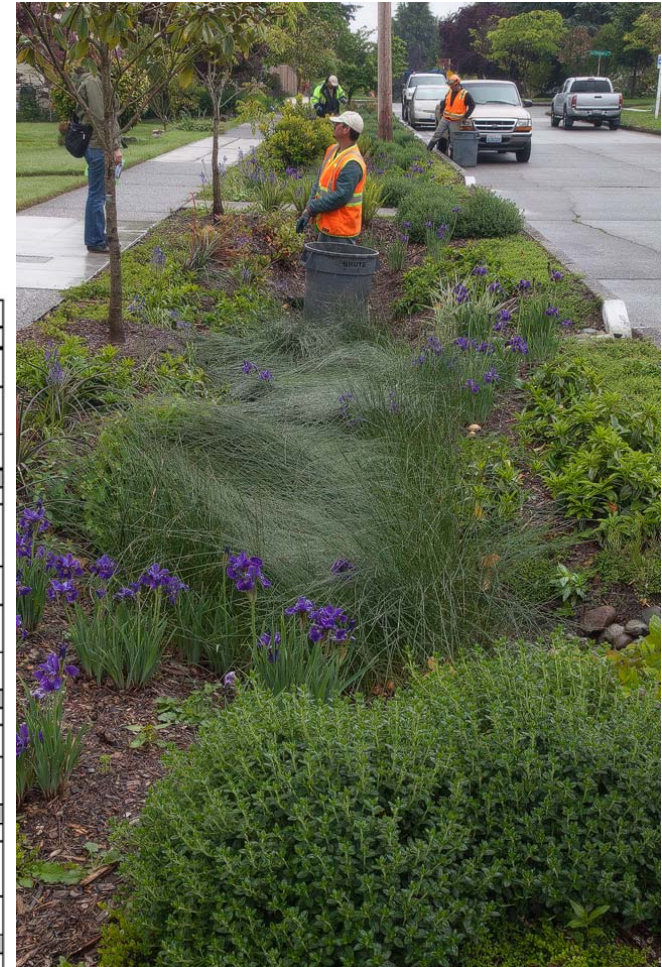


Plant – Construction Establishment



Operation and Maintenance

- Maintained by King County as a CSO facility
- O&M Plan



Street Name (btw streets: intersection to intersection):			
Checked By:	Ph:	Date of Site Visit:	Time of Site Visit:
Date of Last Inspection:	As-Built Plan Available Yes <input type="checkbox"/> No <input type="checkbox"/>	Does site need maintenance action? (Yes, if condition/function Moderate or Low)	Ok <input type="checkbox"/> Action Required <input type="checkbox"/>
Weather at time of site visit:		Does site need follow-up review upon completion of maintenance action (condition moderate or low)?	Ok <input type="checkbox"/> Action Required <input type="checkbox"/>
Purpose of visit:	<input type="checkbox"/> Routine Maintenance <input type="checkbox"/> Check swales before rain event	Rain Precipitation (inches) in last 72 hours (note source for information):	
Drain Structure Inlets, Grates, Curb Cuts & Weirs			
HIGH	MODERATE	LOW	
<input type="checkbox"/> Facility is ready for a storm event: No blockage from sediment or vegetation, no damaged structures, and no ponding.	<input type="checkbox"/> Facility is partially ready for a storm event: Some blockage from sediment or vegetation, some damaged structures, and/or some ponding.	<input type="checkbox"/> Facility is NOT ready for a storm event: Significant blockage from sediment or vegetation, many damaged structures, and/or ponding.	Comment:
<input type="checkbox"/> There is minimal blockage from plants at drain curb cuts, weirs, and CB grates.	<input type="checkbox"/> There is moderate blockage from plants at drain curb cuts, weirs, and CB grates.	<input type="checkbox"/> There is significant blockage from plants at drain curb cuts, weirs, and CB grates.	Comment:
<input type="checkbox"/> There is minimal trash, debris, fall leaf litter and sediment at drain curb cuts, weirs, and CB grates.	<input type="checkbox"/> There is moderate trash, debris, fall leaf litter and sediment at drain curb cuts, weirs, and CB grates.	<input type="checkbox"/> There is significant trash, debris, fall leaf litter and sediment at drain curb cuts, weirs, and CB grates.	Comment:
<input type="checkbox"/> No damaged drain curb cuts, grates or weirs.	<input type="checkbox"/> One or two damaged drain curb cuts, grates or weirs.	<input type="checkbox"/> Several damaged drain curb cuts, grates or weirs.	Comment:
Paved Paths & Sidewalks			
HIGH	MODERATE	LOW	
<input type="checkbox"/> Less than 25% of pavement is covered with Moss, debris, leaves and sediment.	<input type="checkbox"/> Between 25-40% of pavement is covered with Moss, debris, leaves and sediment.	<input type="checkbox"/> More than 40% of pavement is covered with Moss, debris, leaves and sediment.	Comment:
<input type="checkbox"/> There are no grade changes, cracks or upheaval. The surface is smooth.	<input type="checkbox"/> There are slight grade changes, cracks or upheaval. The surface is moderately smooth.	<input type="checkbox"/> There are grade changes greater than 1" or significant cracks or upheavals. The surface is uneven or very rough.	Comment:
Bioretention Soils in Swale			
HIGH	MODERATE	LOW	
