

# Green Infrastructure In the City of Portland, Oregon

January 26<sup>th</sup>, 2015

The City of Portland  
covers 135 square miles

18 square miles of rooftops

15 square miles of streets

12 square miles of parking lots

City of Portland, Bureau of Environmental Services

Brian Wethington - ASLA, CLARB, LEED AP  
Sustainable Stormwater Division (2010-2014)

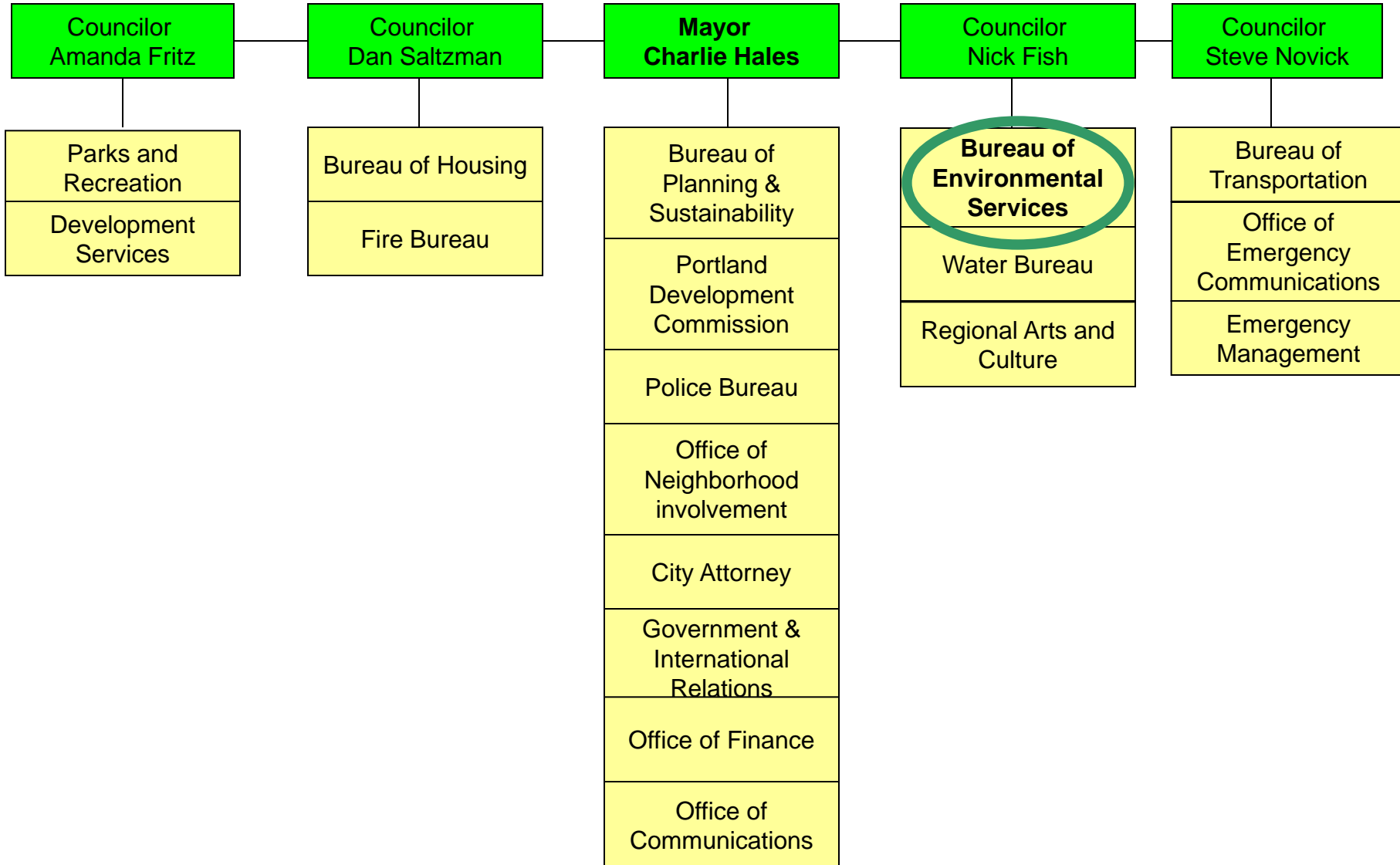


ENVIRONMENTAL SERVICES  
CITY OF PORTLAND  
working for clean rivers

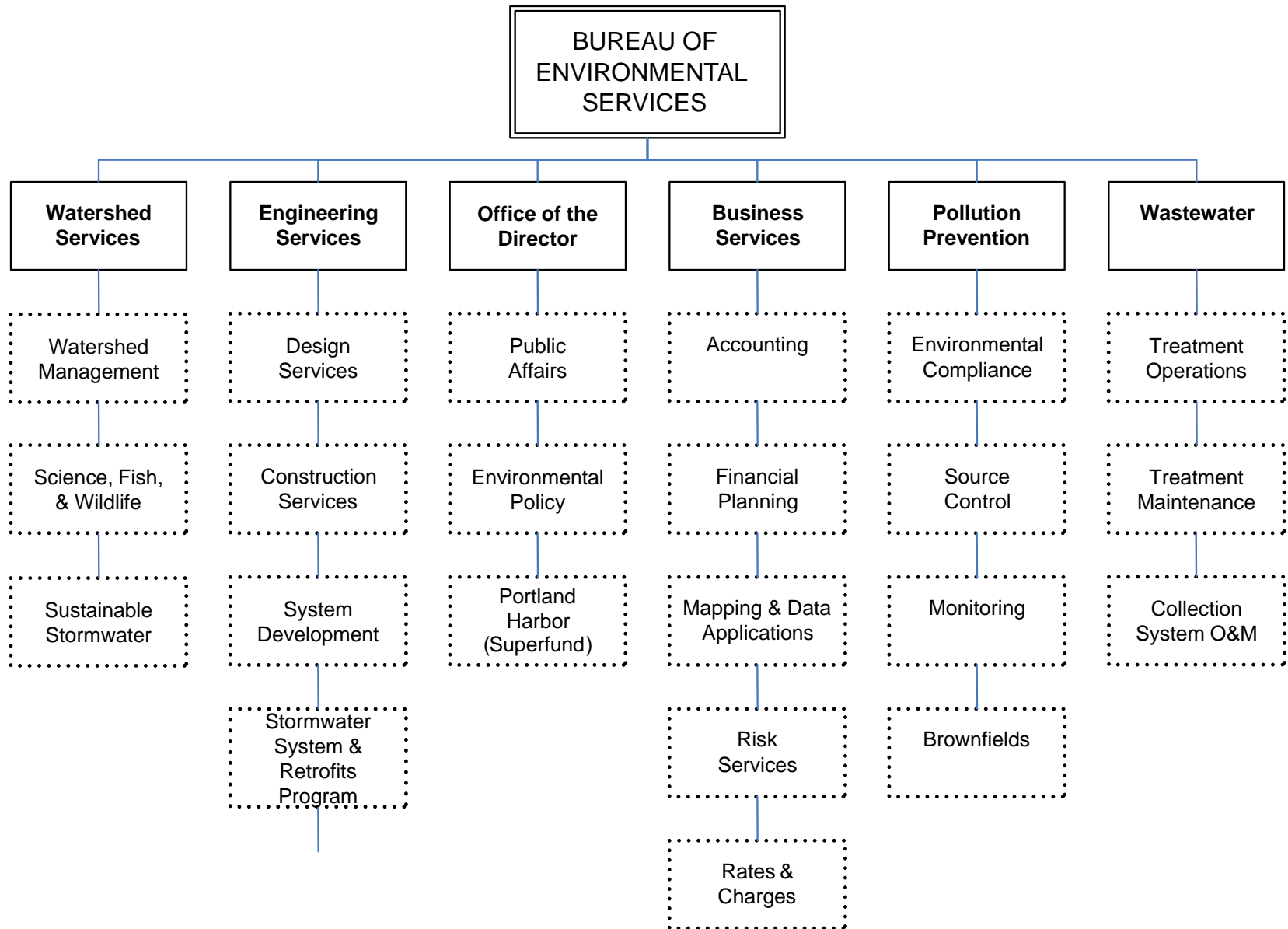
# Portland's Green Infrastructure

- Portland overview
- History
- Projects
- Monitoring & Maintenance
- Partnerships
- Future

