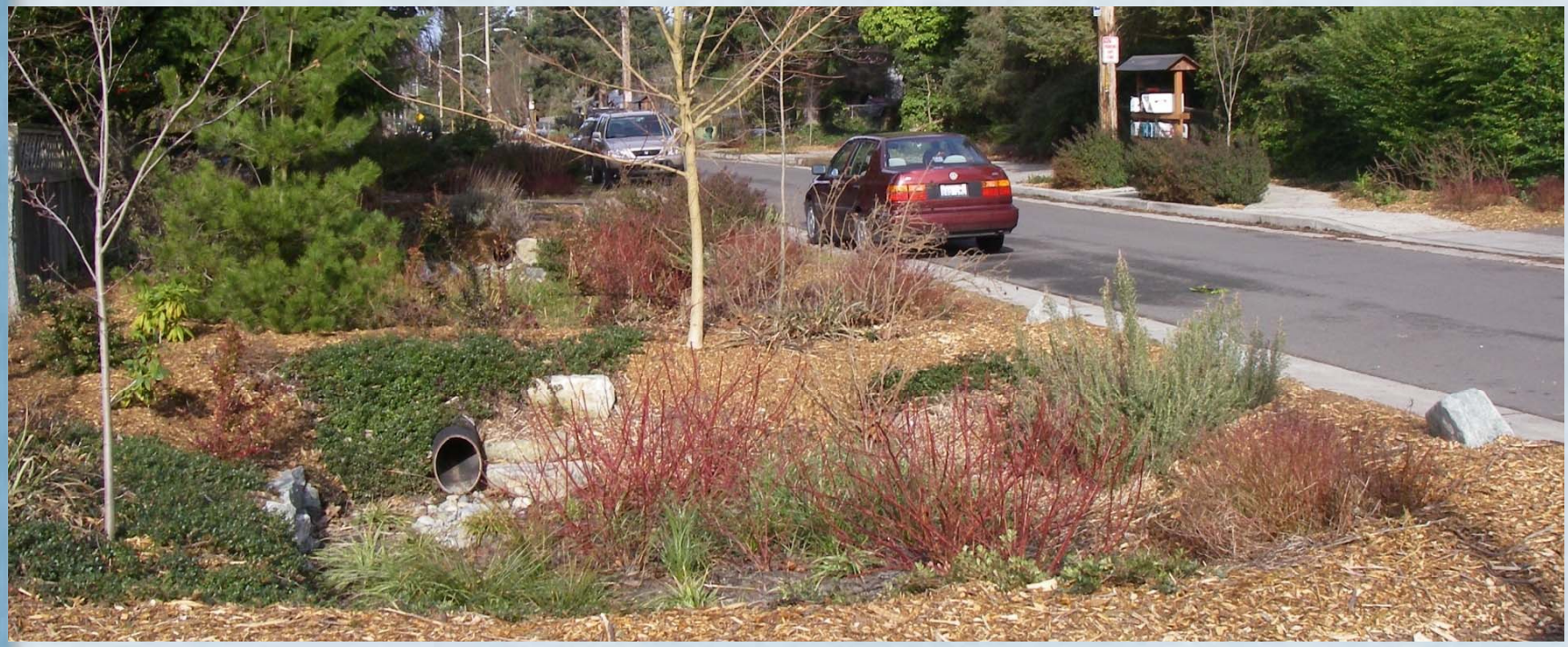
Green Stormwater Infrastructure to the Maximum Extent Feasible



Presented by:

Tracy Tackett

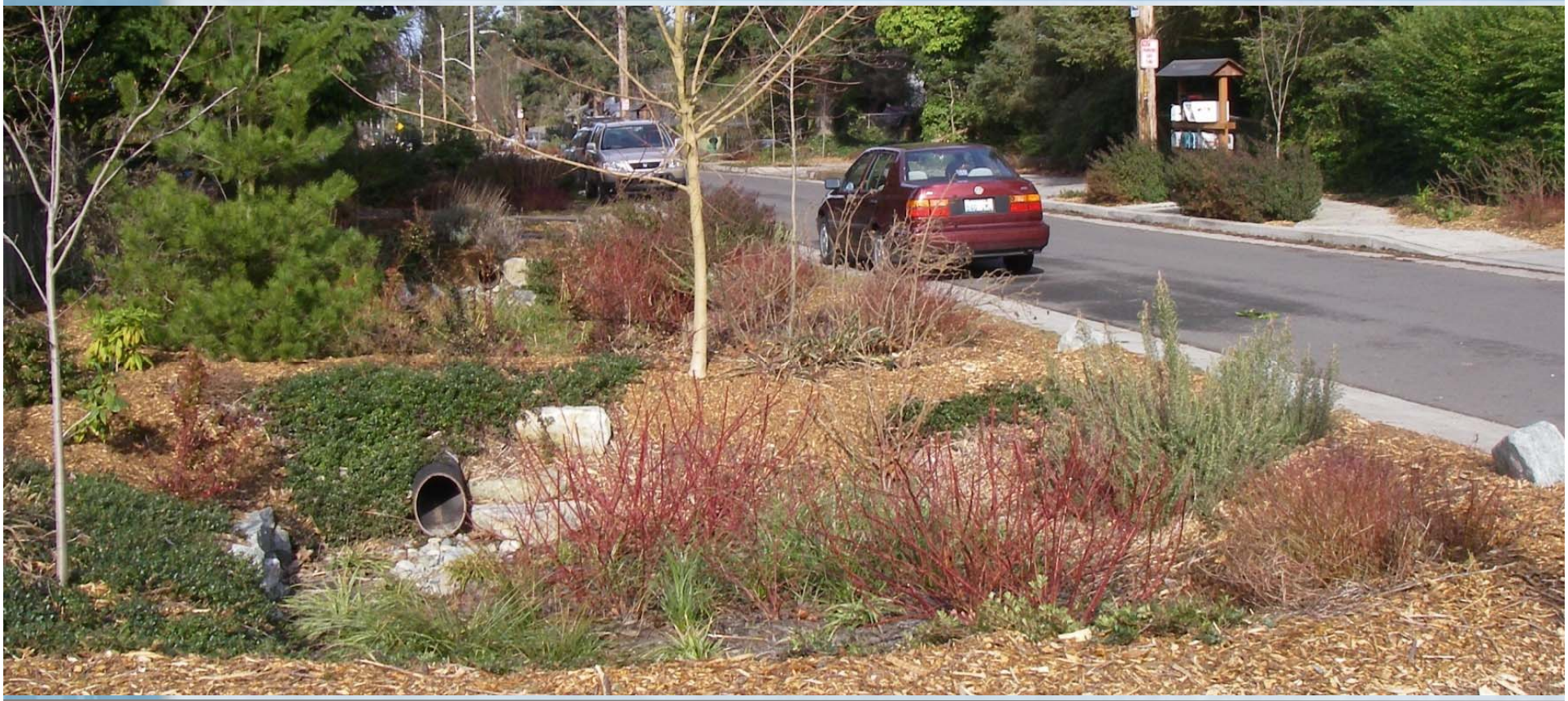
Green Stormwater Infrastructure Program Manager

Seattle Public Utilities

Green Stormwater Infrastructure (GSI) to Maximum Extent Feasible (MEF) Presentation Outline