<input type="checkbox"/> No erosion, channelization or scouring with less than 25% bare spots. Settlement is less than 1 inch.	<input type="checkbox"/> Some erosion, channelization or scouring with less than 40% bare spots. Settlement is between 1" and 3" inches.	<input type="checkbox"/> Significant erosion, channelization or scouring with greater than 40% bare spots. Settlement is greater than 3 inches.	Comment:
<input type="checkbox"/> Soil is loose, not compacted and water drains within 24 hours and is not ponding.	<input type="checkbox"/> Soil is slightly compacted and/or signs of slower infiltration.	<input type="checkbox"/> Soil highly compacted and water is ponding.	Comment:
Spill Prevention and Response, and Pest Control			
HIGH			
<input type="checkbox"/> Exercise spill prevention measures whenever handling or storing potential contaminants. Fertilizers, Herbicides, Fungicides and Insecticides are prohibited in GSI.			Comment:
<input type="checkbox"/> Clean up spills as soon as possible to prevent contamination of stormwater. See O&M Manual and follow Specification 01560, Environmental Management, for spill prevention and response.			
<input type="checkbox"/> Insects: No standing water observed in the basin for time periods suitable for insect development (designed to drain in 24 hours).			Comment:
<input type="checkbox"/> Rodents: Few or no rodent holes are present.			



King County



Maintenance – Acceptable vs Unacceptable

ACCEPTABLE
MAINTNANCE



Mostly healthy vegetation with good appearance



Appearance is good



Occasional weedy species (5-10%)



Some erosion and bare spots (0-5%)

UNACCEPTABLE
MAINTENANCE



Debris buildup



Appearance is poor



Weedy



Overgrown



COMMUNITY MEETING - NOVEMBER 14, 2012
BARTON CSO CONTROL PROJECT WITH GSI

King County
Department of Natural Resources and Parks
Wastewater Treatment
Division

svr
DESIGN COMPANY

Monitoring



- Cells and wells are taking all the water that drains to them
- Monitoring flows out of basin.
- Less water flowing to treatment plant = reduction in treatment costs.
- Data loggers in UIC Wells to measure water level
- Adaptive management to be applied if needed. Four more streets design and permitted.
- Stay tuned.....

Next Steps

- Continue “Establishment” O&M for 2-3 years. Begin routine maintenance in 2017/2018.
- Continuing flow & CSO monitoring within basin
- Compliance reporting in 2017
- King County will be expanding and looking to use GSI for CSO control in more areas within Seattle where feasible.
- Joint GSI Program between King County WTD and Seattle Public Utilities on design standards, policies and procedures for CIP GSI projects. www.700milliongallons.org



The banner features a blue background with a green wave at the bottom. On the left, it includes the Seattle Public Utilities logo and the King County Department of Natural Resources and Parks Wastewater Treatment Division logo. The main title is 'Green Stormwater Infrastructure in Seattle' in large, bold, black text. Below the title is the website 'www.700MillionGallons.org' and the slogan 'Working Together to Protect our Waterways' in a light blue font.

Seattle Public Utilities

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

Green Stormwater Infrastructure in Seattle

www.700MillionGallons.org

Working Together to Protect our Waterways





THANK YOU!