# Portland | City Government

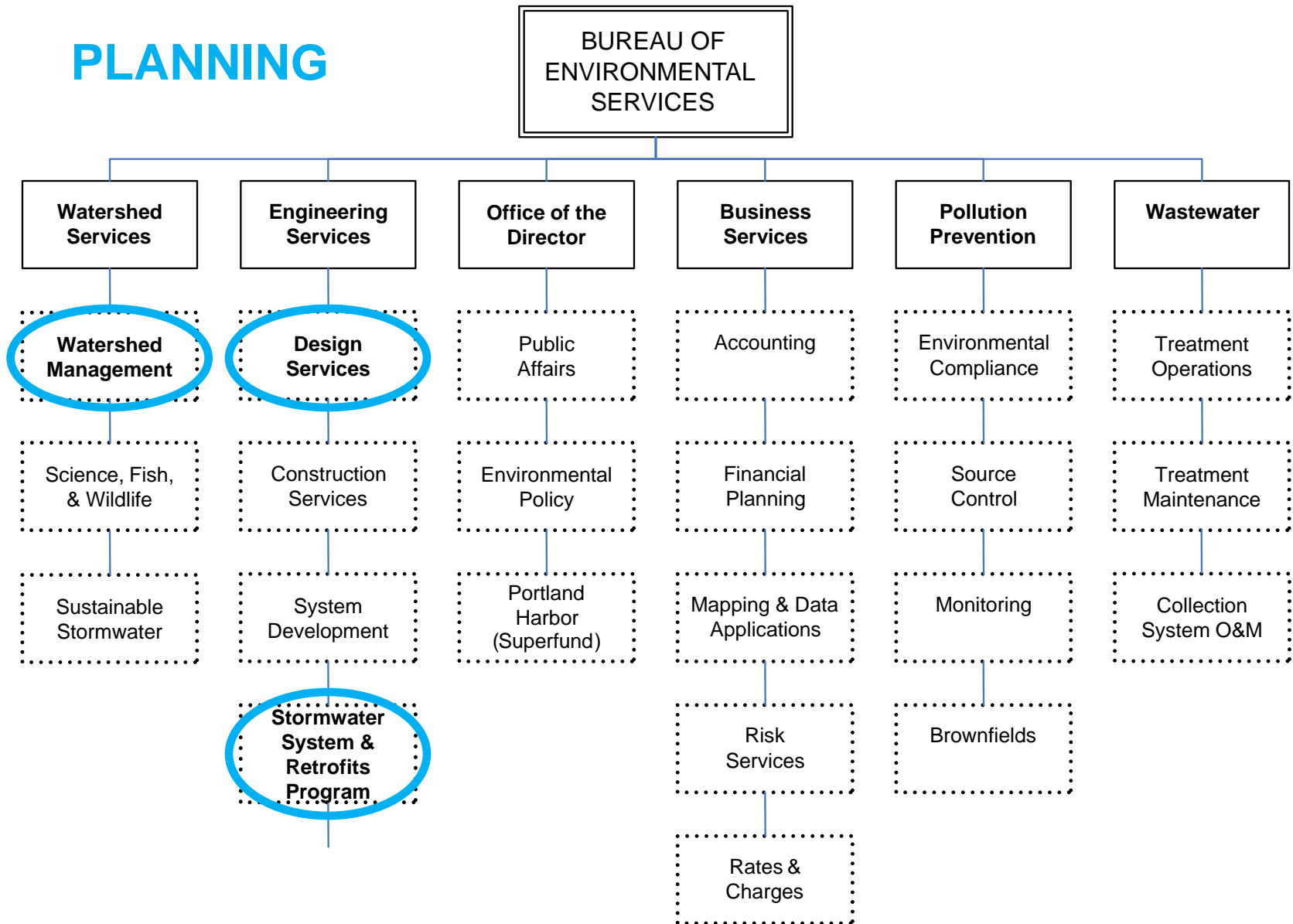


# Organization | Environmental Services



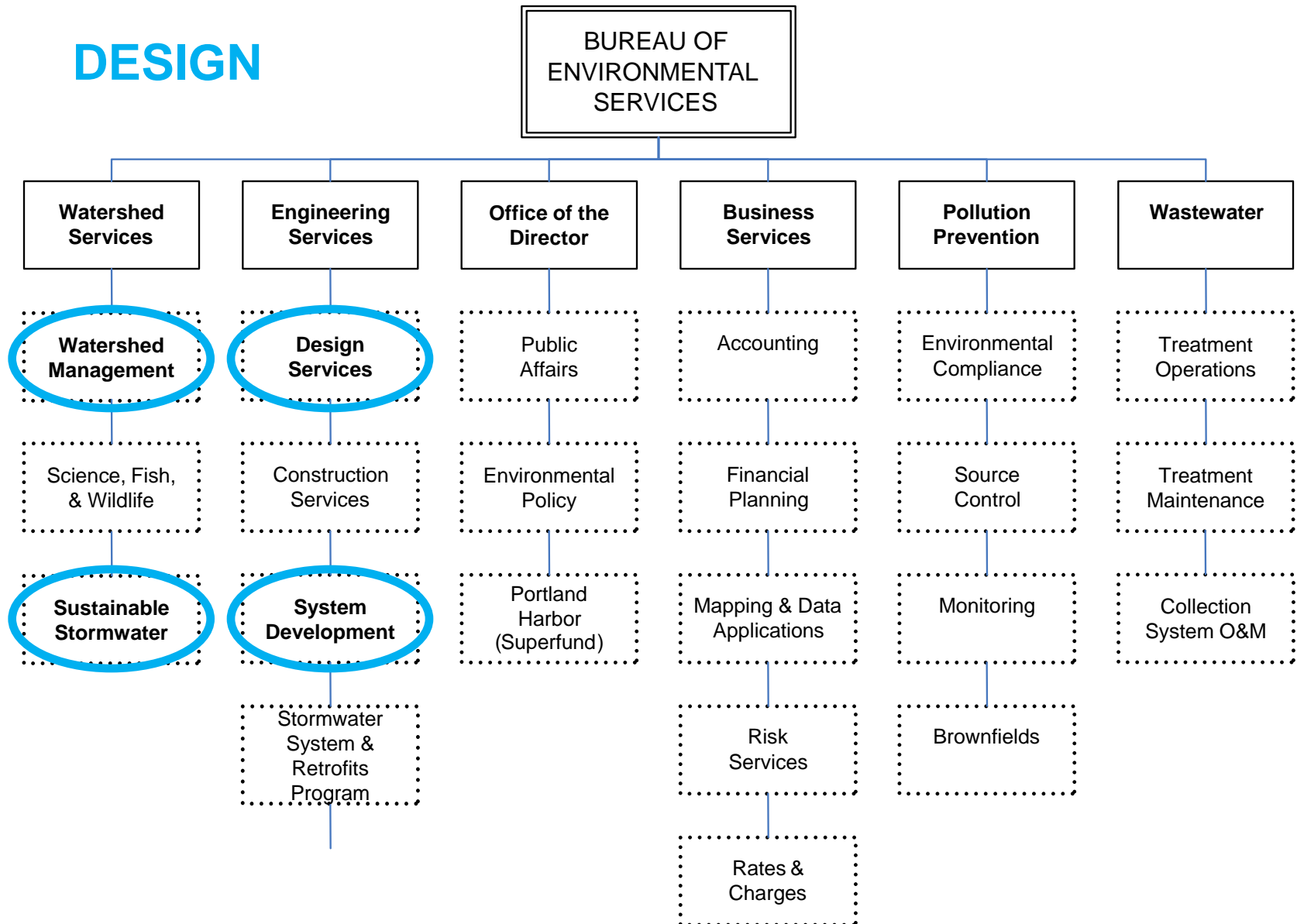
# Organization | Environmental Services

## PLANNING



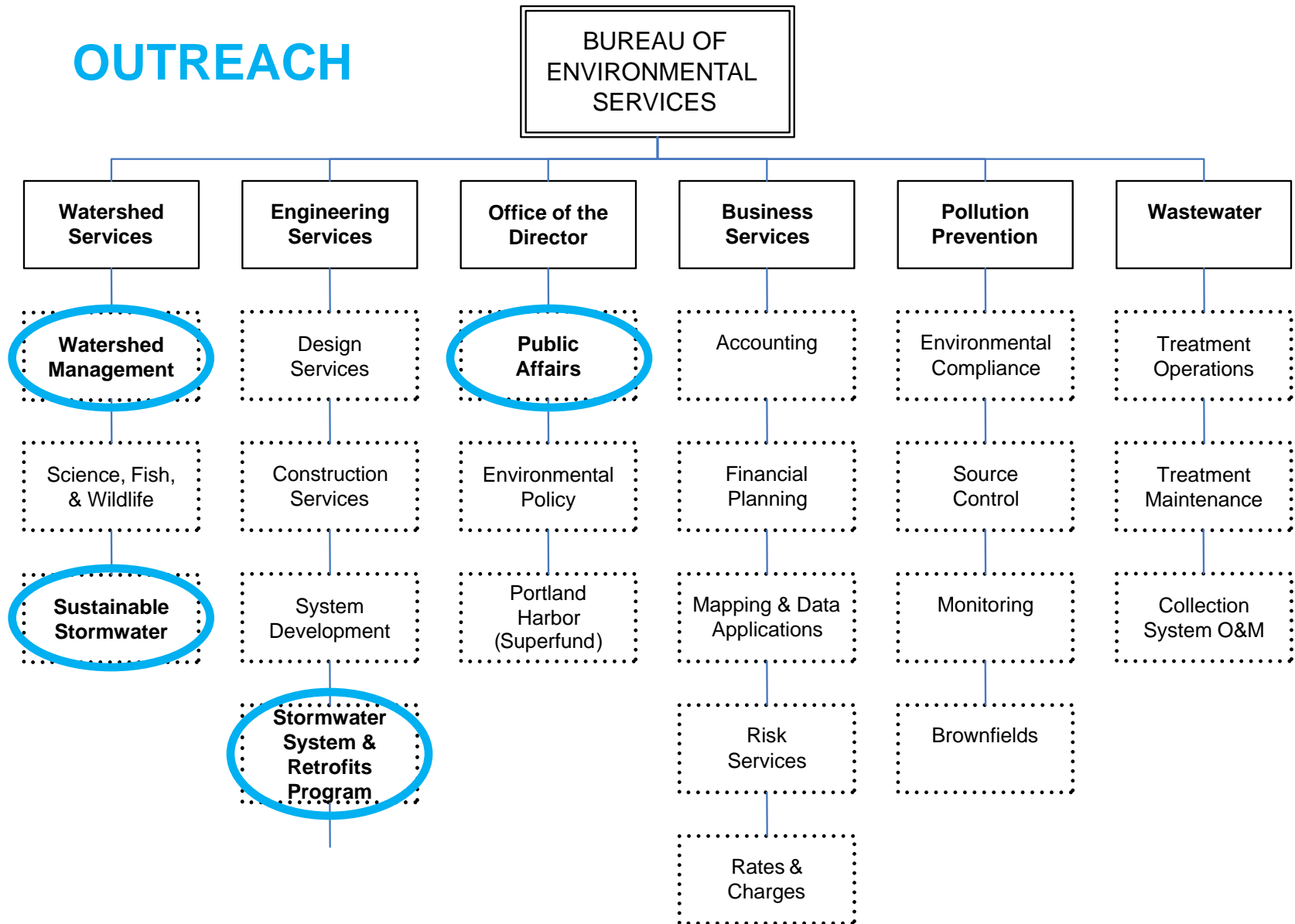
# Organization | Environmental Services

## DESIGN



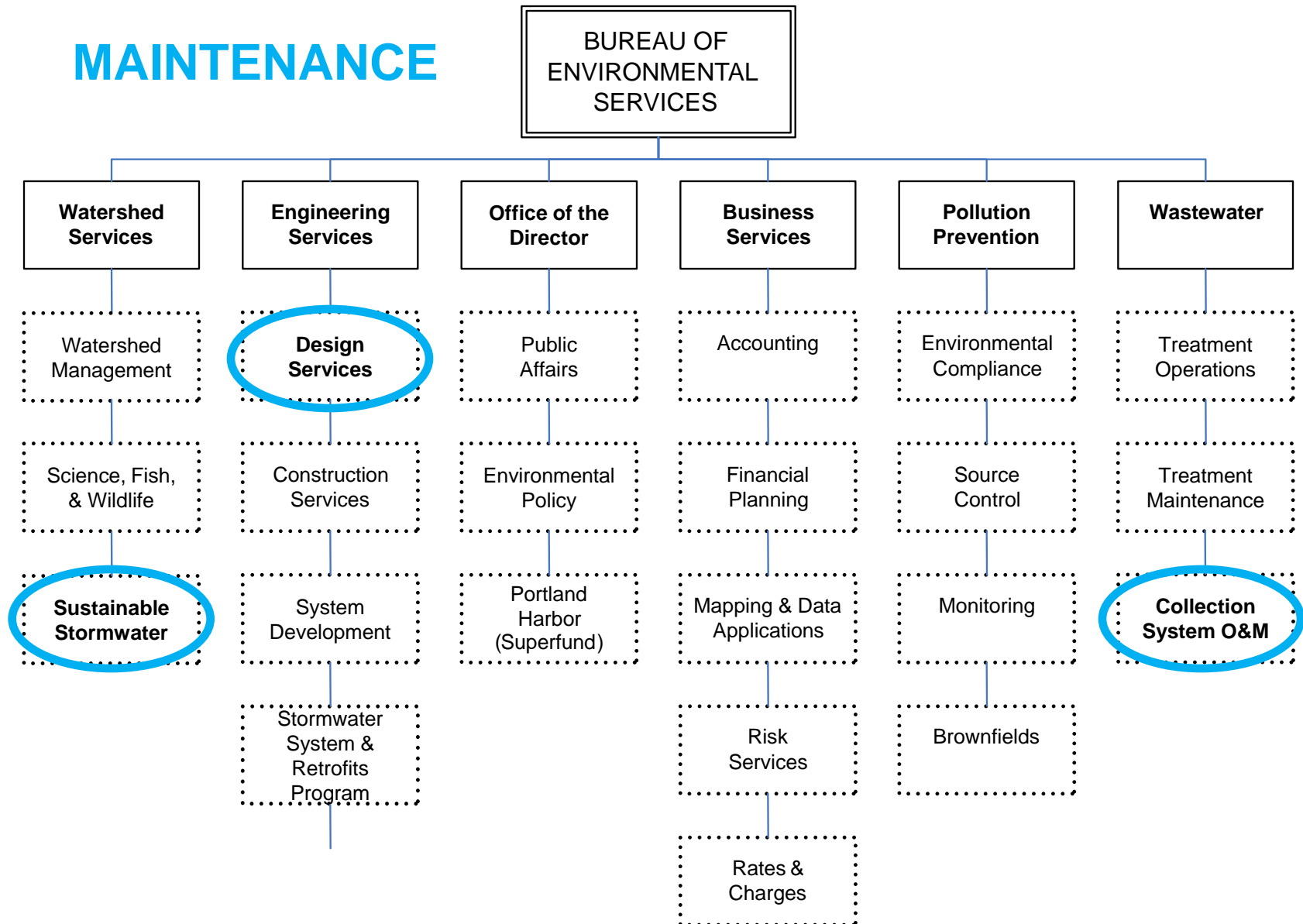
# Organization | Environmental Services

## OUTREACH

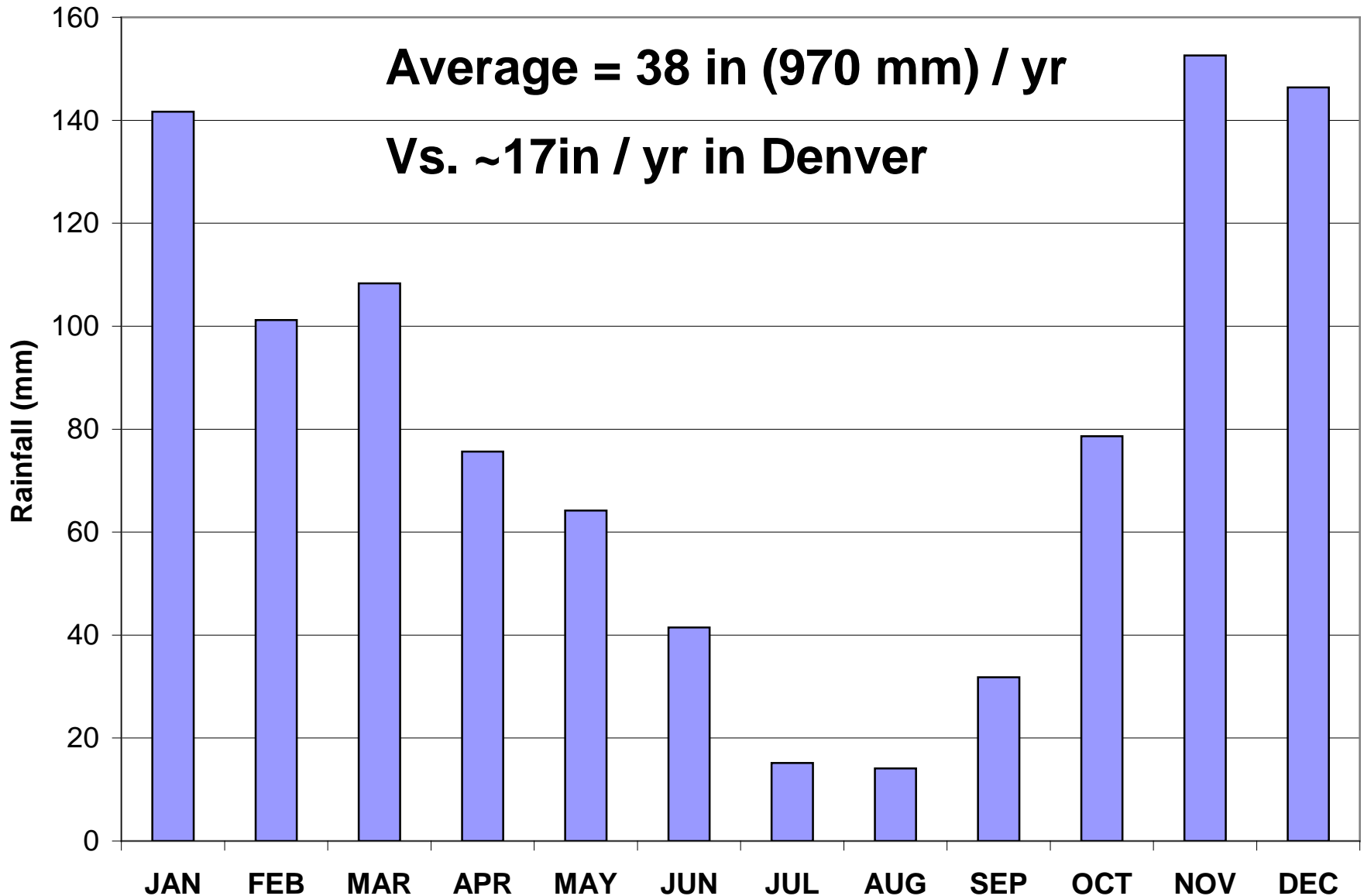


# Organization | Environmental Services

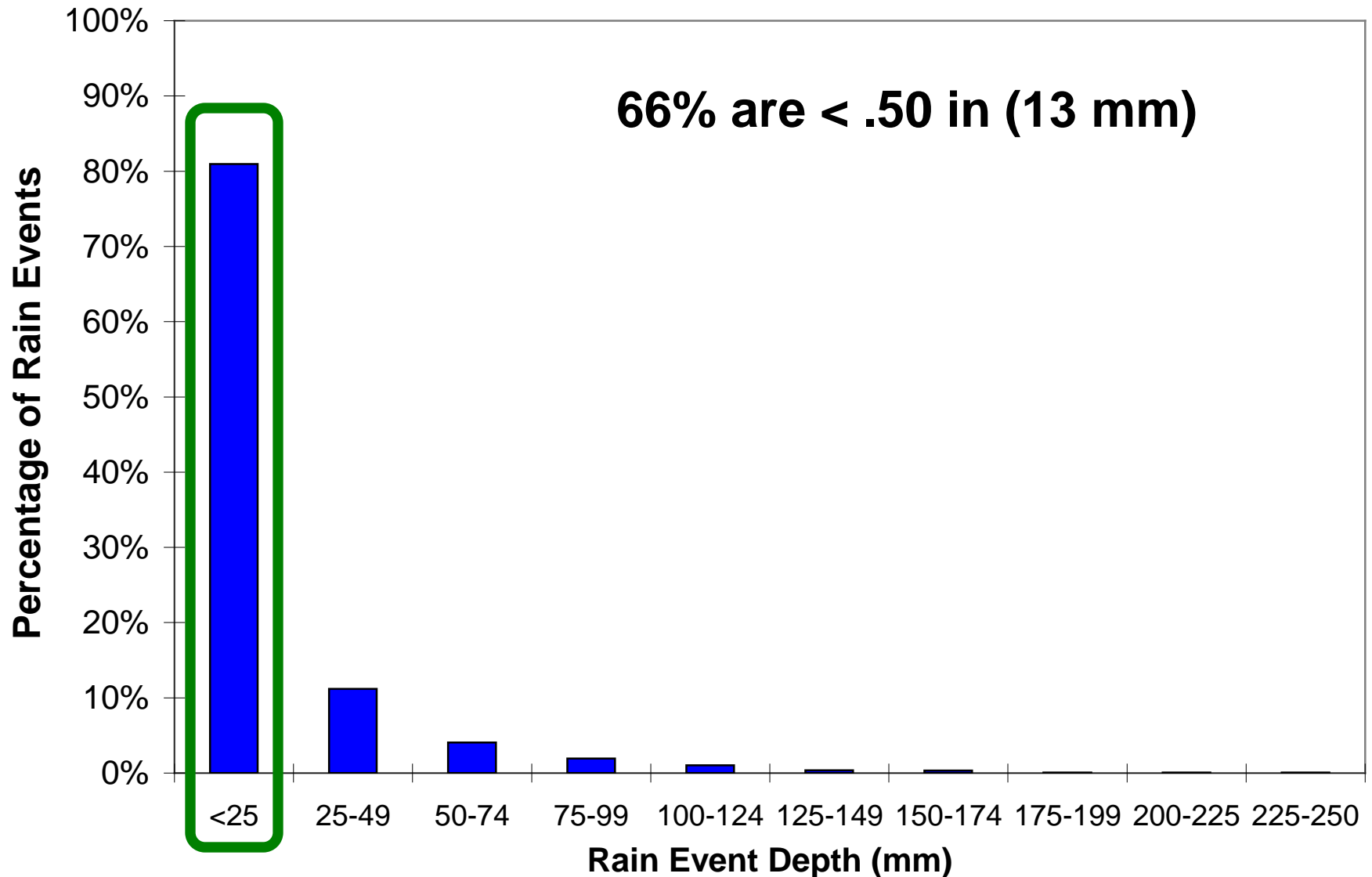
## MAINTENANCE



# Portland | Monthly Rainfall



# Portland | Rainfall Events (1983-2012)



# Portland | Snow



SW 4<sup>th</sup> & College



Portland average 4.5 in / year

Denver average 55 in/year

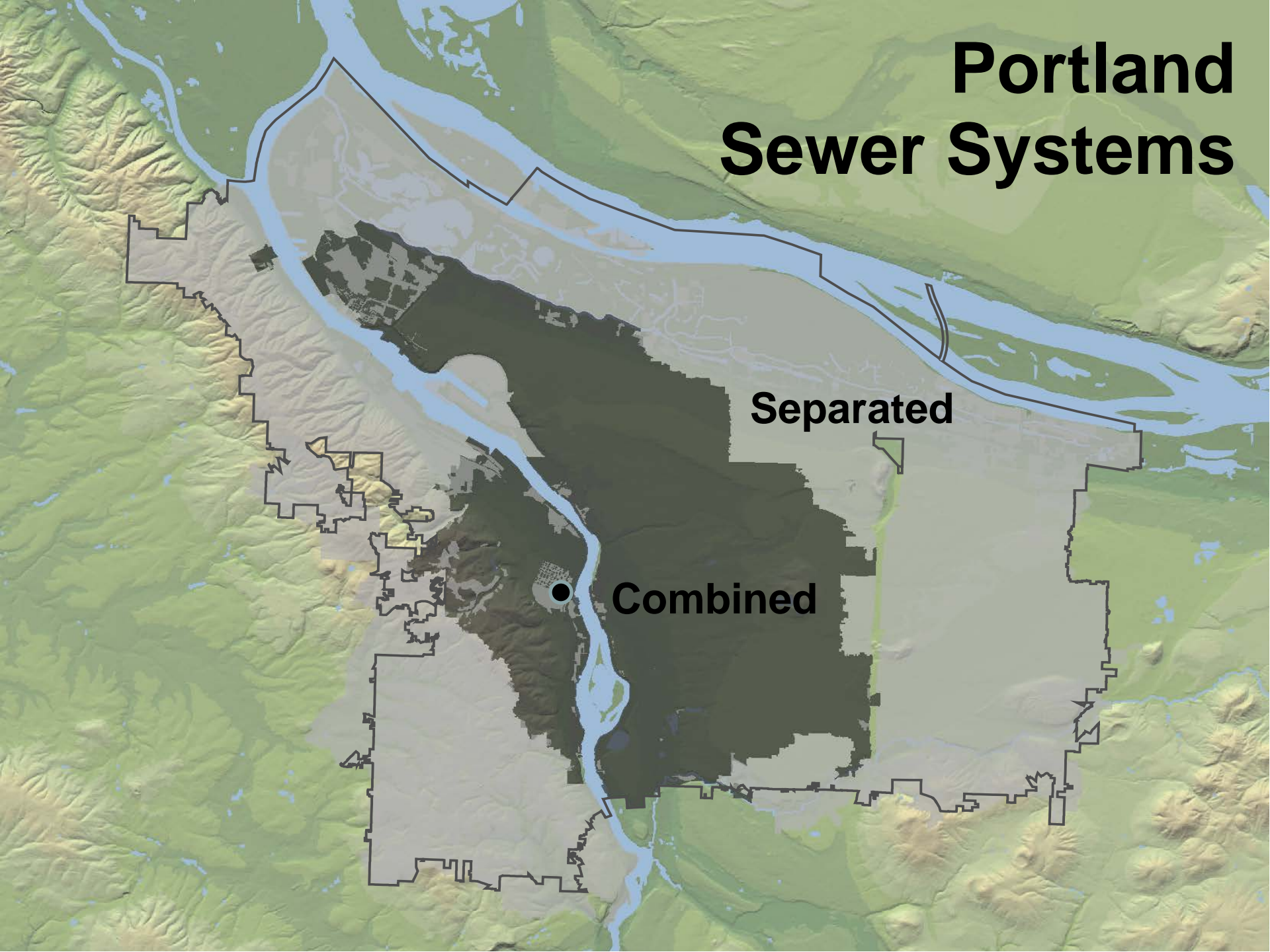
# Portland Watersheds



# Portland Sewer Systems

Separated

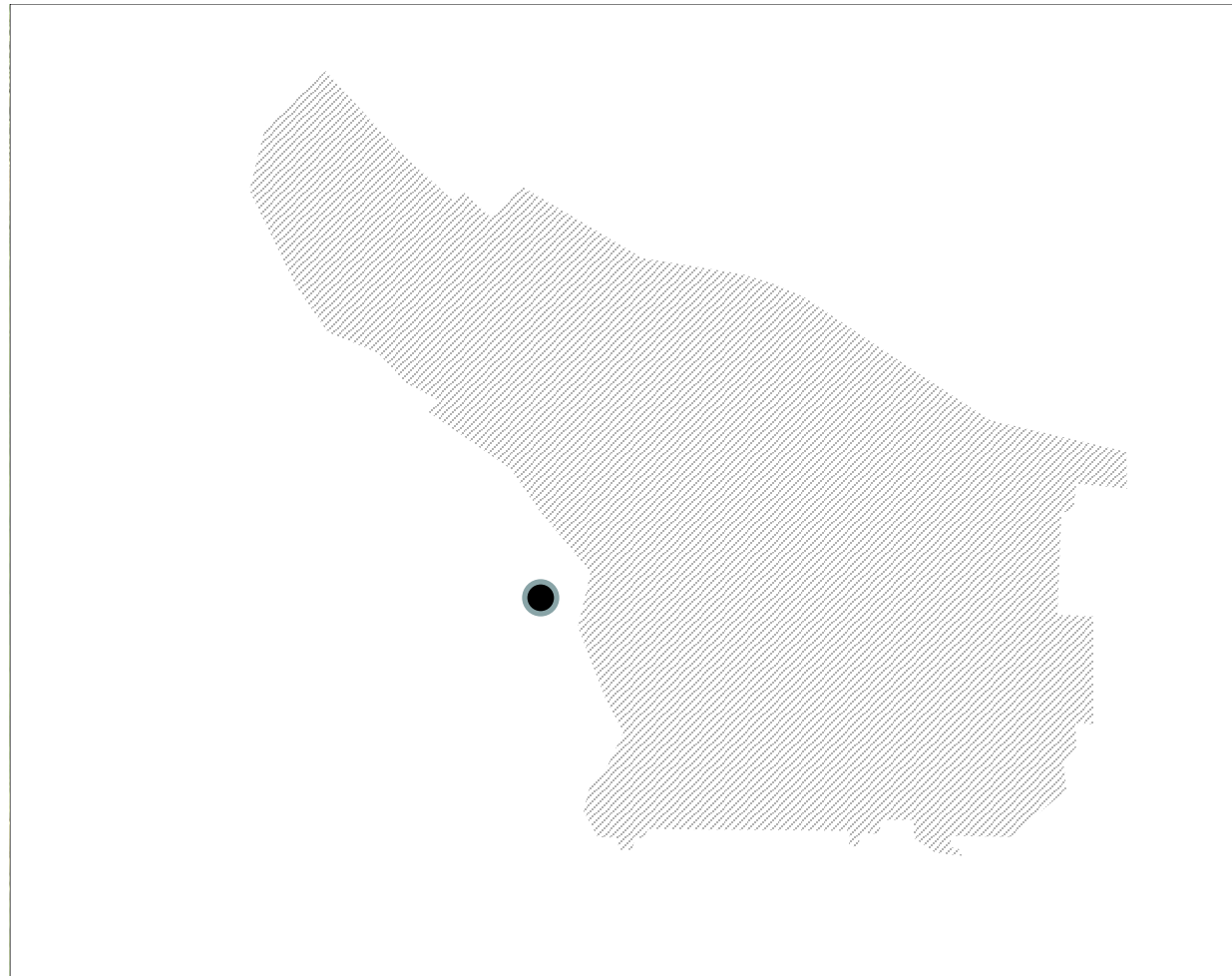
● Combined



# Portland | Soils

## – Eastside

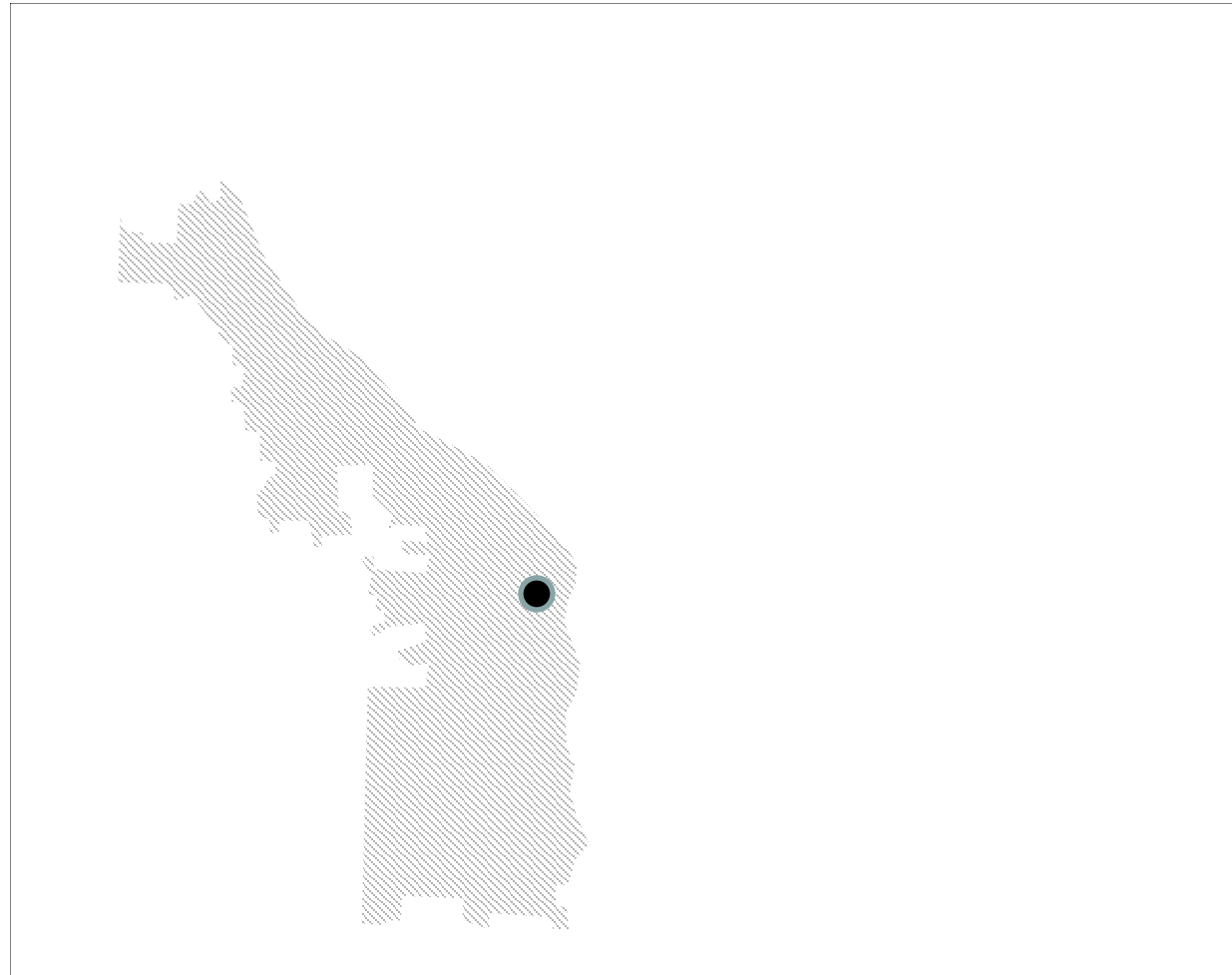
- 6 ft. of silt, grading into sand and gravel
- typical percolation rates = 1-2 in/hr



# Portland | Soils

## – Westside

- silt, sometimes over fragipan
- typical percolation rate  $\leq .50$  in/hr



# Green History | Private Property

## Early Private Property Projects (1989 – 1996)

- opportunity driven
- impending water quality regulations



OMSI Parking Lot Swales (1992)



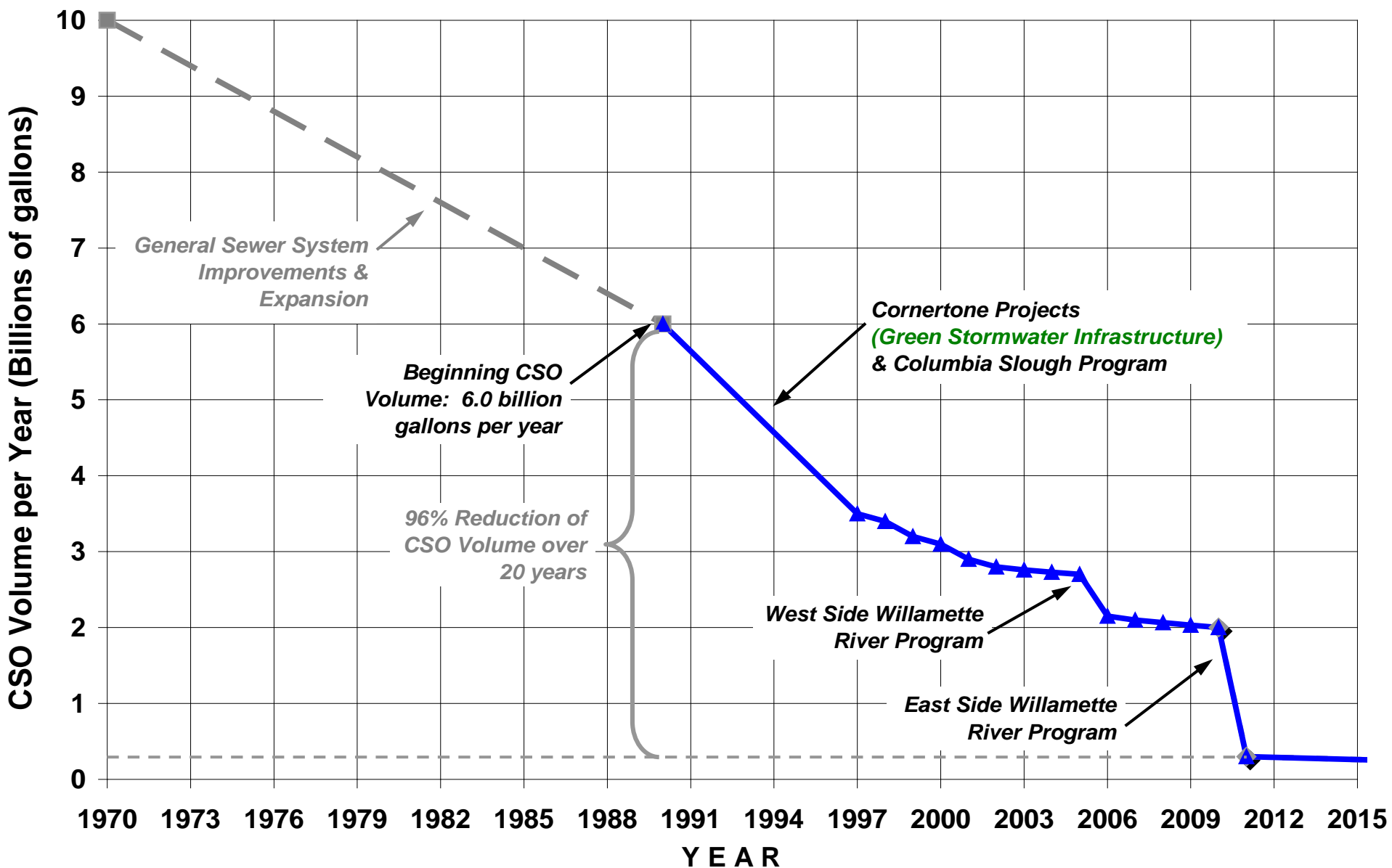
Liptan garage (1996)

# Portland's 20-Year CSO Program 1991 – 2011 (\$1.4 Billion)

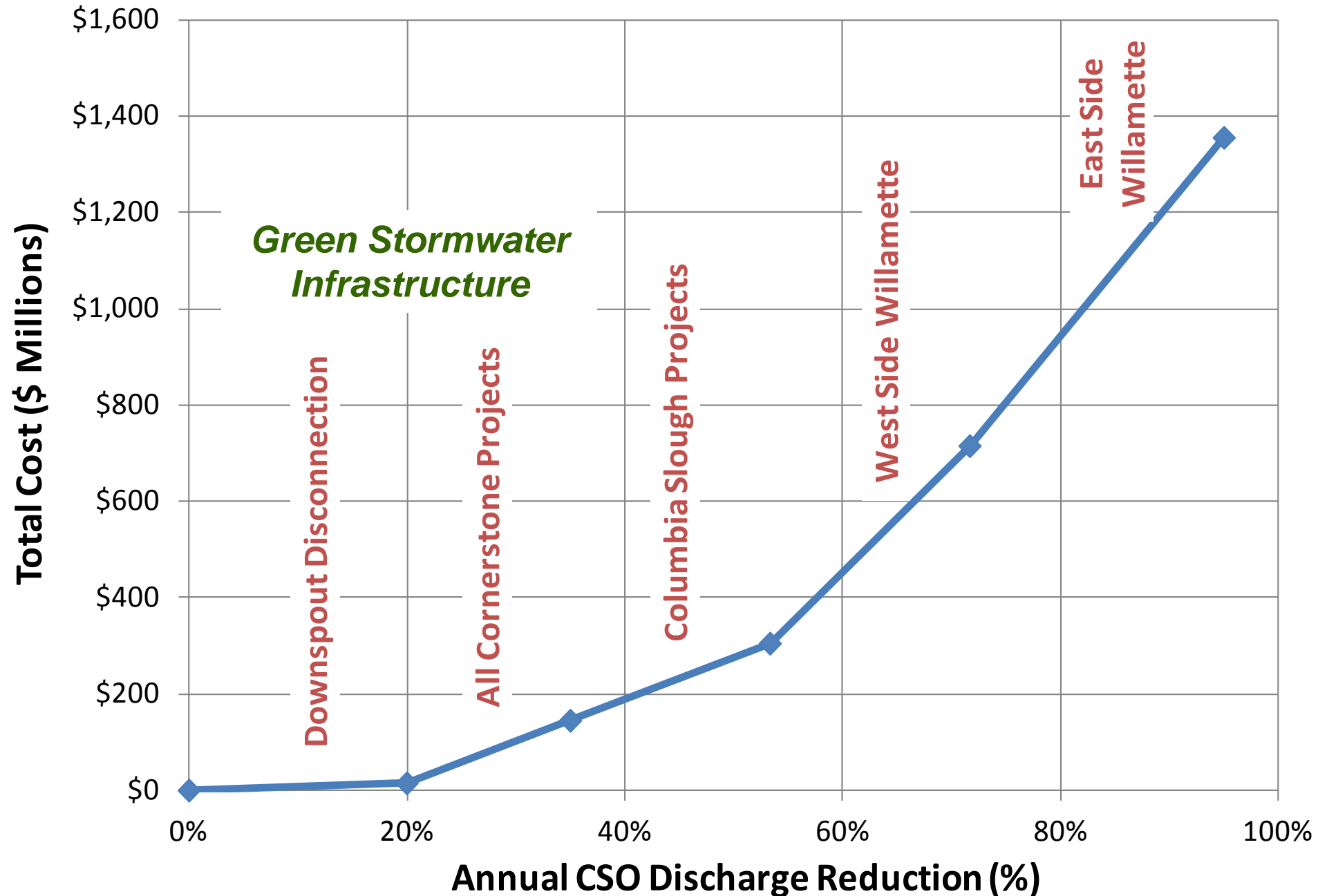
- Three Major Components
  - **Cornerstone** (Green Stormwater) Projects – Reduced CSO 35%
  - Wet Weather Treatment at Wastewater Treatment Plant (Works)
  - Tunnel Collection, Storage, Pumping
    - Columbia Slough Tunnel & Influent Pump Station
    - West Side Willamette River CSO Tunnel & Pump Station – Phase I