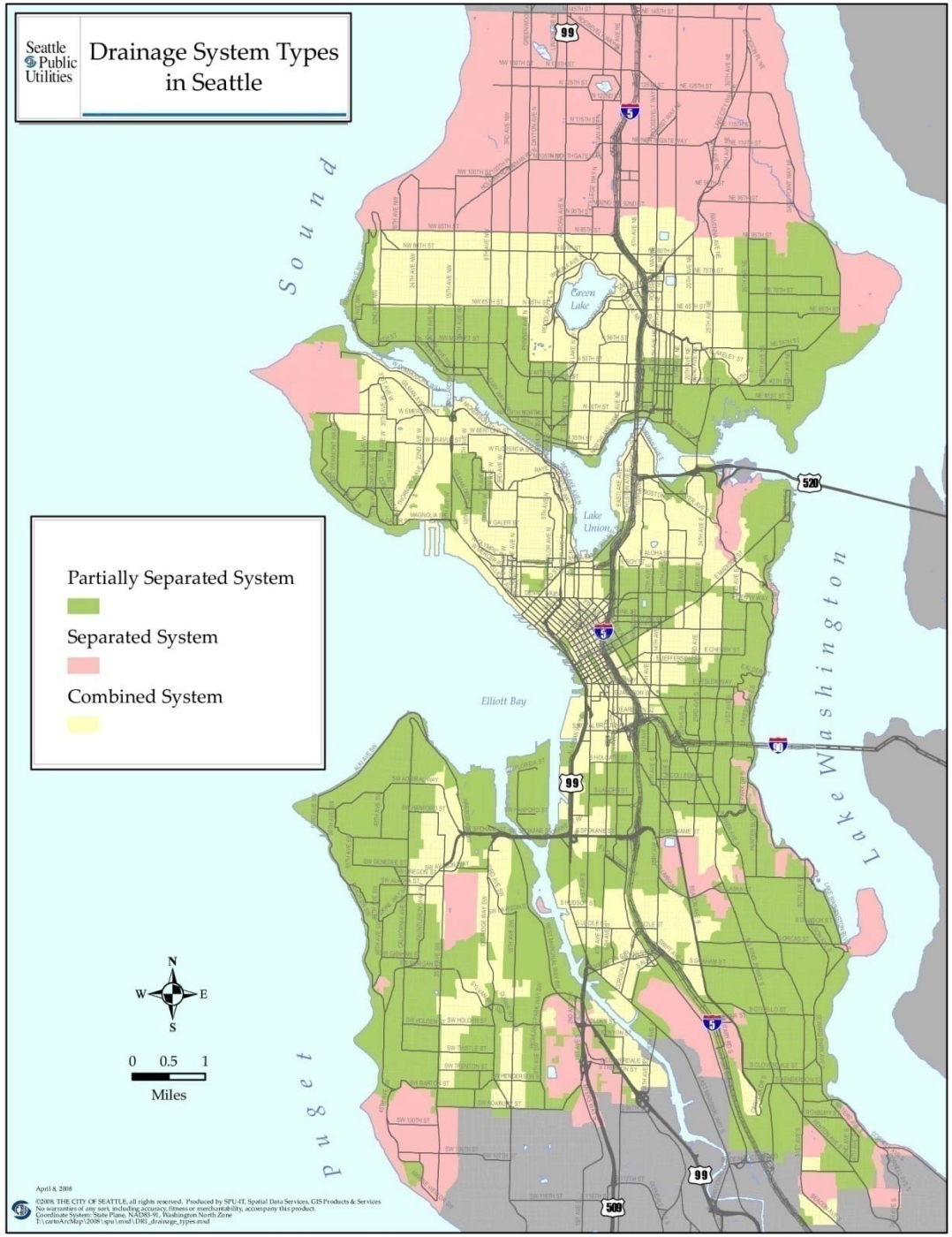
- GSI in Seattle Stormwater Code
  - *Where GSI rules apply*
  - *What GSI BMPs*
  - *Why GSI not LID focus*
- GSI Standard and Targets
- Feasibility Checklist

GSI in Seattle Stormwater Code



Seattle's Drainage System

- Pink – separated storm and sewer system
- Yellow – combined sewer system
- Green – partially separated



Seattle's Drainage System

Separated (pink)
- Creek standards (flow and water quality requirements)
- Water Quality Standard
- Some Capacity Constrained (peak flow requirements)