For more information about the Barton CSO control project with GSI go to:
<http://www.kingcounty.gov/environment/wtd/Construction/Seattle/BartonCSO-GSI.aspx>
<http://www.kingcounty.gov/environment/wastewater/CSO.aspx>
<http://www.kingcounty.gov/environment/wastewater/CSO/BeRainwise.aspx>

SPU & King County Wastewater Joint GSI program: www.700milliongallons.org

John Phillips, King County, john.phillips@kingcounty.gov

Kathryn Gwilym, MIGISvR kgwilym@migcom.com, ph 206-223-0326

Peg Staeheli, MIGISvR, pstaeheli@migcom.com

Steve Burke, MIGISvR, sburke@migcom.com



www.svrdesign.com

Before & After



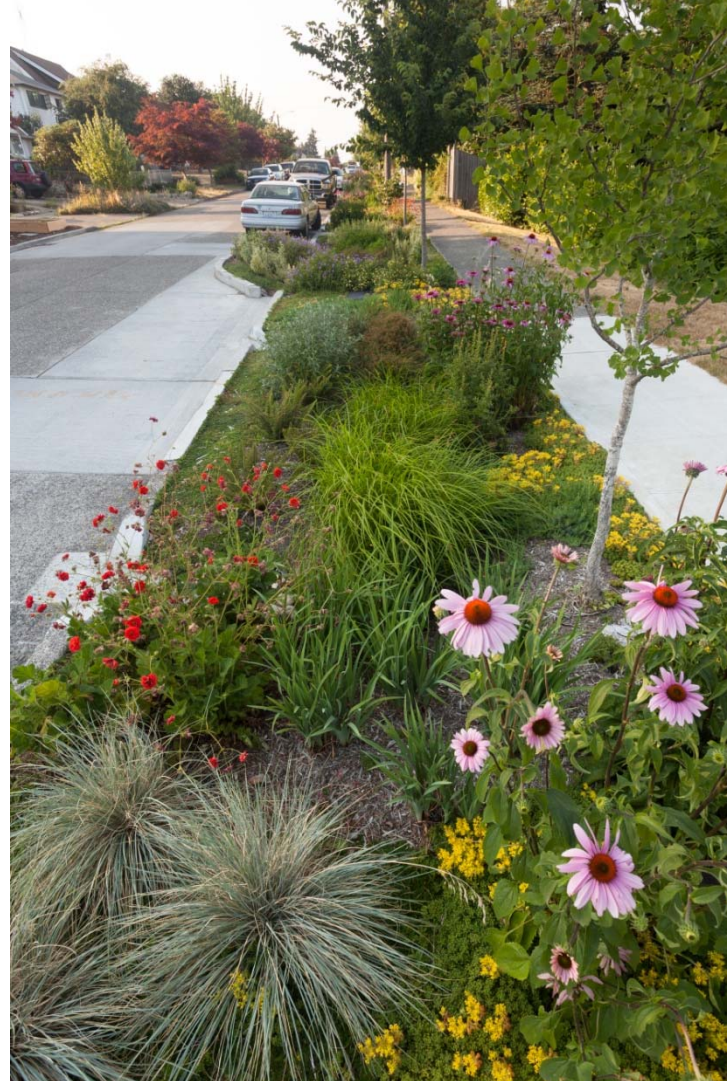
Before & After



Before & After



Before & After



December 8, 2015 Storm Event



RainWise



What is RainWise?

More than 500 Seattle homeowners have installed rain gardens and cisterns that are helping to control stormwater runoff and preventing combined sewer overflows as part of the RainWise program in Seattle.

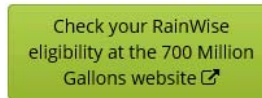
Fall, winter and early spring are great times to start a RainWise project:

- Plants have time to grow healthy roots and with plenty of rain you don't need to water them until summer
- Contractors who install rain gardens and cisterns tend to be more available fall, winter and early spring.

TAKE A VIRTUAL TOUR!

Do more online

Contact us



You can also call the Garden Hotline at 206-633-0224 for eligibility information.

Resources

Download the [Be RainWise flier](#) to learn more about this program.



Se dispone de más

- Rebate to homeowners to redirect building downspouts to rain garden/cistern
- So far 82 Installations in Barton (\$230,255 in rebates, 121,402 sf roof disconnected)
- Opportunity for residents to take action on their property
- www.700milliongallons.org