    - East Side Willamette River CSO Tunnel & Pump Station – Phase II
- On-going CSO Reduction: Green Stormwater Infrastructure



# CSO Reductions Required & Achieved



# Costs-Effectiveness of \$1.4B CSO Program Elements



# Green History | CSO Program

## Combined Sewer Overflow (CSO) Program

- 1991 – 2011
- control 6B gallons of overflow volume each year
- total cost ~ \$1.4B



## Post-2011 CSO Facilities Plan

- another 600 acres managed by 2050
- largely through green infrastructure

# Green History | Roof Downspouts

Residential roof downspouts  
disconnected from the combined sewer



CONNECTED DOWNSPOUT



DISCONNECTED DOWNSPOUT

# Green History | Roof Downspouts

## Downspout Disconnection Program (1993-2011)

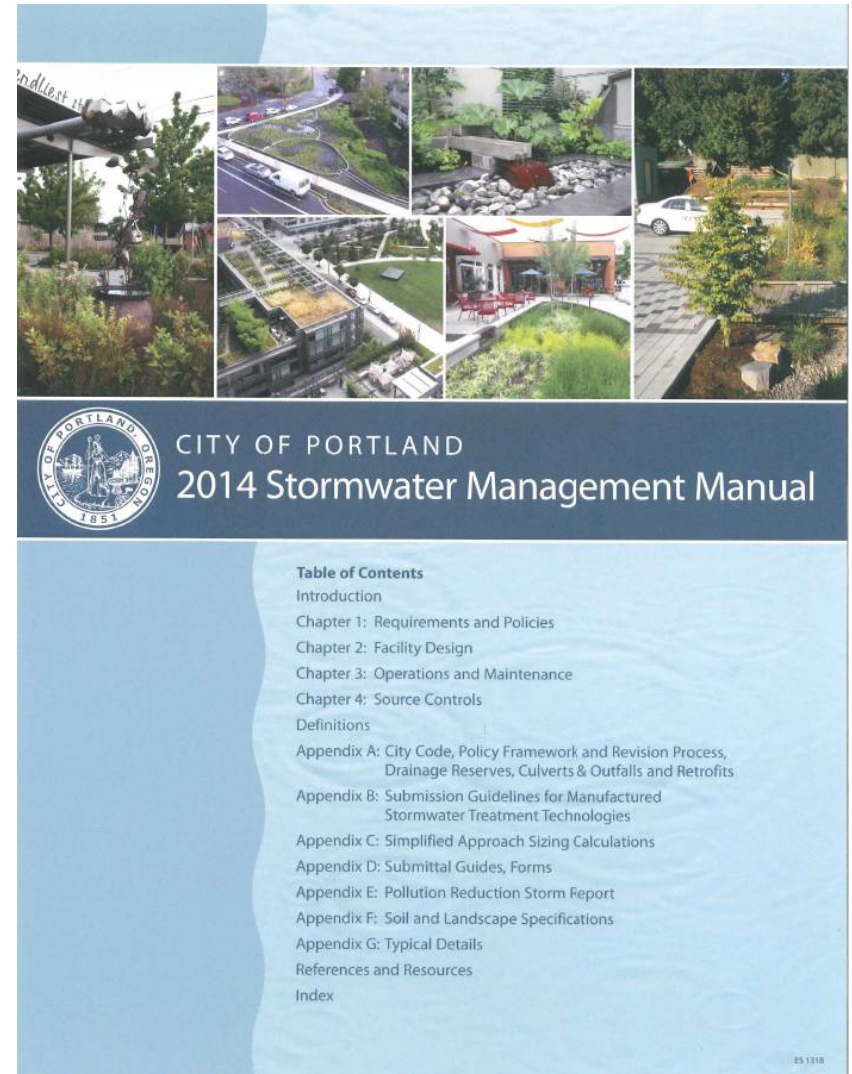


- Over 56,000 disconnected downspouts at over 26,000 residential homes
- Annual volume reduction estimated at almost 20%
- Cost of \$13M (operational /capital) saved \$300M in Capital Cost
- Required significant building code changes and assurances of safe places to discharge

# Green History |

- Applies to new development and re-development
- **Public & Private**
- triggers:
  - new or redirected impervious area > 500 Square Feet

## Stormwater Management Manual (1999)

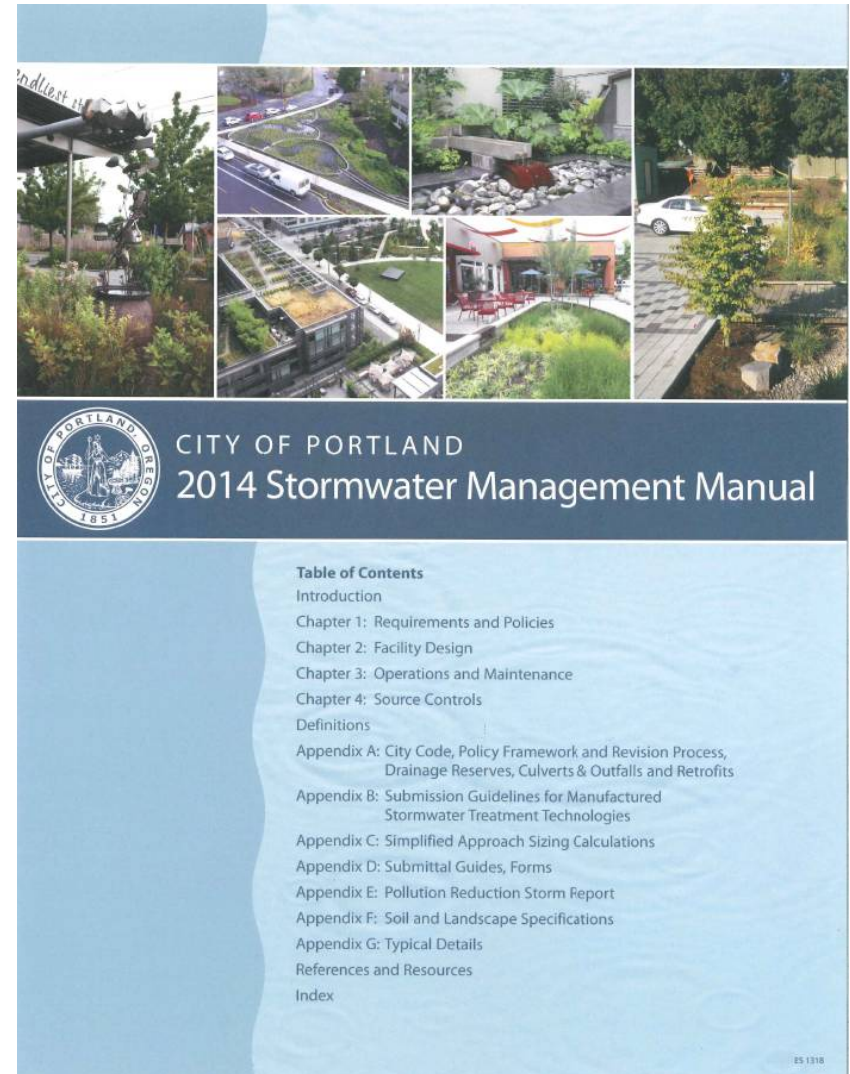


# Green History |

## Requirements:

- retain as much runoff on site as possible
- control peak flows
- use green infrastructure whenever possible
- design storms
  - 10-yr Storm (~3.2 in)
  - Water Quality Storm (0.83 in)

# Stormwater Management Manual (1999)



# Green History | Stormwater Management Manual

- design guidelines & drawings
- sizing tools (spreadsheets)

## Basin

Vegetated Facility for the Simplified and Presumptive Approaches



Exhibit 2-18: Glencoe School Infiltration Basin. See Appendix G.1 SW-140 for typical basin details.