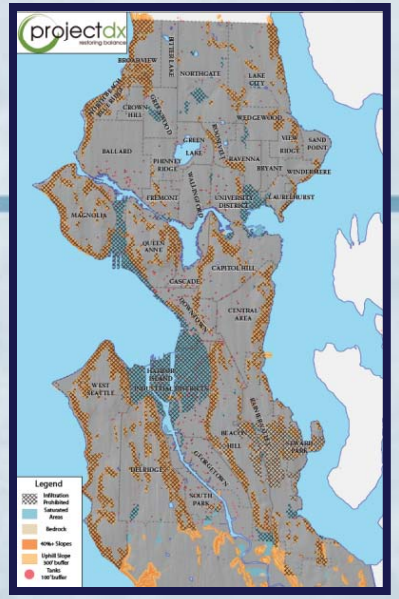
- Combined (yellow)
  - Capacity Constrained
- Partially separated (green)
  - Water Quality Standard
  - Some Capacity constrained areas

All GSI to MEF, but GSI is not one size fit all

Seattle Stormwater Code Thresholds (simplified)

- >750SF triggers drainage review
- GSI requirement
  - All Single Family Residential Projects
  - All projects with
    - >7,000 sf land disturbing activity OR
    - **>2,000sf impervious surface**
- Prescriptive Performance standards (in addition to GSI to MEF)
  - Creek watersheds >2,000SF
  - Capacity constrained >10,000sf
  - Separated areas, >5,000PGIS

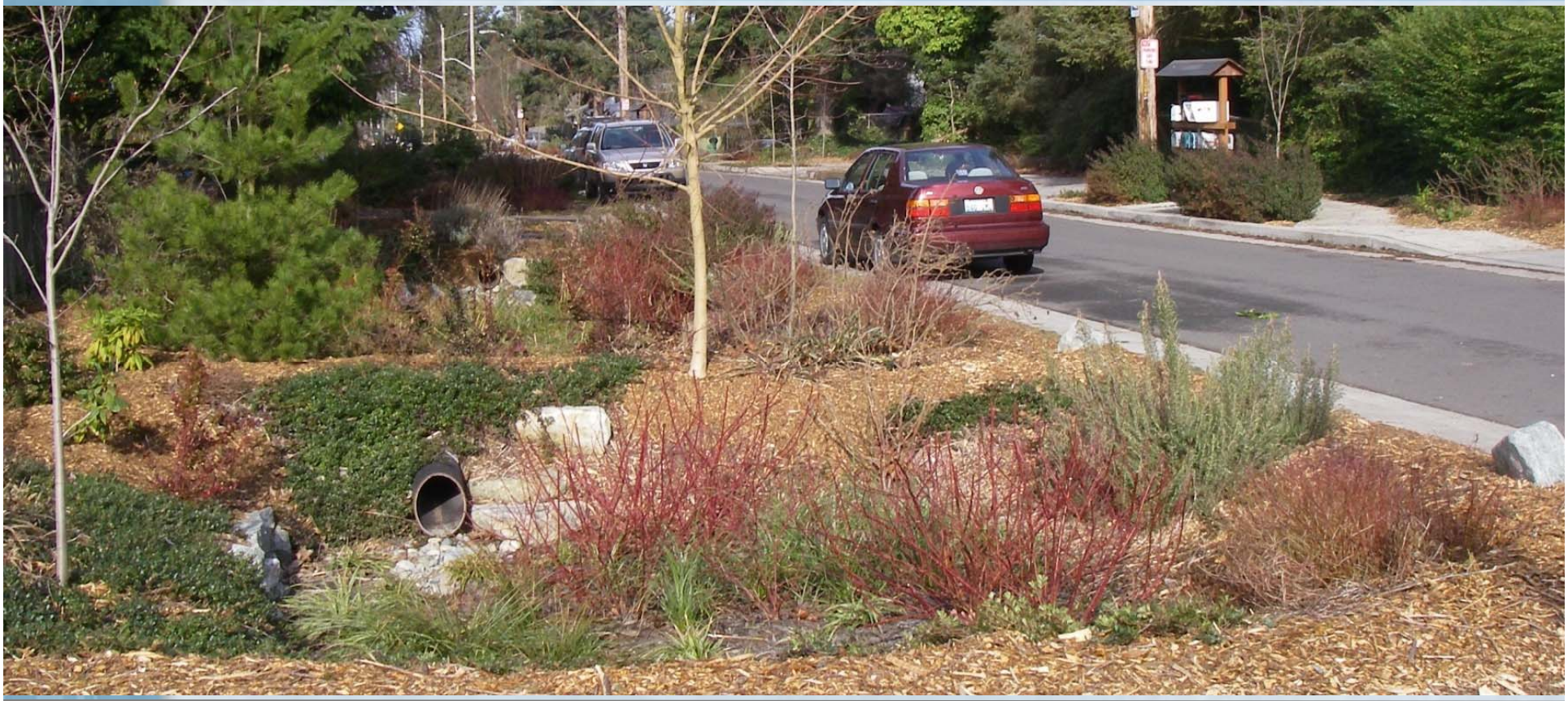
Green Stormwater Infrastructure – Infiltrating Systems