## Facility Description

Vegetated infiltration basins are flat-bottomed, shallow landscaped depressions used to collect and hold stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground. They are either excavated or created with bermed side slopes. An inlet pipe or sheet flow over impervious area conveys the stormwater into the basin, where it is temporarily stored until it infiltrates into the ground. Basins often provide complete on-site infiltration for small storm events. They can be sized to infiltrate large storms in areas where soils drain well or overflow to an approved discharge point. Basins can have a formal or informal design that can be used to help fulfill a site's landscape requirements.

## Design Requirements

- Site suitability:** Existing infiltration rates will determine if the facility can be designed to achieve infiltration, partial infiltration, or allow the stormwater to flow through the facility. See Appendix F.2 for infiltration testing procedures. For the Simplified Approach (Section 2.2.1), if the tested infiltration rate is greater than or equal to 2 inches per hour, the basin must overflow to a subsurface infiltration facility. If the tested infiltration rate is less than 2 inches per hour, the basin should be designed as a partial infiltration or flow-through

Microsoft Excel - Presumptive Approach Calculator Ver 1.2.xls

Presumptive Approach Calculator ver. 1.2

Catchment ID: **A**

Project Name: **enter project name** Catchment ID: **A** Date: **2/1/2010**

Run Time: 9/13/2010 11:01:47 AM

Instructions:

1. Identify which Stormwater Hierarchy Category the facility.
2. Select Facility Type.
3. Identify facility shape of surface facility to more accurately estimate surface volume, except for Swales and sloped planters that use the PAC Sloped Facility Worksheet to enter data.
4. Select type of facility configuration.
5. Complete data entry for all highlighted cells.

Catchment facility will meet Hierarchy Category: **2**

Goal Summary:

Hierarchy Category	SWMM Requirement	RESULTS box below needs to display...
2	On-site infiltration through use of approved UIC facility (e.g. below grade rock storage, public infiltration pump system, private drywell or soakage trench.)	PASS

Facility Type = **Basin**

Facility Shape: **Rectangle/Square**

Facility Configuration: **A**

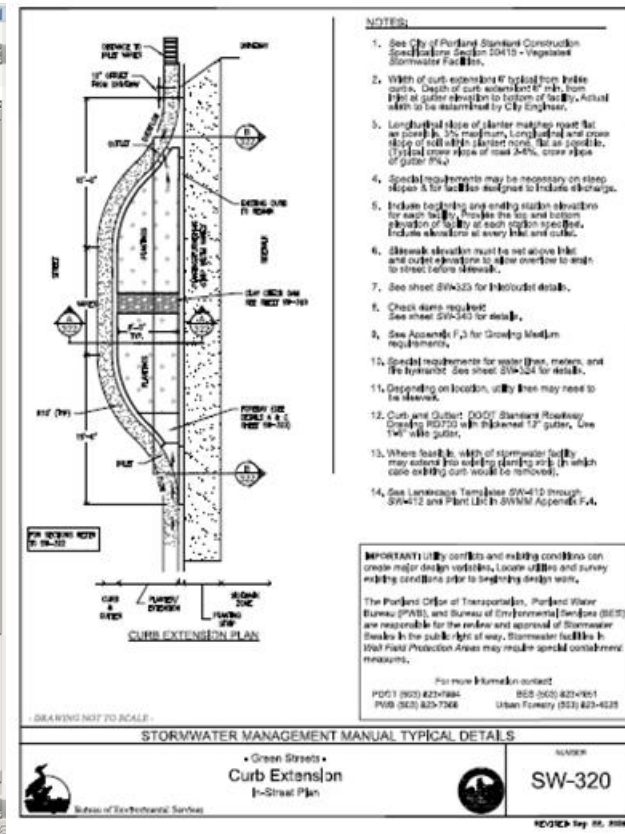
DATA FOR ABOVE GRADE STORAGE COMPONENT

Facility Bottom Area	250	sf
Bottom Width	3.0	ft
Facility Side Slope	3	to 1
Storage Depth 1	6	in
Growing Medium Depth	10	in
Freeboard Depth	N/A	in
Surface Capacity at Depth 1	197	cf
Infiltration Area of 75% Depth 1	462	SF

BELOW GRADE STORAGE

Rock Storage Bottom Area	462	sf
Rock Storage Depth	0	in
Rock Storage Capacity	0	cf

Chapter 2: Facility Design  
Portland Stormwater Management Manual – August 1, 2008



# Green History |

# Stormwater Management Manual

- private facility O&M filed with the county
- enforcement actions are difficult and rare

## O&M Plan Outline

- I. **Description**
  - Summary of overall Stormwater Management Plan.
  - Table identifying each stormwater facility, its size, the stormwater source to each facility, square footage treated, and discharge point.
  - Specific location of stormwater facilities.
  - Identification of who will assume responsibility for ongoing operations.
- II. **Schedule**
  - When and how often facilities will be inspected.
  - Specific intervals between particular O&M duties.
  - Definition of what size storms require additional inspections.
  - Irrigation Schedule
- III. **Procedures**
  - Specific procedures for each facility type.
  - Likely deficiencies and corrective actions.
  - Course of action for unexpected deficiencies.
- IV. **Inspection and Maintenance Logs**
  - Example and instructions for maintaining required logs.

**FORM 2 OPERATIONS & MAINTENANCE**  
Required in accordance with City Code Chapter 17.38

*for official county use only*

Date: \_\_\_\_\_  
Expected Construction Completion Date: \_\_\_\_\_  
Permit #: \_\_\_\_\_  
R # \_\_\_\_\_  
(6 digit property ID)

Permit Application No. \_\_\_\_\_  
Owner Name: \_\_\_\_\_  
Phone: (area code required) \_\_\_\_\_  
Mailing Address: (return address for records) \_\_\_\_\_  
City/State/Zip: \_\_\_\_\_  
Site Address: \_\_\_\_\_  
City/State/Zip: \_\_\_\_\_

Site Legal Description: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**1 Responsible Party for Maintenance (check one)**  
☐ Homeowner association    ☐ Property Owner    ☐ Other (describe) \_\_\_\_\_

**2 Contact Information for Responsible Party(ies) if Other than Owner**  
Daytime Phone: (area code required) \_\_\_\_\_    Emergency/After Hours Phone: \_\_\_\_\_  
Contact Name and Address: \_\_\_\_\_

**Instructions**  
Simplified Sizing Approach: Attach O&M Specifications from the Stormwater Management Manual (SWMM) Section 3.3.1.  
Presumptive and Performance Sizing Approach: Attach the site-specific O&M Plan (See SWMM Section 3.3.2).

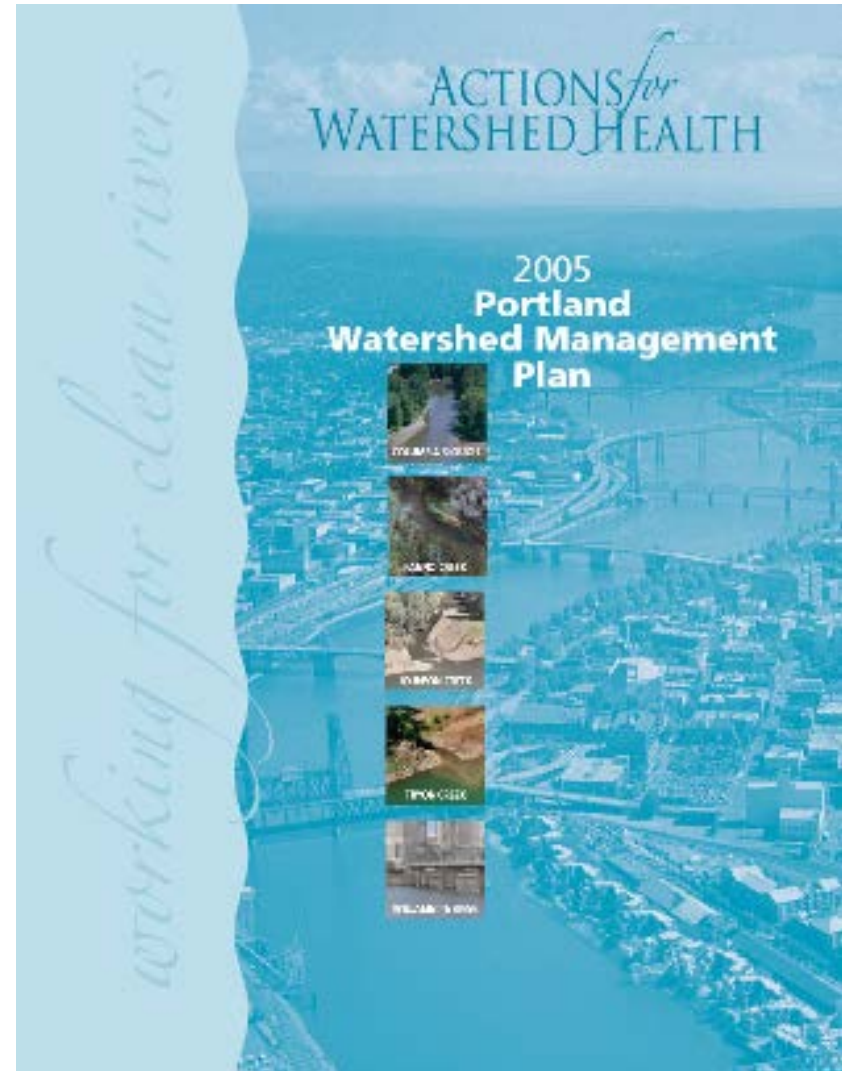
CITY OF PORTLAND - STORMWATER MANAGEMENT MANUAL - JULY 2008    SIDE 1 of 3

# Green History | Early Integration

- Water Quality Friendly Streets (2000)
  - working with developers on right-of-way solutions
- Sullivan / Stark / Holladay (2002)
  - combined sewer predesign incorporate some green infrastructure
- Sustainable Stormwater Management Division formed (2002)
  - multi-discipline: engineering, landscape architecture, environmental science, planning
  - technical assistance, design, outreach, monitoring
- EPA Innovative Wet Weather Grant (2002)
  - \$3.4M for innovative GI projects

# Green History | Watersheds

- Watershed Management Plan (2005)
  - Watershed Health Goals:
    - Hydrology
    - Water Quality
    - Physical Habitat
    - Biological Communities
  - currently developing the Watershed Health Index

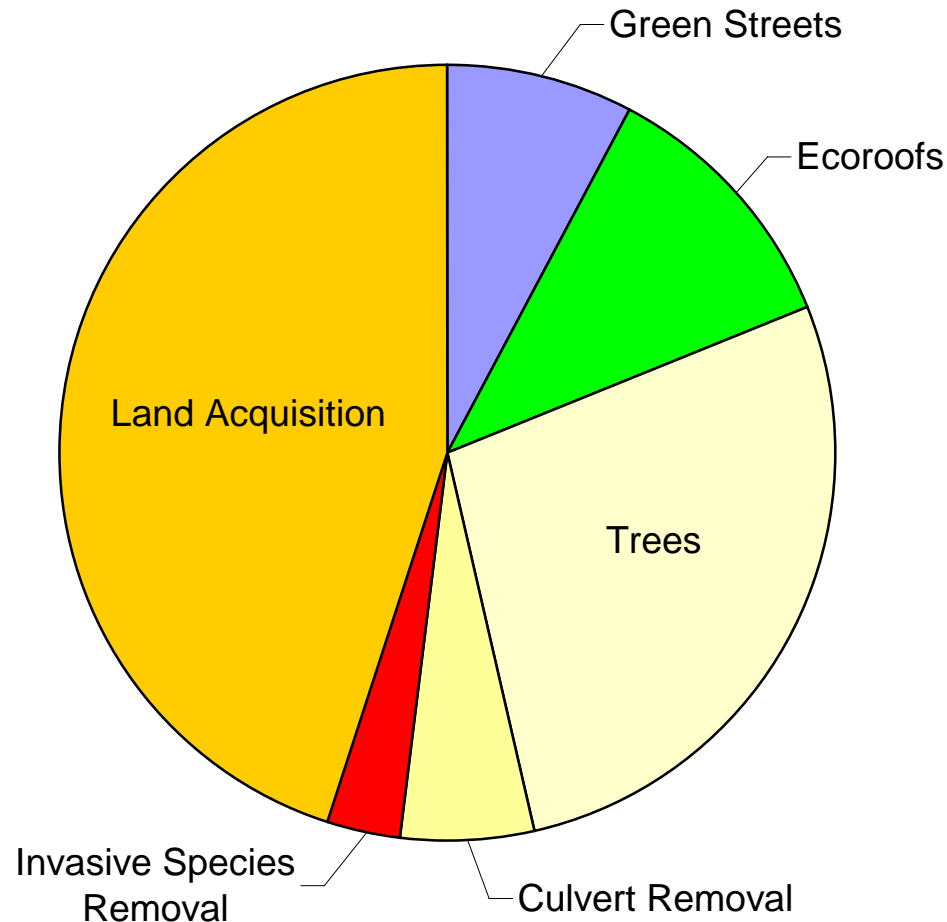


# Green History | Full Speed Ahead

- City Green Building Policy (2005)
  - City funded construction must meet energy & environmental design (LEED) requirements
  - ecoroof must be considered
- Tabor to the River (2006)
  - very large green+grey combined sewer basin project
- Green Street Policy (2007)
  - consider incorporating Green Streets into all City funded right-of-way projects
  - % for Green

# Green History | Grey to Green (2008-13)

- funded by a stormwater rate increase (0.1%)
- \$50 million for...
  - 200+ green streets
  - 80,000+ private / public trees
  - 43 acres of ecoroof
  - invasive species removal on 7,500 acres
  - land purchase 400 hectares
  - removal of 9 culverts



# Green History | PPRP

- Private Property Retrofit Program (2009)
  - partner with private property owners to implement stormwater retrofit projects that contribute to T2R flow-removal goals
  - budgeted for \$6 / SF; early projects ~ \$5 / m<sup>2</sup>



Nuestra Cocina



Dara Apts



Terrazzo

# Green History | Incentives

## – Clean River Rewards (2006-)

- up to a 35% stormwater fee reduction

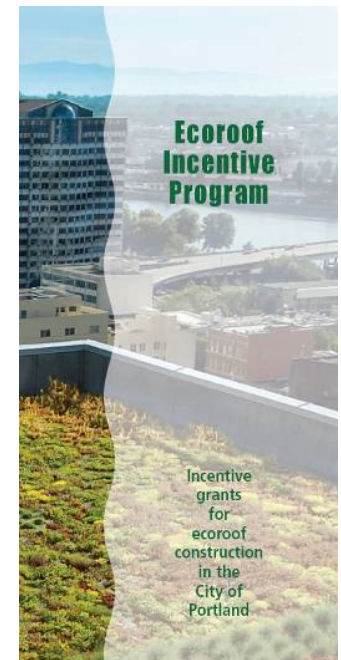


## – Ecoroof Incentive (2008-2013)

- up to \$5 / SF

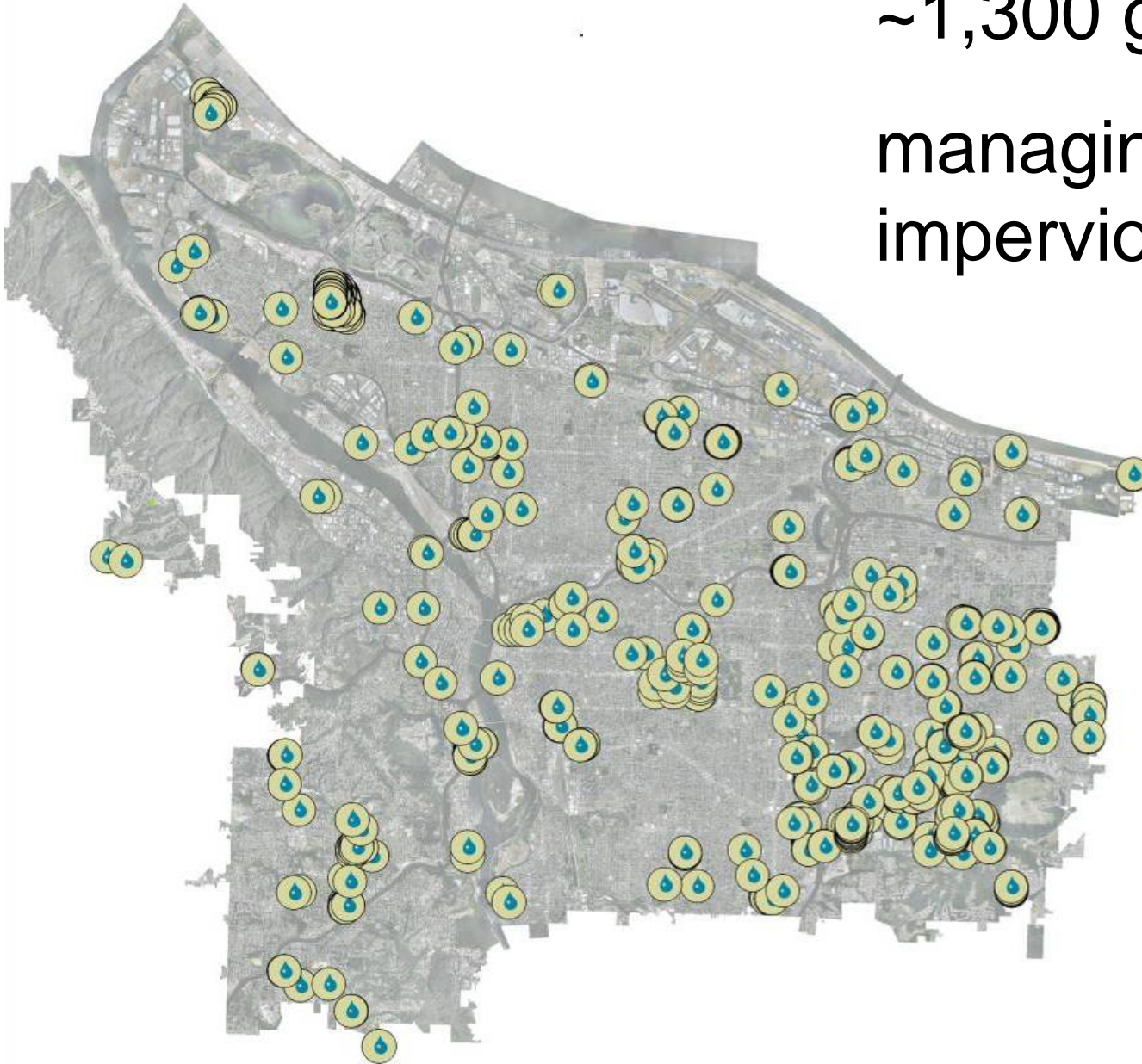
- Treebate Program (2008-)

- reimburse up to 50% of the cost of private property trees

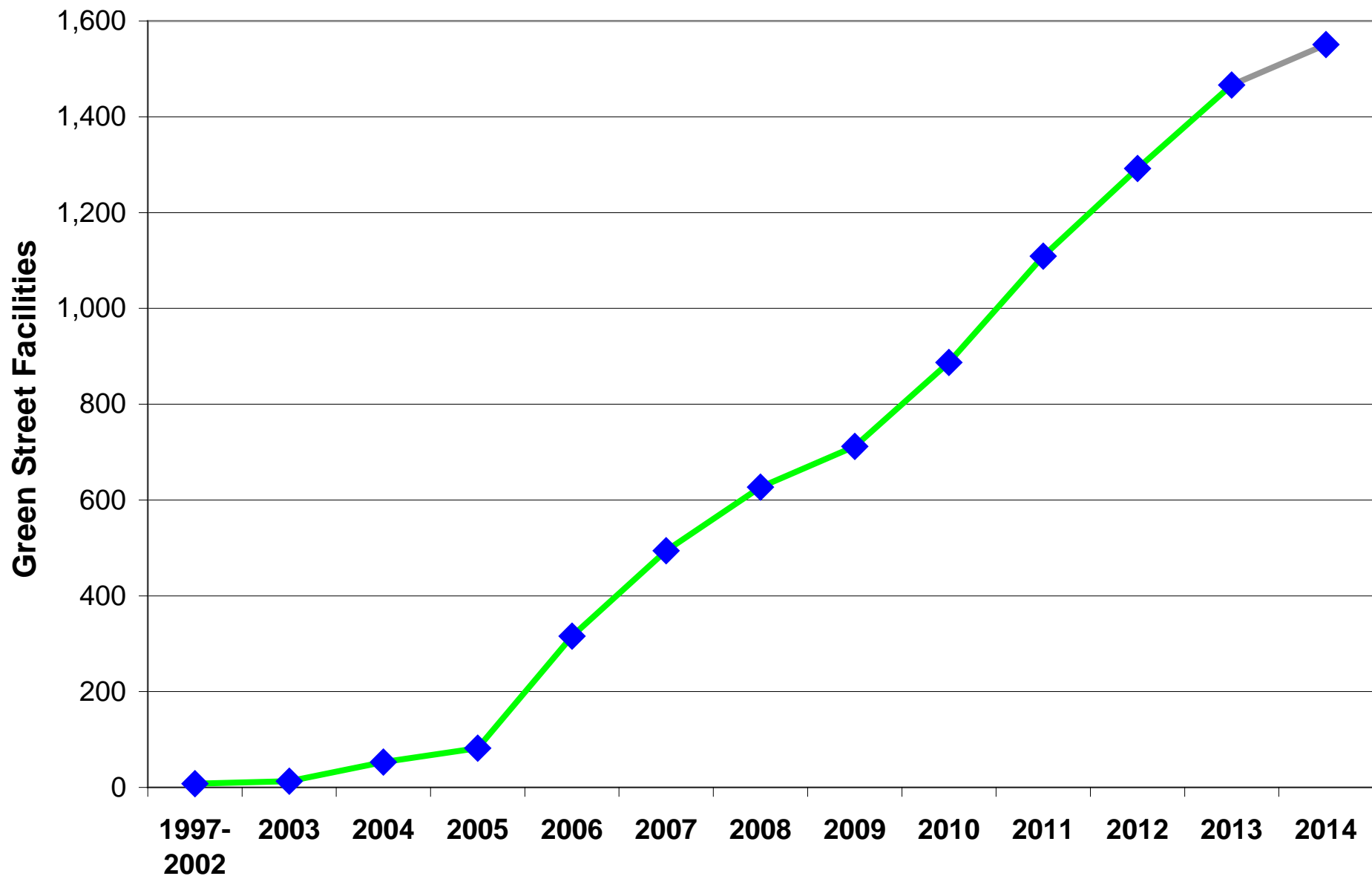


# Green Streets

~1,300 green streets  
managing 120 acres  
impervious area



# Facilities | Green Streets



# Green Streets | Swales



N Willamette & Denver (2005)

# Green Streets | Swales



N Willamette & Denver (2006)

# Green Streets | Swales



Swan Island (N Channel Ave)

# Green Streets | Planters



SW 12<sup>th</sup> & Montgomery (2004)

# Green Streets | Vegetated Planters



SW 12<sup>th</sup> & Montgomery (2005)

# Green Streets | Mechanical Planters



SE Water Ave

# Green Streets | Planters



NE Davis & 7<sup>th</sup>

# Green Streets | Basins



NE Sandy & Davis (2006)

# Green Streets | Basins



NE Sandy & Davis (2007)

# Green Streets | Curb Extensions



NE Siskiyou & 35th (2002)

# Green Streets | Curb Extensions



NE Siskiyou & 35th (2003)

# Green Streets | Curb Extensions



NE Fremont & 131st

# Green Streets | Curb Extensions



NE Everett & 16th

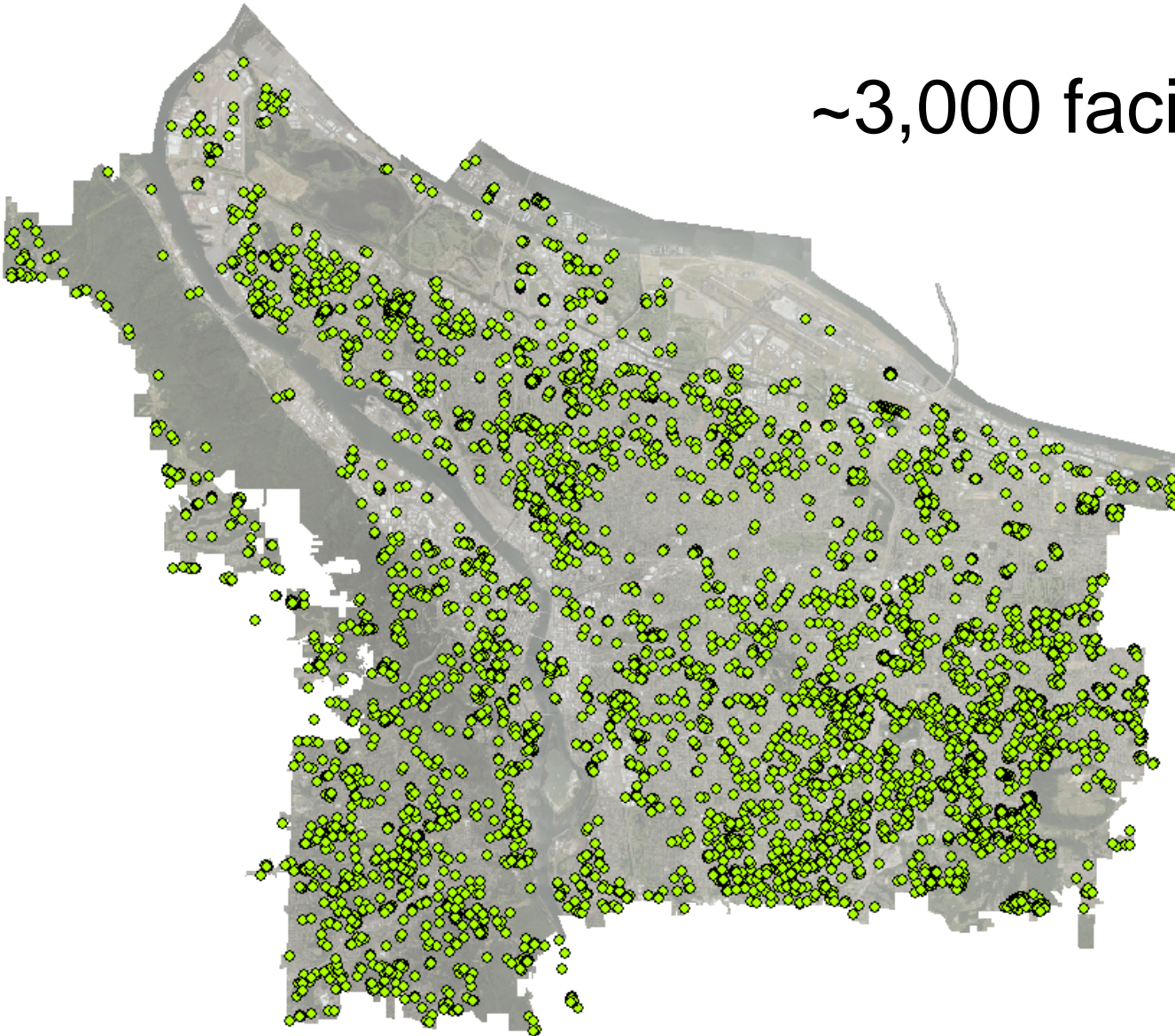
# Green Streets | Curb Extensions



Multnomah Village (SW Troy & 35<sup>th</sup>)

# Facilities | Private Property

~3,000 facilities total

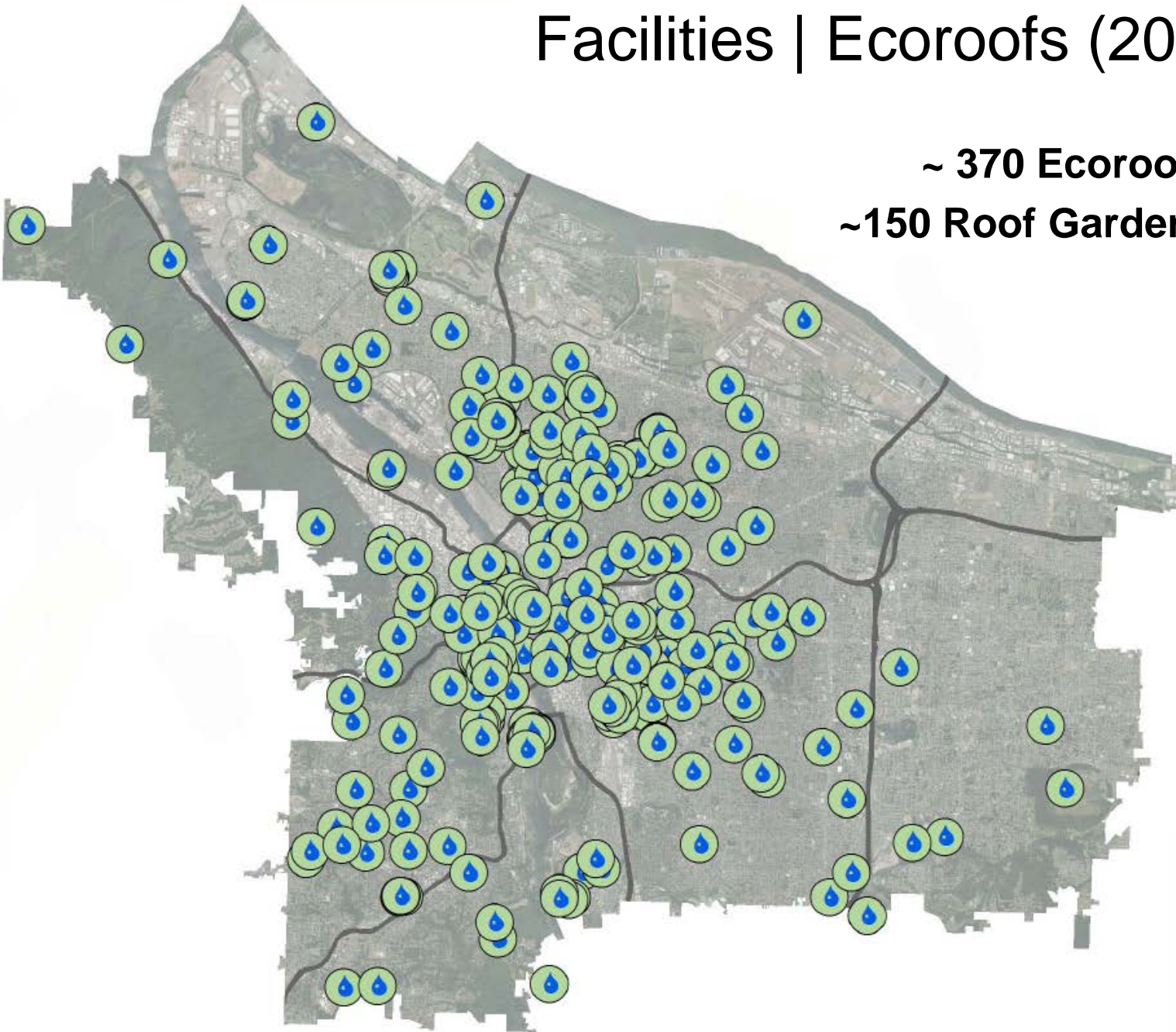


- ecoroofs
- swales
- planters
- basins
- ponds

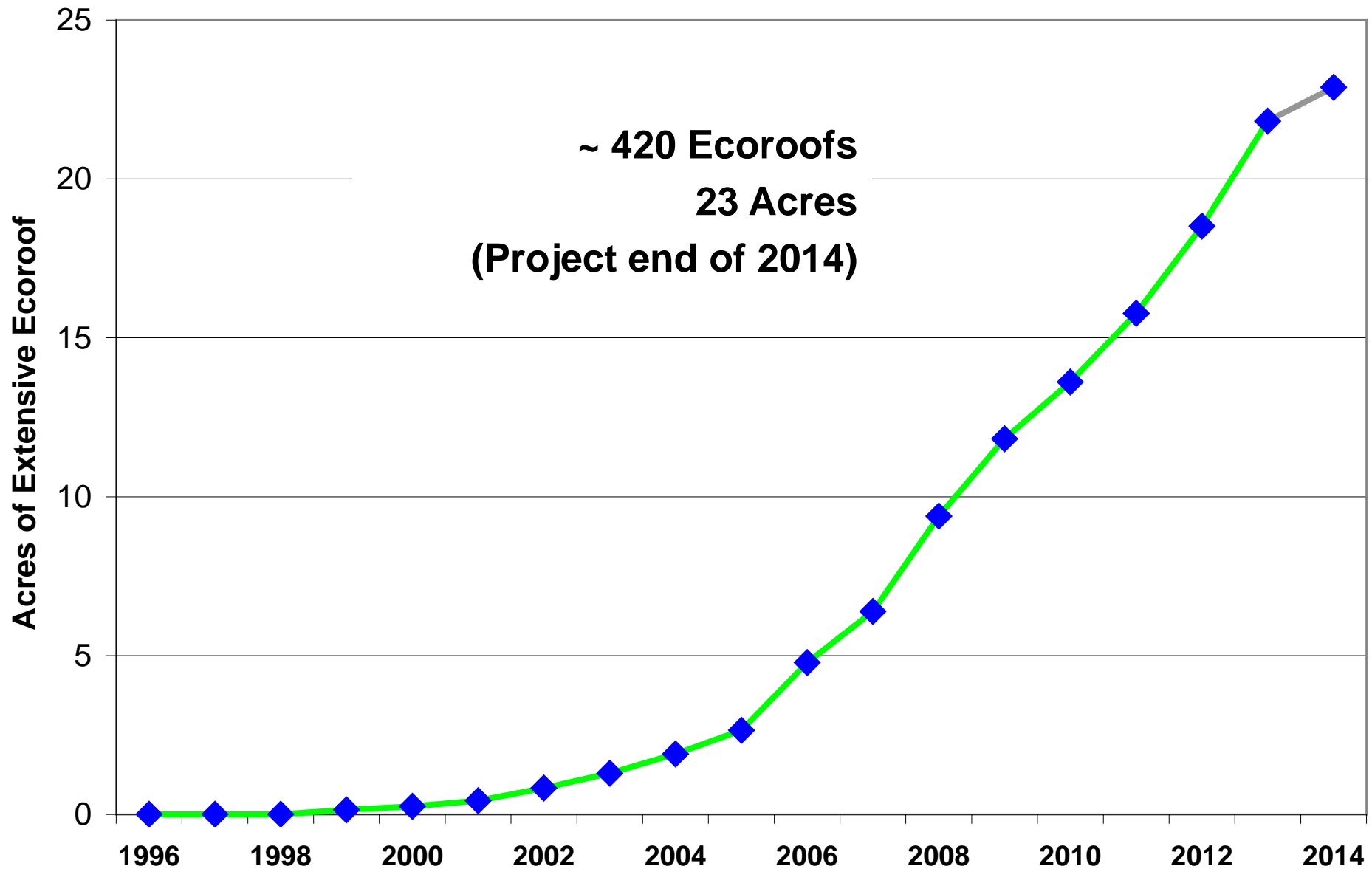
# Facilities | Ecoroofs (2013)