Green Stormwater Infrastructure – Non-infiltrating systems

Why Green Stormwater Infrastructure not LID focus?

GSI Standard and GSI Targets



Sizing Factors for Stormwater Code's Prescriptive Hydrologic Performance Standards

BMP	Design Infilt. Rate (in/hr)	Creek Standard	Capacity Standard	Treatment Standard
Appx. Average annual volume		**98.6%**	**99.8%**	**91%**
Bioretention Cell (w/o underdrain)				
2 inch ponding depth	0.25	23.0%	--	--
	0.5	15.8%	--	--
	1.0	9.3%	--	--
6 inch ponding depth	0.25	14.6%	33.1%	5.0%
	0.5	**9.9%**	**20.5%**	**2.9%**
	1.0	6.4%	10.6%	1.6%
12 inch ponding depth	0.25	8.9%	19.3%	3.0%
	0.5	6.5%	13.4%	1.7%
	1.0	4.1%	6.7%	0.9%

GSI Hydrologic Performance Standard for sizing, Goals

- Impervious Surface Based
  - Clear messaging – impervious is the problem
- Measurable and Accountable
  - “effective” impervious vague
- Complement Established Hydrologic Performance Standard
  - Peak and duration standards solid foundation
  - Need approach for smaller projects (in Seattle <22,500 SF impervious cannot technically achieve creek peak and duration standard)
  - Need approach focus on total volume and decreasing impacts from smaller storms
  - Minimize unanticipated consequences
- Goal for rule is Maximum Extent ***Feasible***

“GSI Standard” for Evaluation of Compliance with GSI to MEF requirement

- GSI standard applied to determine GSI facility sizes. Facilities were calculated as the average performance of the BMPs relative to two standards:
  - 95-percent reduction of the average annual runoff volume, and
  - 95-percent reduction in the 1-year recurrence interval flow
- “GSI standard” not a site hydrologic performance standard for runoff from the site. Sizing is combined with GSI impervious area mitigation targets

GSI BMPS ability to achieve GSI Standard are NOT equal

- Some BMPs sized, and can be designed to achieve a performance standard
  - Bioretention
  - Permeable Pavement Facilities
  - Rainwater Harvesting
- Some BMPs are what they are and credits must be adjusted to reflect performance
  - Trees
  - Dispersion
  - GreenRoofs
  - Bioretention with Underdrain
  - Detention Cisterns

Sizing Factors for Stormwater Code GSI Standard

BMP	Design Infilt. Rate (in/hr)	Rainwise Sizing, bottom area
Average Annual Volume		**95%**
Bioretention Cell		
6 inch ponding depth	0.25	7.4%
	0.5	**4.6%**
	1.0	2.8%

E.g.. Site with 0.5”/hr infiltration rate.
1000 SF roof area X .046 = 46 SF bottom swale area