**~ 370 Ecoroofs, 20 Acres**

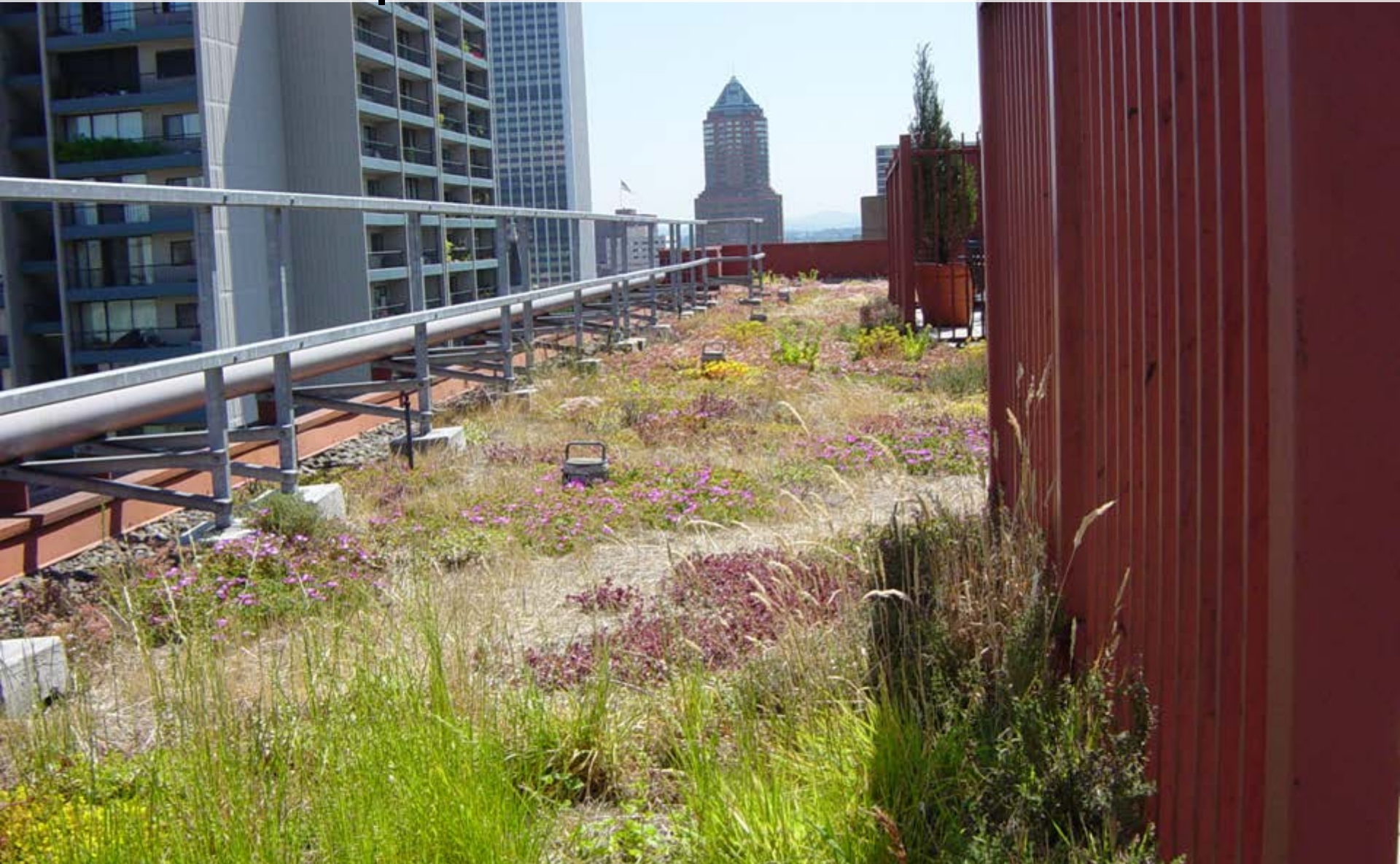
**~150 Roof Gardens, 17 Acres**



# Facilities | Ecoroofs



# Facilities | Ecoroofs



Hamilton Apartments (new, 1999)

# Facilities | Ecoroofs



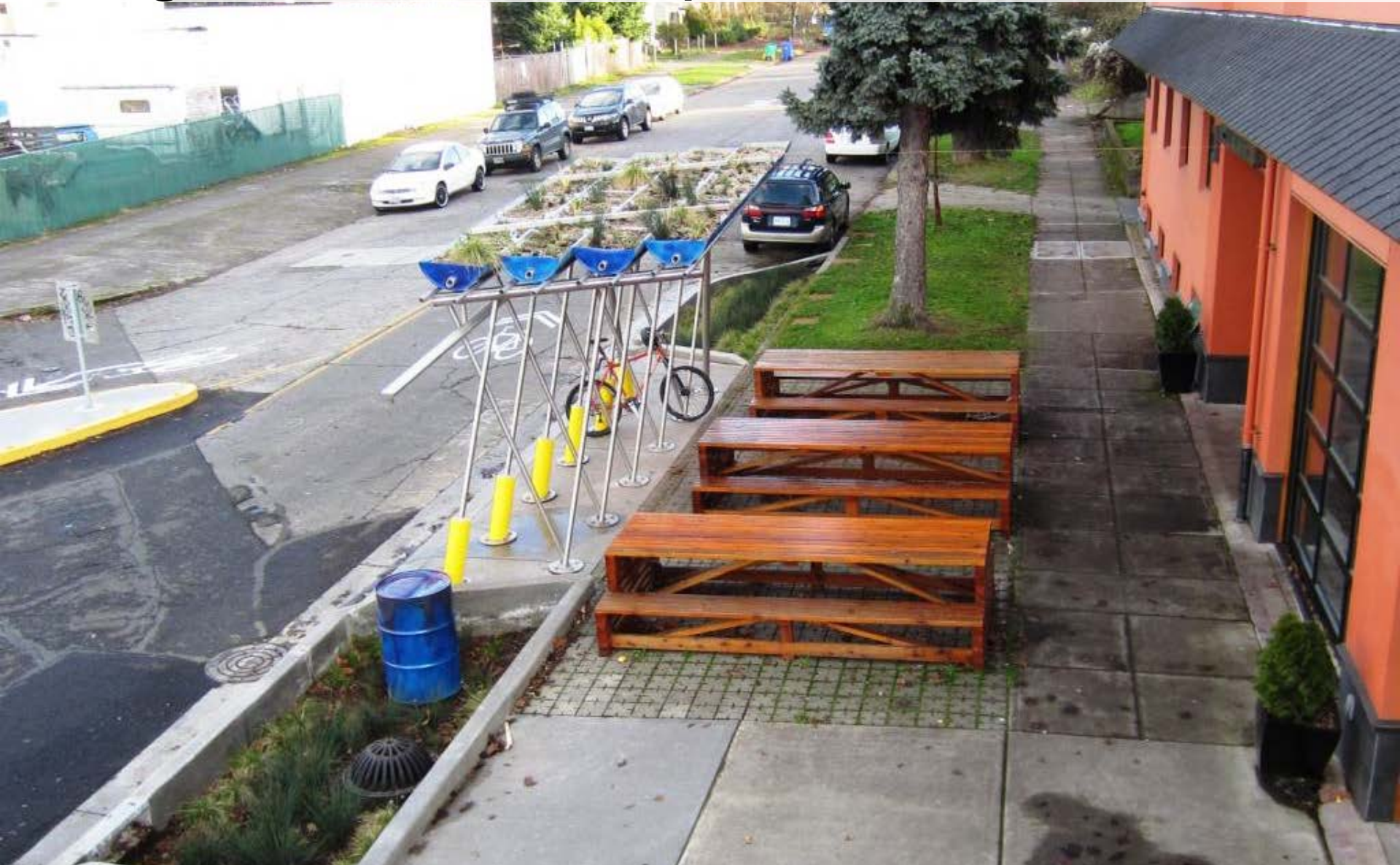
Multnomah County Building (retrofit, 2004)

# Facilities | Ecoroofs



Portland Building (retrofit, 2006)

# Integrated Landscapes



NE Dekum & Durham

# Green Streets | Integration



Holman Pocket Park

# Green Streets | Integration



PCC Climb Center

# Private Property | Swales



Oregon Zoo Parking Lot

# Private Property | Swales



BES Water Pollution Control Lab

# Private Property | Basins / Rain Gardens



Boys & Girls Club

# Private Property | Planters



Mt Tabor School Rain Garden

# Private Property | Planters



Epler Hall – Portland State University (2003)

# Private Property | Planters



Ed Bennedict Skate Park

# Private Property | Pervious Pavement



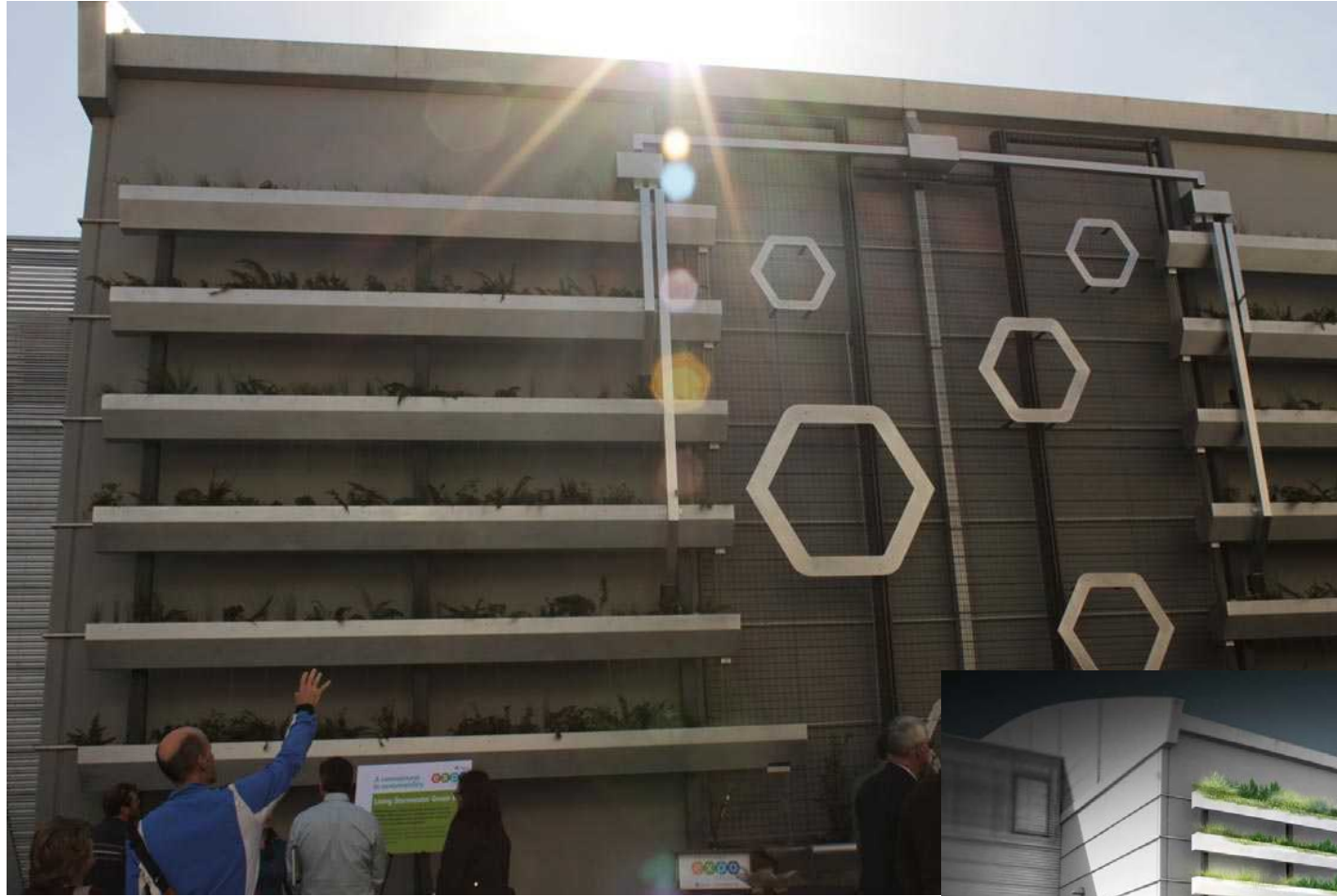
East Holladay Park Parking Lot



Private Property | Harvesting

Youth Hostel – SE Hawthorne

# Private Property | Green Stormwater Wall



Portland Expo Center

# Facilities | Private + Public



RiverEast



PCC Climb Center

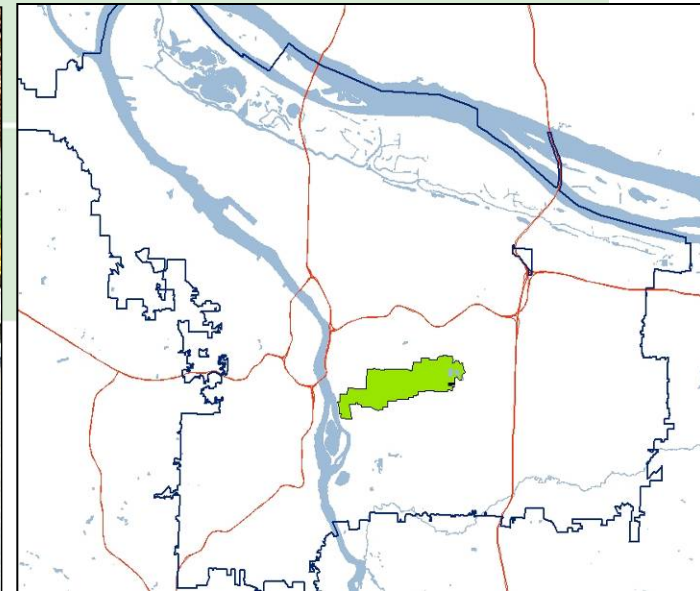
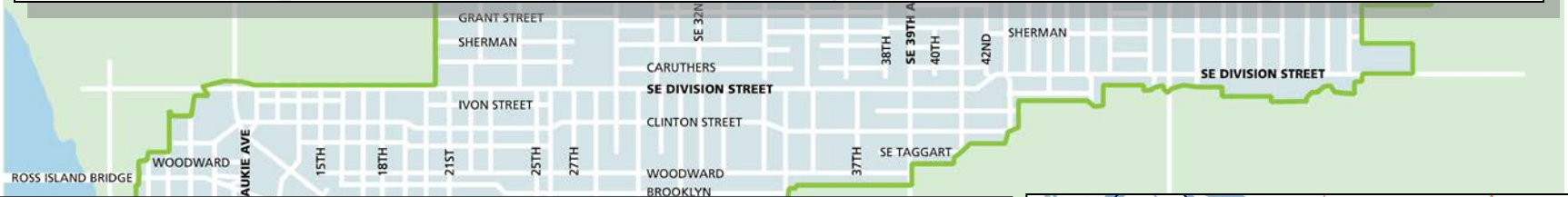