Area ratio = (1 / 4.6%):1 = 21.7 : 1

GSI BMPS are NOT equal

Type	GSI BMPs	Credit toward GSI standard
Runoff reduction methods	Retain Existing Trees	10-20% SF canopy
	Dispersion (downspout or sheet flow)	78% (need better modeling?)
	Plant New Trees	20-50 SF credit/tree
Infiltrating and reuse facilities	Bioretention Cells (without underdrain)	100%
	Rainwater Harvesting	100%
	Permeable Pavement Facilities (with storage reservoir and overflow)	100%
Impervious surface reduction methods	Green Roofs	38-55%
	Permeable Pavement Surfaces	40-100%
Non infiltrating facilities	Bioretention Planter	30-35%
	Detention Cisterns with harvesting capacity (Single Family Parcels only)	44-53%

Maximum Extent Feasible

"the requirement is to be fully implemented, constrained only by the physical limitations of the site, practical considerations of engineering design, and reasonable considerations of financial costs and environmental impacts."

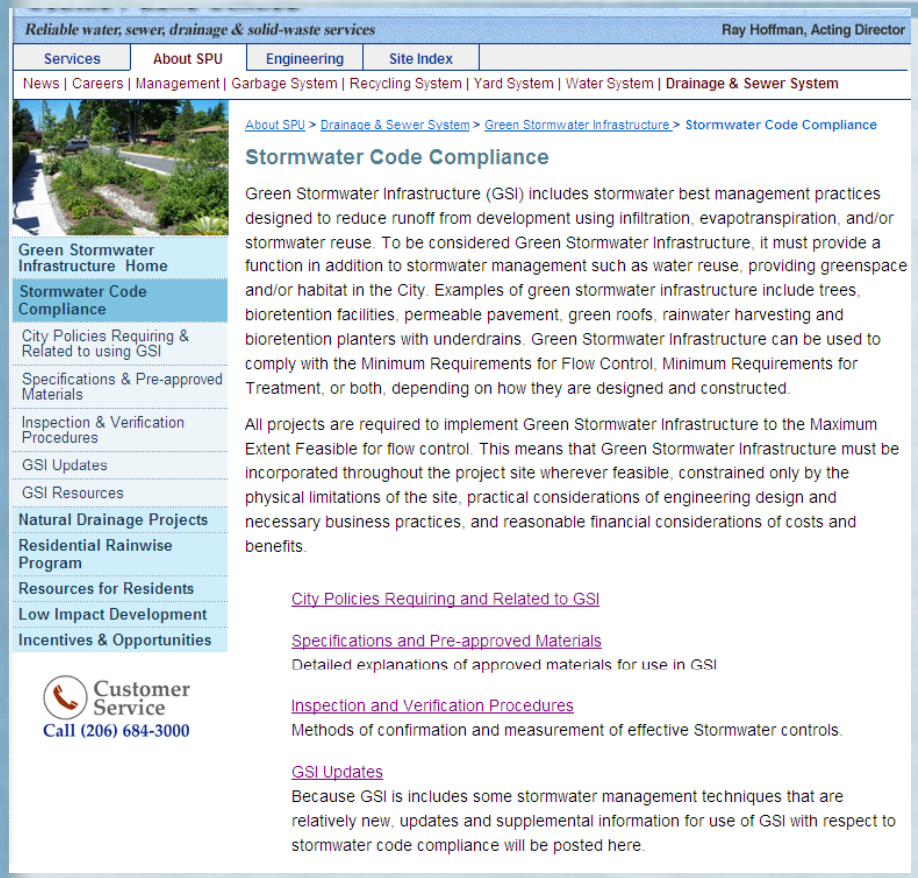
GSI Targets

- **Single Family Residential** –For single family residential projects only, the GSI target is that **all but 1,500 square feet of new plus replaced impervious surface** must be mitigated using GSI, limited only by feasibility based on practical considerations of engineering design, physical limitations of the site, and reasonable considerations of financial costs.
- **Other** - For all other projects requiring GSI to the MEF, the **GSI target is to mitigate 100 percent of the project's new plus replaced impervious surface using GSI**, limited only by feasibility based on practical considerations of engineering design, physical limitations of the site, and reasonable considerations of financial costs

GSI Targets – Vision for Future - Set Minimum % Impervious Areas that must be mitigated with GSI based on Land use

	Creek Watersheds	Non-flow control
SFR	?	?
Multifamily residential	?	?
Commercial	Estimate 50-60%	?
Industrial	Estimate 50-70%	?
Institutional	Estimate 70-100%	?
Sidewalk only	Estimate 60%-90%	?
Residential Roadways	Estimate 100%	?
Higher Use Roadways	Estimate 10-25%	?