Café au Play

*working for clean rivers*

# TABOR *to the* RIVER

**Partnerships for sewer, stormwater, and watershed improvements**

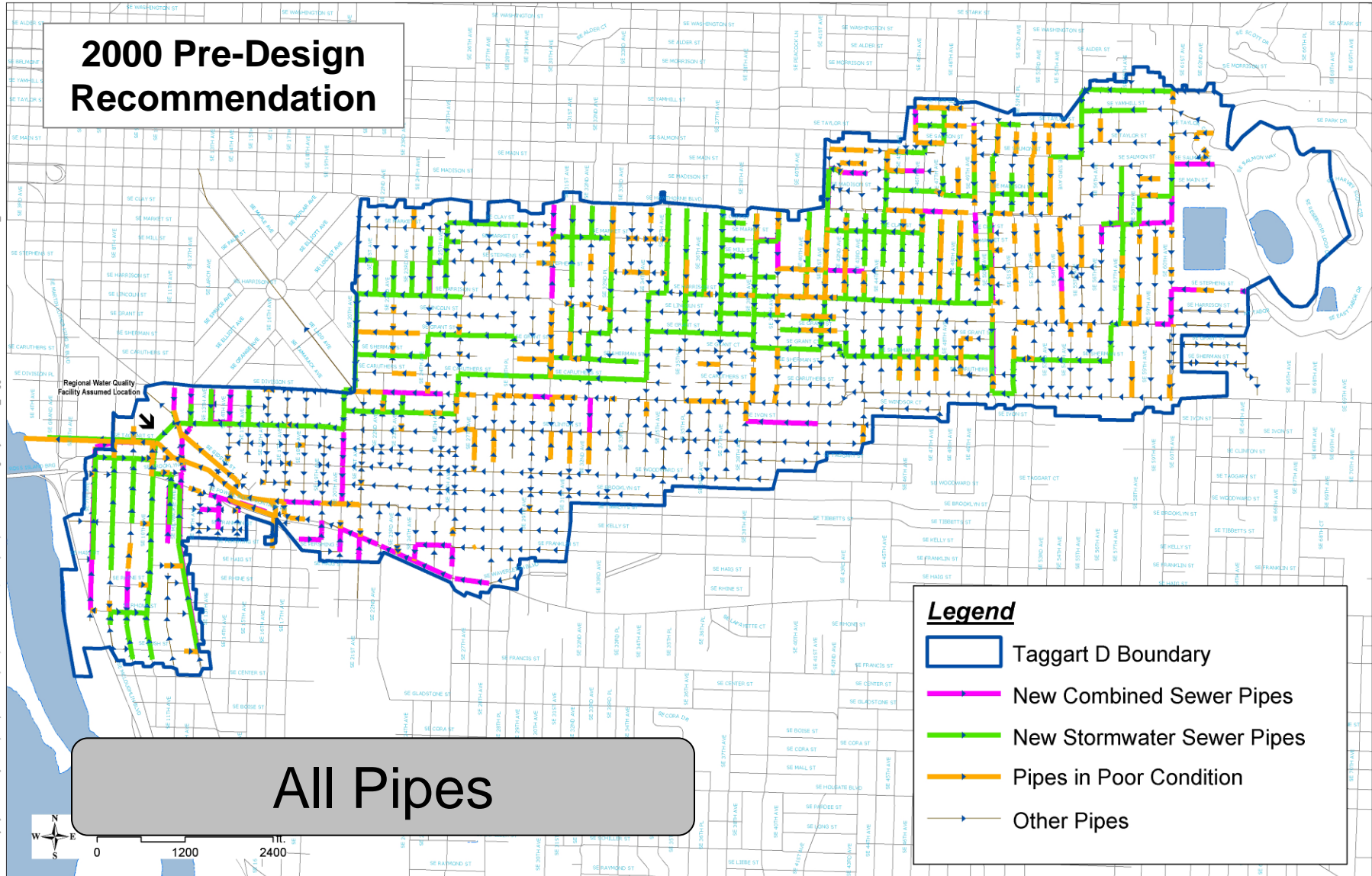


# Tabor to the River (T2R)



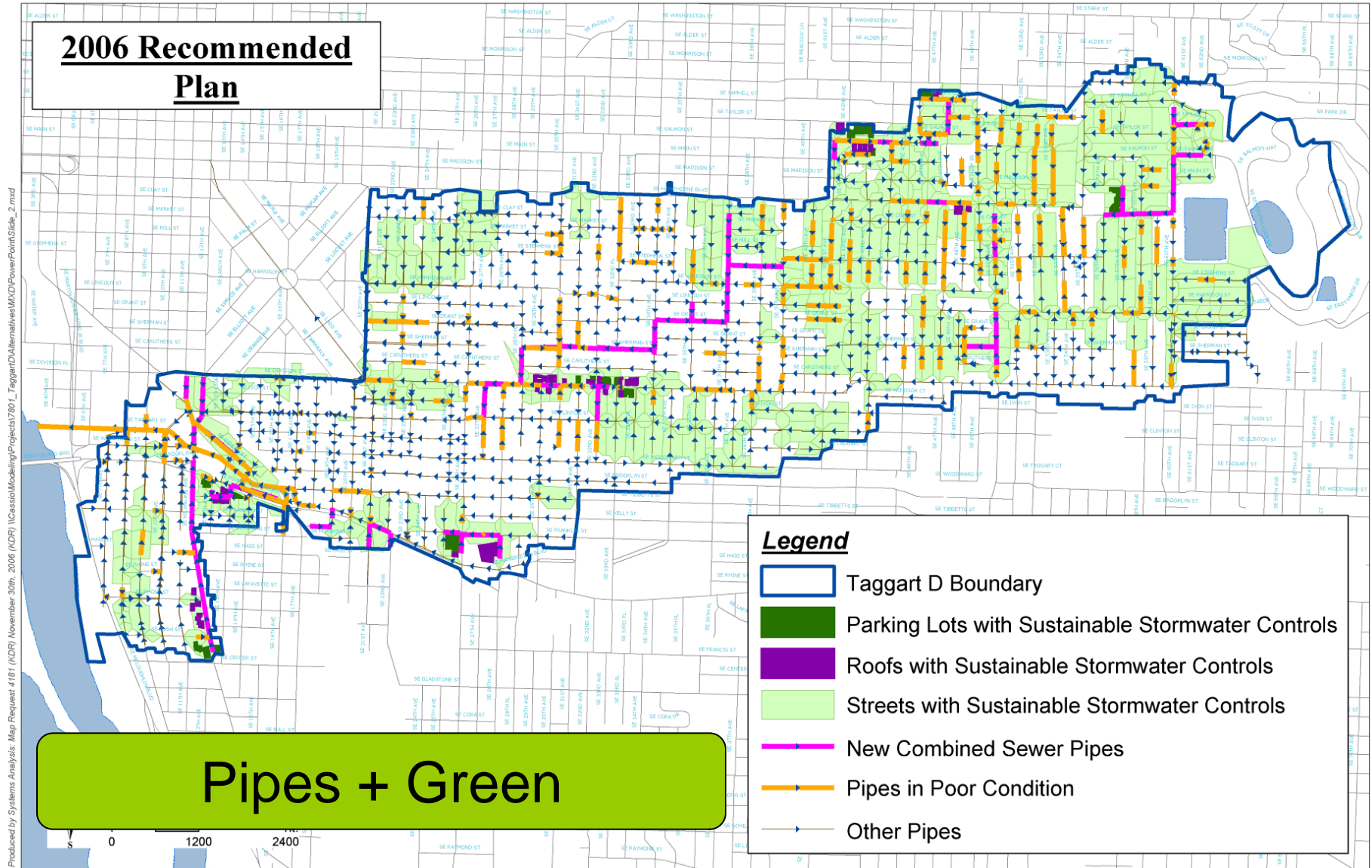
# T2R | 2000 Pre-Design

## 2000 Pre-Design Recommendation

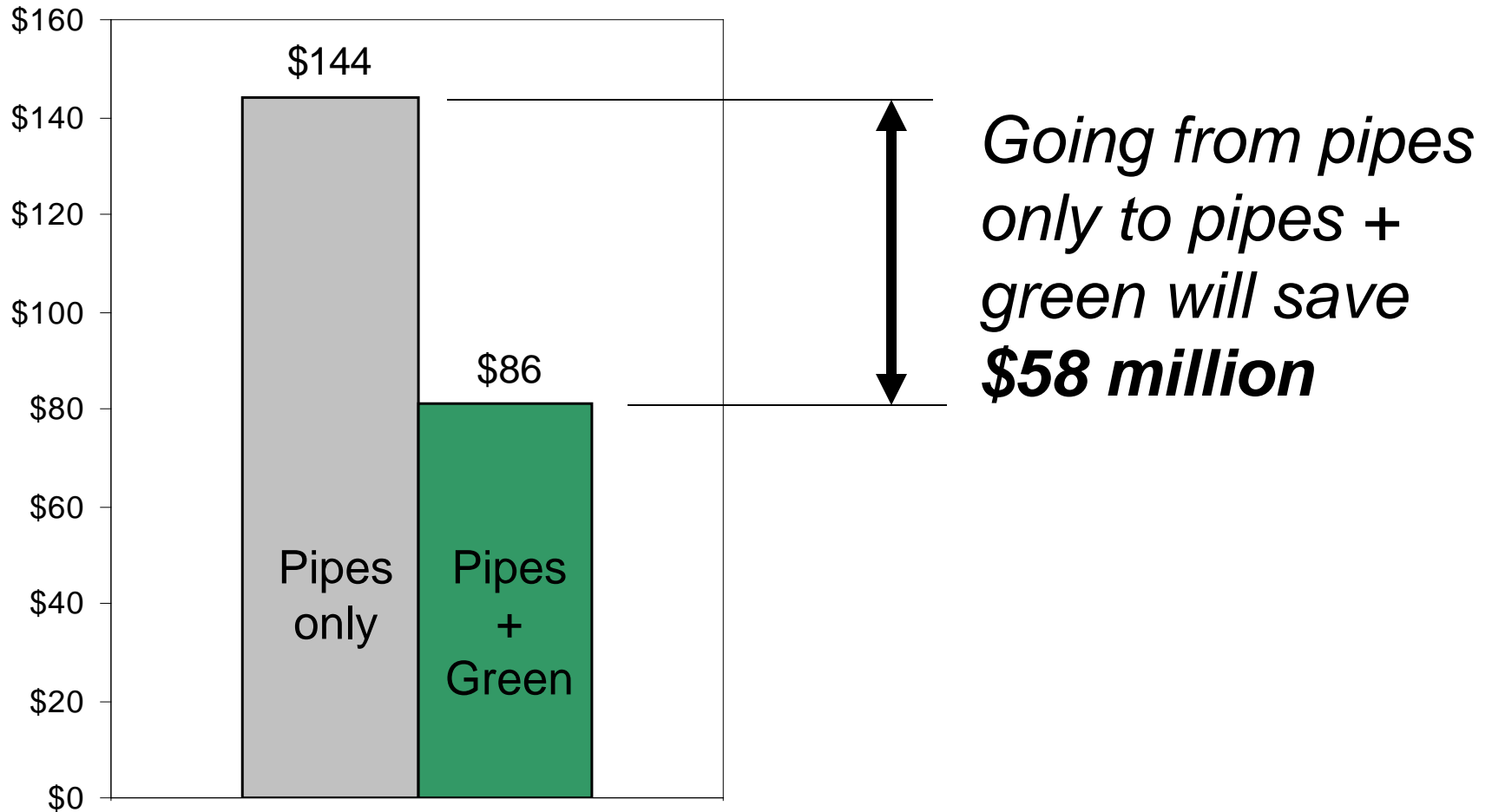


# T2R | 2006 Pre-Design

## 2006 Recommended Plan



# T2R | Estimated Cost Comparison

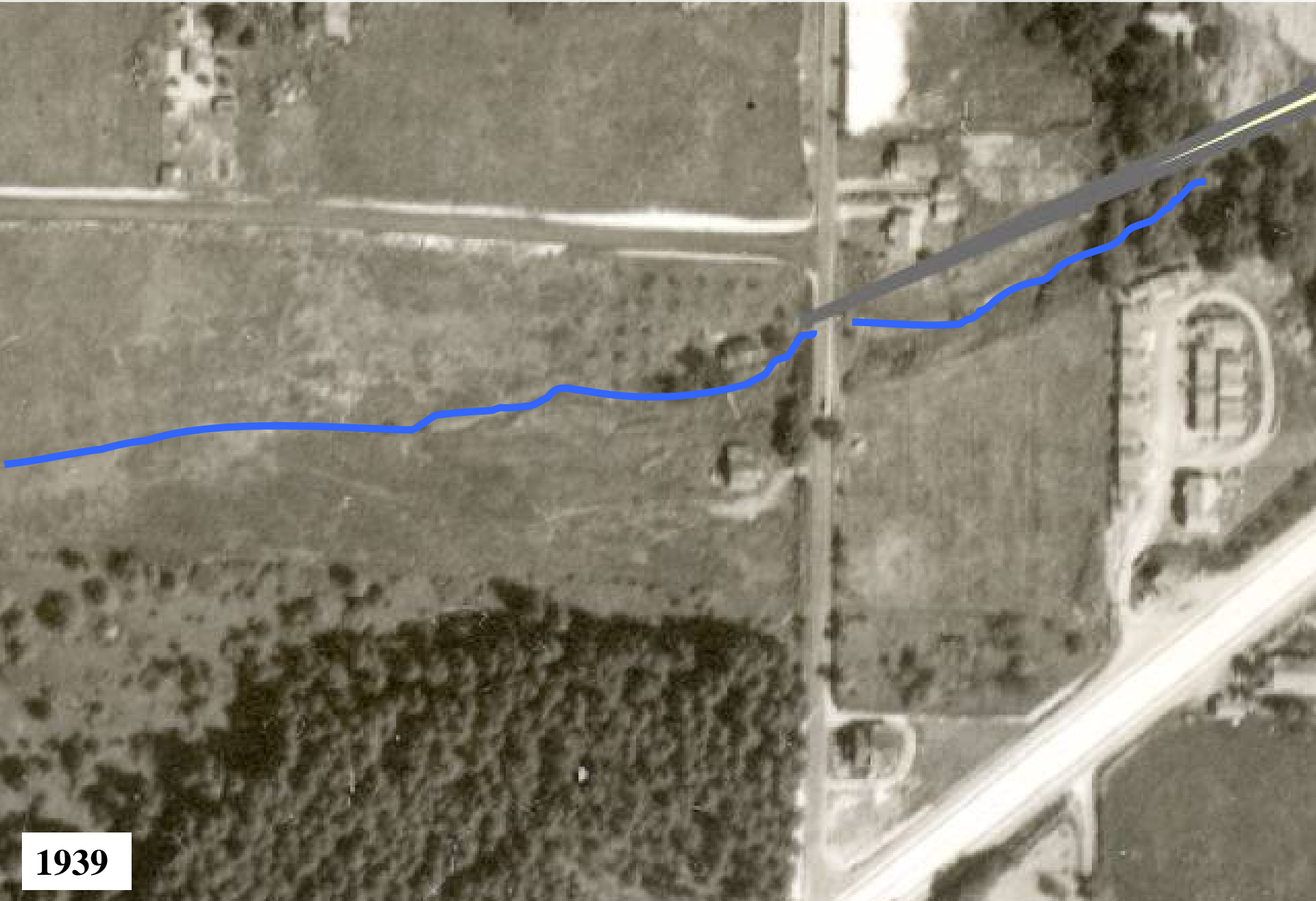


# T2R | Overview

- 500 green street facilities
- 81,000 feet of poor condition pipe replaced
- 3,500 street trees
- Private Property Retrofit Program (~5.4 acres)
- Invasives removal & native planting
- Community partnerships, public outreach / education / involvement

# Tryon Creek Headwaters Project

# Tryon Creek Headwaters Project



1939

# Tryon Creek Headwaters Project



NOV 7 2002

# Tryon Creek Headwaters Project

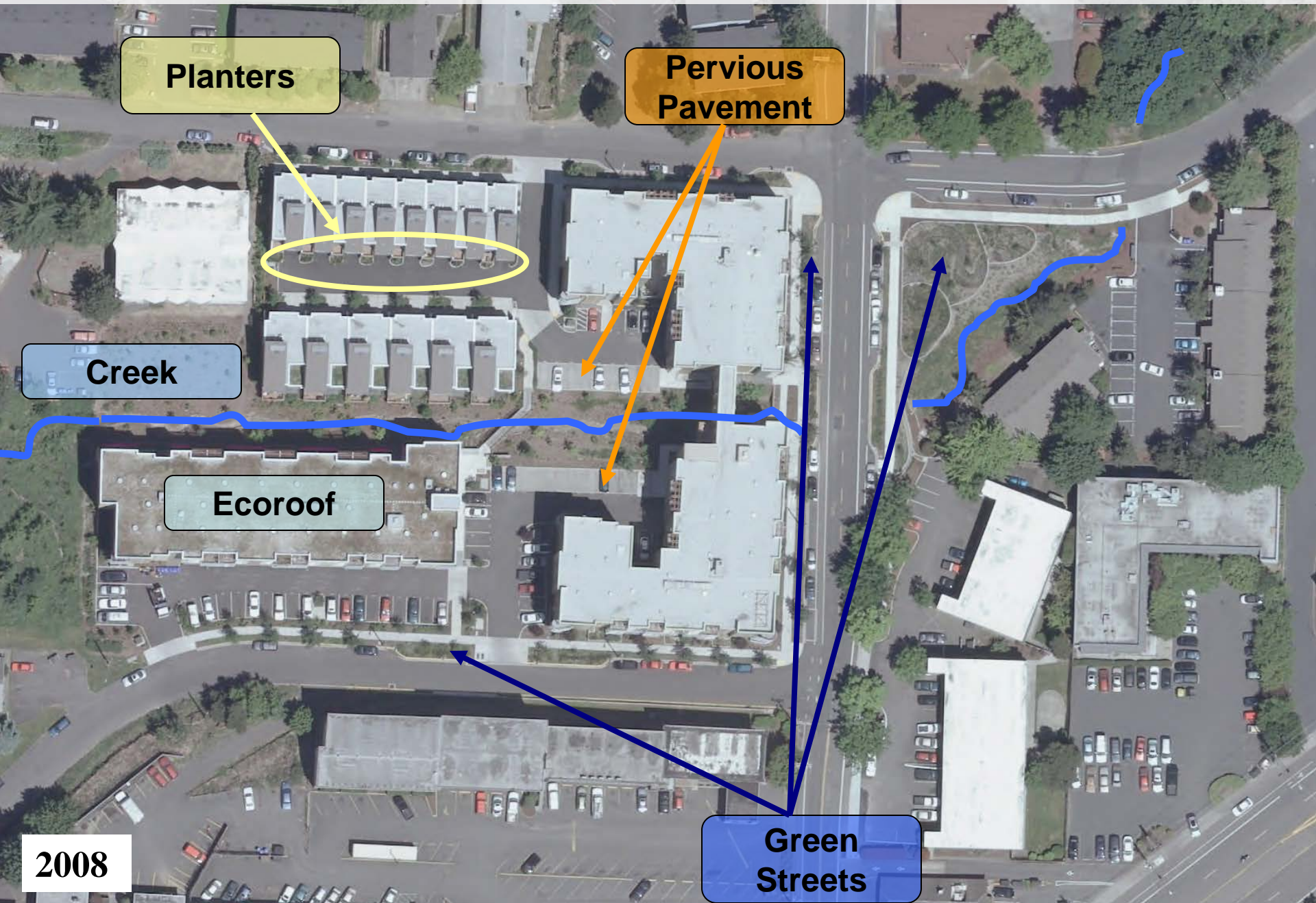


2004

# Tryon Creek Headwaters Project



# Tryon Creek Headwaters Project



**Planters**

**Pervious  
Pavement**

**Creek**

**Ecoroof**

**Green  
Streets**

**2008**

# Tryon Creek Headwaters Project



Daylit creek through the complex

# Tryon Creek Headwaters Project



Solar hot Water and photovoltaics on Village Ecoroof

# Tryon Creek Headwaters Project



Raingarden

# Tryon Creek Headwaters Project



Raingarden

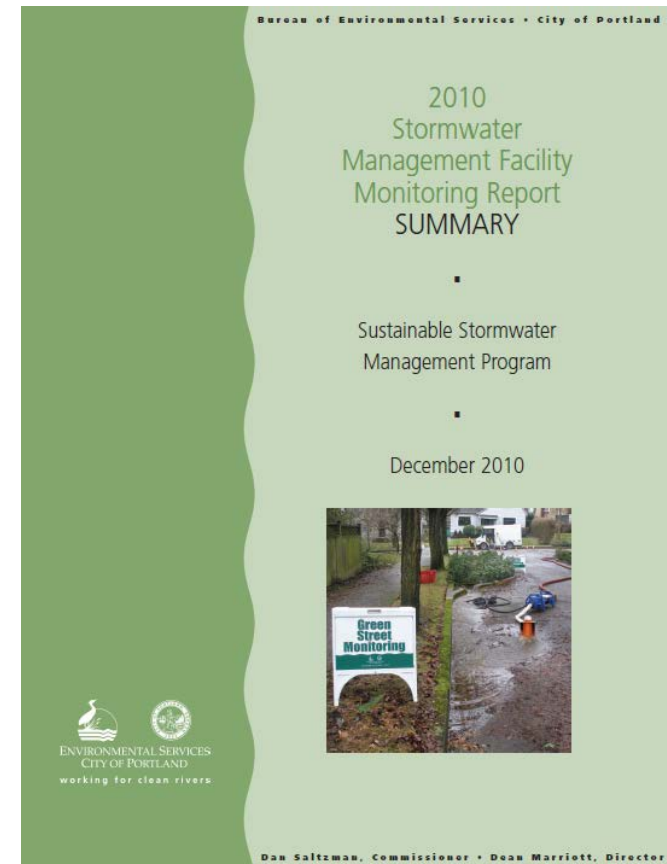
# Monitoring



# Monitoring | Results

## Summary Report

- Peak Flow Reduction
- Flow Volume Reduction
- Groundwater
- Facility Soils



# Maintenance



# Maintenance | Responsibility

- Public Facilities
  - Bureau of Environmental Services is responsible
  - public facilities built by private developers have a 2-year warranty period
- Private Property
  - property owners are responsible
  - recorded on the deed
  - infrequent City inspection

# Maintenance | Green Streets

- Primary Tasks
  - weeding
  - trash removal
  - sediment removal
  - watering (first two years)
  - plant replacement



# Maintenance | Green Street Costs

- Startup / Warranty Period (first two years)
  - ~ \$3 / SF / year
    - ~ \$750 / year for a typical green street (~ 250 SF)
  - most crucial task: summer watering

# Maintenance | Green Street Costs

- Long-term (after two years)
  - ~ \$1.75 / SF / year
    - ~ \$400 / year for a typical green street
  - 4 visits per year (some monitoring, some to perform work)
  - \$550,000 forecast for 2015
  - funding is an ongoing issue

# Maintenance | The Future

- Green Street Stewards
  - six month pilot program (2010)
  - began citywide in 2011
    - 111 Stewards have adopted 232 facilities
  - provides training for basic maintenance
  - not allowed:
    - plant replacement
    - pruning
    - sediment removal



# Partnerships | Portland State Univ.

- Intergovernmental Agreement approved by City Council for \$500,000 over 3 years:
  - broad application across multiple disciplines
  - student-led projects
  - Stormwater Management Manual support
    - Independent review of proprietary stormwater treatment devices



Portland State  
UNIVERSITY

# Partnerships | Regional Exchange

- Metro Regional Stormwater Group
  - monthly meetings with: Clean Water Services, City of Gresham, Clackamas WES, Port of Portland, City of Lake Oswego
- State of Washington
  - Seattle Public Utilities
  - Washington State University Extension

# Partnerships



Metro | Making a great place

SEARCH THE SITE

HOME

CALENDAR

+ PLACES AND ACTIVITIES

+ GARBAGE AND RECYCLING

+ TOOLS FOR LIVING

+ PLANNING AND CONSERVATION

GET INVOLVED

REGIONAL PLANNING AND POLICY

URBAN DEVELOPMENT AND REVITALIZATION

TRANSPORTATION AND LAND USE PROJECTS

NATURAL AREAS, PARKS AND TRAILS

MANAGING GARBAGE AND RECYCLING

POLICY AND PLANNING NEWS

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Contact Metro

**Nature in Neighborhoods**

PLANNING AND CONSERVATION > REGIONAL PLANNING AND POLICY > NATURE IN NEIGHBORHOODS

Nature in Neighborhoods is a broad based regional initiative to restore and protect the region's natural assets.

The Portland metropolitan region is set in an exceptional natural landscape. It is surrounded by hills and mountains and laced with rivers and streams. It is a region of national distinction for clean water, clean air, outdoor recreation, and an abundance of green, a place where nature is always nearby. This tremendous natural inheritance sustains residents' health, fosters the region's economy, provides healthy activities for all and is central to the region's identity.

**Working together to protect water quality and natural areas**

The Metro Council launched Nature in Neighborhoods in 2005, concluding years of contentious deliberations about a state-mandated regulatory framework called "Goal 5" and ushering in an era of public/private innovation, investment and collaboration.

Metro plays a lead role in Nature in Neighborhoods but recognizes that the protection and restoration of fish and wildlife habitat and the integration of natural areas into the urban environment eclipse the reach of any one organization; they require the coordinated and strategic action of many.

REGION'S SIX DESIRED OUTCOMES

2040 GROWTH CONCEPT

+ URBAN GROWTH MANAGEMENT

+ MPO FOR THE PORTLAND REGION

+ CLIMATE CHANGE

+ NATURE IN NEIGHBORHOODS

+ PROTECTING HABITAT AND WATER

BY THE NUMBERS

64%

Amount of Portland metropolitan area residents who live within 1/4 mile of a public park, trail or natural area. 97% of Boston's children live within 1/4 mile of a park. > Learn about The Intertwine

Source: Trust for Public Land, 2004

NATURE IN NEIGHBORHOODS

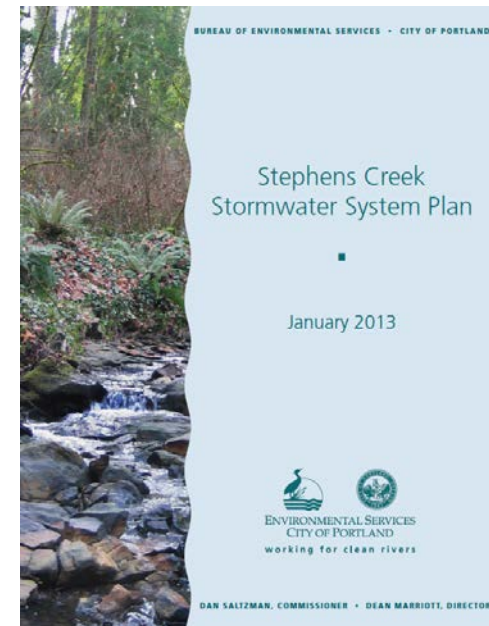
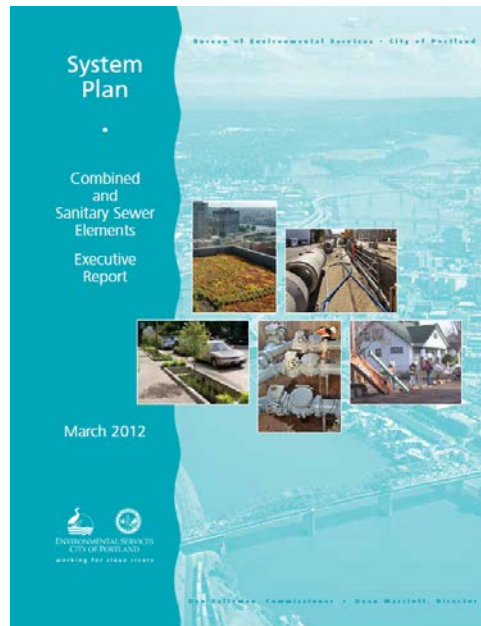
Capital grant project

This project will transform a historic property in North Portland's Humboldt neighborhood into the



# Into the Future

- Green infrastructure integrated into City wide planning:
  - **System Plan**
    - long-term facilities plan for stormwater & combined



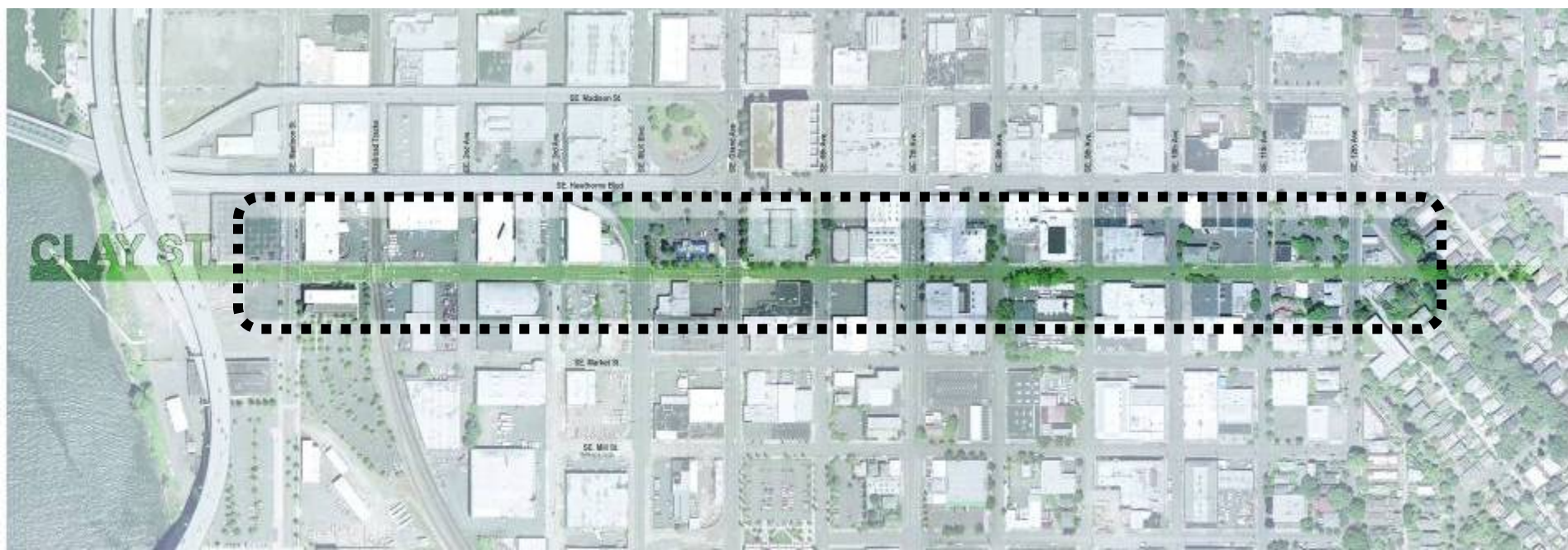
# Into the Future

- Green infrastructure integrated into City wide planning:
  - **City Greenways, Green Connectors (The Portland Plan)**
    - multi-modal streets that connect schools, parks, and natural features



# Into the Future | Clay Street

- Green Connector
- integrate needs of:
  - » pedestrians, cyclists, freight, business owners, stormwater management



# Into the Future | Clay Street

## Legend

### PEDESTRIAN IMPROVEMENTS

- 1 Curb Extensions w/ ADA Curb Ramps
- 2 Concrete Crosswalks
- 3 Audible Crosswalk Signals
- 4 Street Trees
- 5 Street Furniture

### BICYCLE IMPROVEMENTS

- 6 Sharrows (subject to approval)
- 7 Bike Racks

### FREIGHT ACCOMMODATION

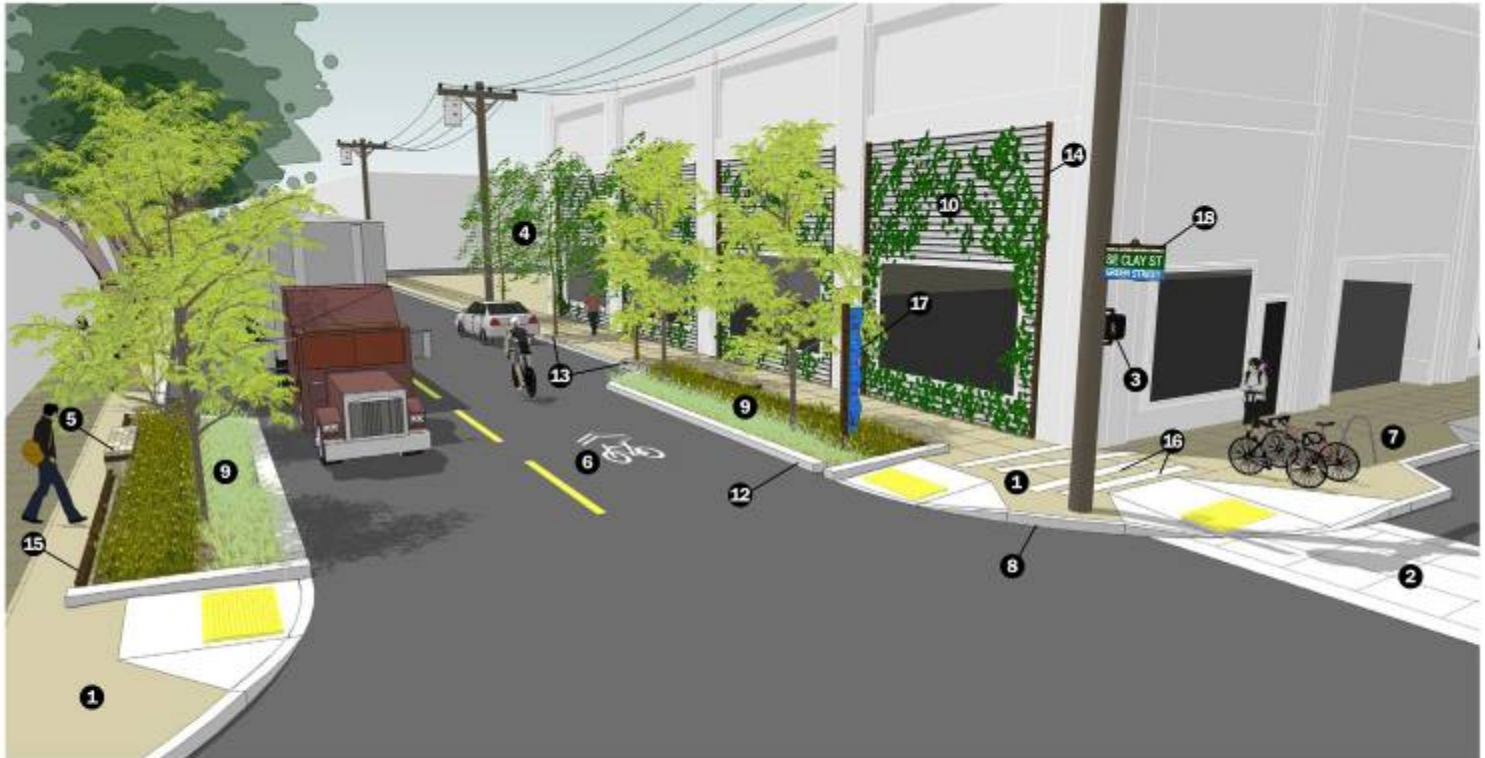
- 8 20' Turning Radius Curb Extension

### STORMWATER ELEMENTS

- 9 Stormwater Curb Extensions
- 10 Green Walls
- 11 Private Property Retrofits (not shown)

### DISTRICT CHARACTER

- 12 Robust Curbs (1' width)
- 13 Steel Pipe Tree Wells
- 14 Railroad Rail Green Wall
- 15 Railroad Rail at top of Stormwater Curb Extension
- 16 "Movement" Inscriptions/Engravings
- 17 ROUTE TO RIVER Signage
- 18 District Signage

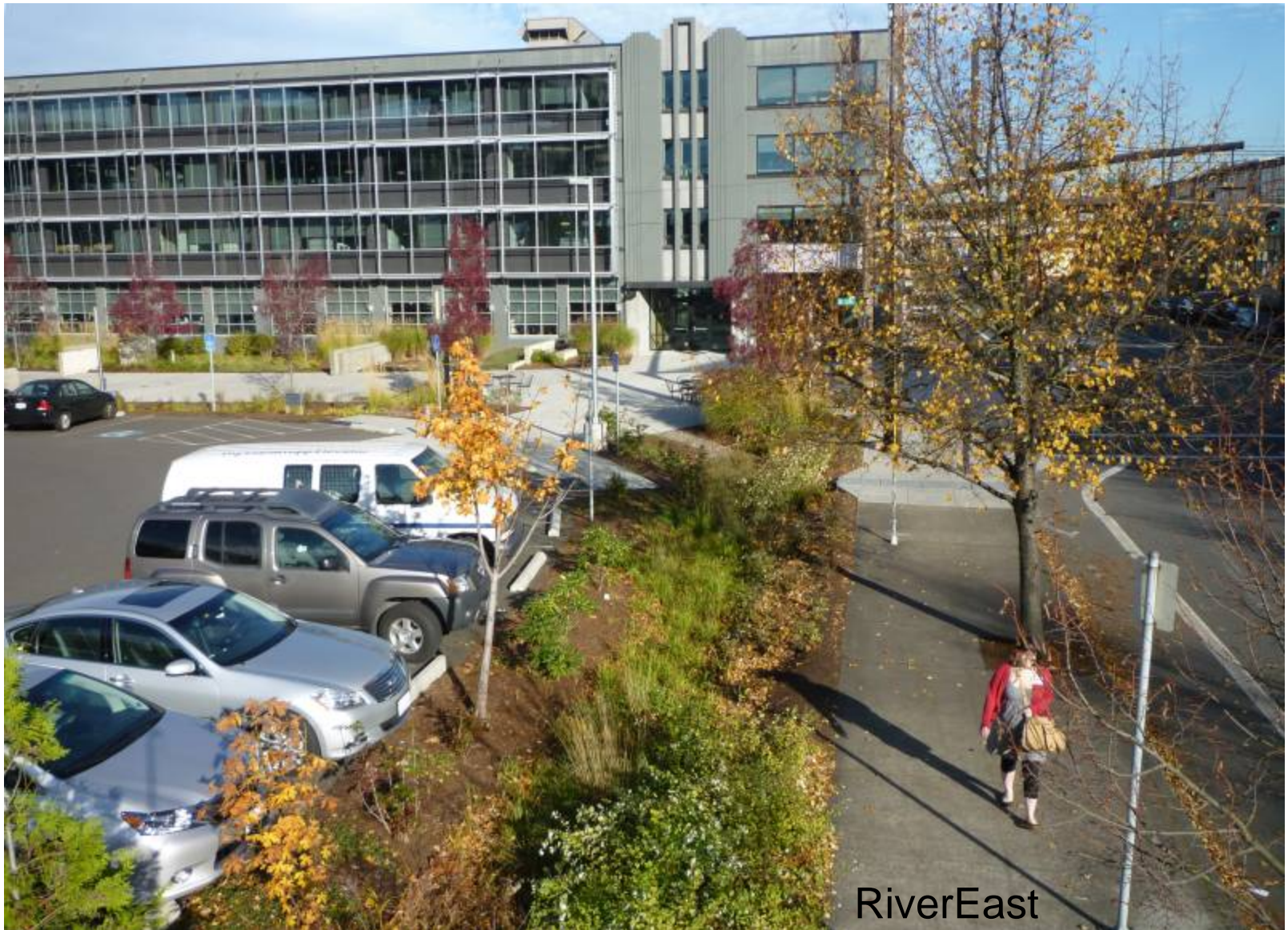


# Into the Future | Clay Street



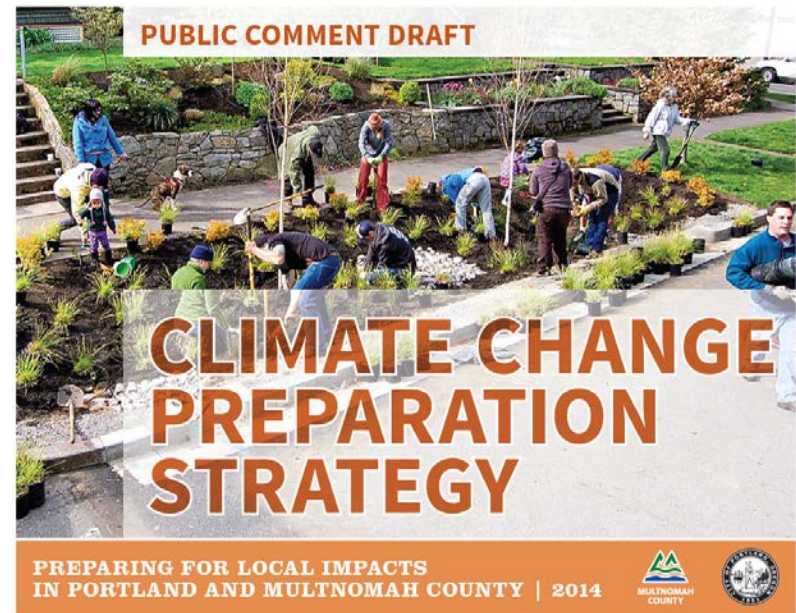
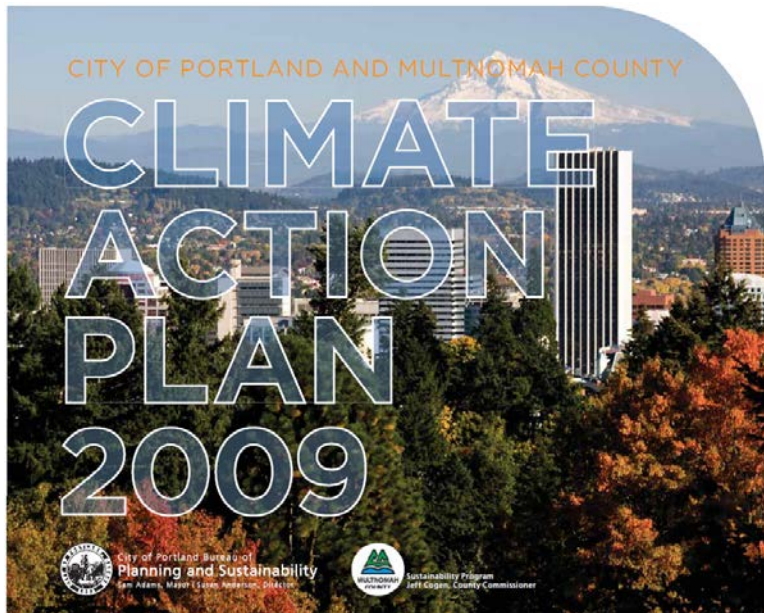
SE 12<sup>th</sup> & Clay

# Into the Future | Clay Street



# Into the Future

- Green infrastructure integrated into City wide planning:
  - **Climate Action Plan**



# Into the Future

- Green infrastructure integrated into City wide planning discussions:
  - **Eco Districts**
    - neighborhood scale, smart growth and urban design
  - **Portland Green Factor**
    - Performance based landscape code for integrated landscapes



?? Questions ??