Resources: Seattle.gov/util/greeninfrastructure



Reliable water, sewer, drainage & solid-waste services — Ray Hoffman, Acting Director

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News | Careers | Management | Garbage System | Recycling System | Yard System | Water System | **Drainage & Sewer System**

About SPU > Drainage & Sewer System > Green Stormwater Infrastructure > **Stormwater Code Compliance**

Green Stormwater Infrastructure Home
Stormwater Code Compliance
City Policies Requiring & Related to using GSI
Specifications & Pre-approved Materials
Inspection & Verification Procedures
GSI Updates
GSI Resources
Natural Drainage Projects
Residential Rainwise Program
Resources for Residents
Low Impact Development
Incentives & Opportunities

Customer Service
Call (206) 684-3000

Stormwater Code Compliance

Green Stormwater Infrastructure (GSI) includes stormwater best management practices designed to reduce runoff from development using infiltration, evapotranspiration, and/or stormwater reuse. To be considered Green Stormwater Infrastructure, it must provide a function in addition to stormwater management such as water reuse, providing greenspace and/or habitat in the City. Examples of green stormwater infrastructure include trees, bioretention facilities, permeable pavement, green roofs, rainwater harvesting and bioretention planters with underdrains. Green Stormwater Infrastructure can be used to comply with the Minimum Requirements for Flow Control, Minimum Requirements for Treatment, or both, depending on how they are designed and constructed.

All projects are required to implement Green Stormwater Infrastructure to the Maximum Extent Feasible for flow control. This means that Green Stormwater Infrastructure must be incorporated throughout the project site wherever feasible, constrained only by the physical limitations of the site, practical considerations of engineering design and necessary business practices, and reasonable financial considerations of costs and benefits.

City Policies Requiring and Related to GSI

Specifications and Pre-approved Materials
Detailed explanations of approved materials for use in GSI

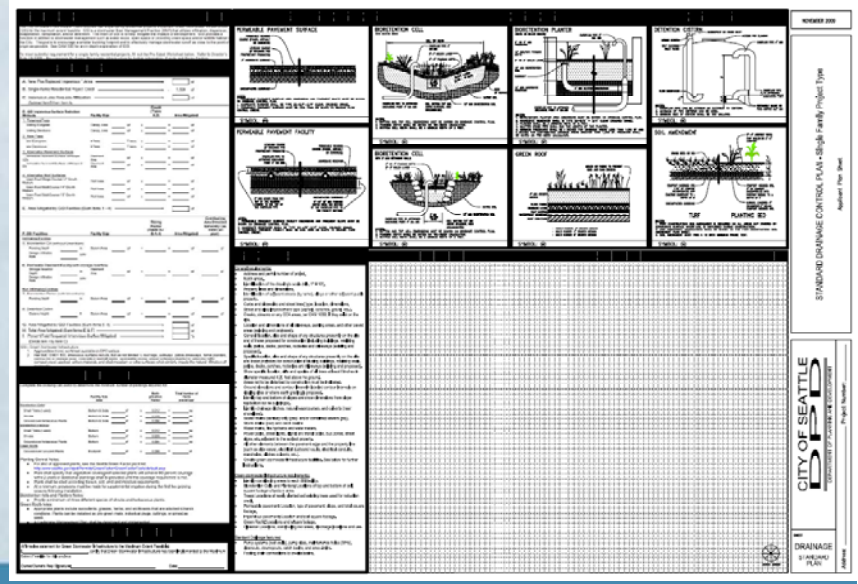
Inspection and Verification Procedures
Methods of confirmation and measurement of effective Stormwater controls.

GSI Updates
Because GSI is includes some stormwater management techniques that are relatively new, updates and supplemental information for use of GSI with respect to stormwater code compliance will be posted here.

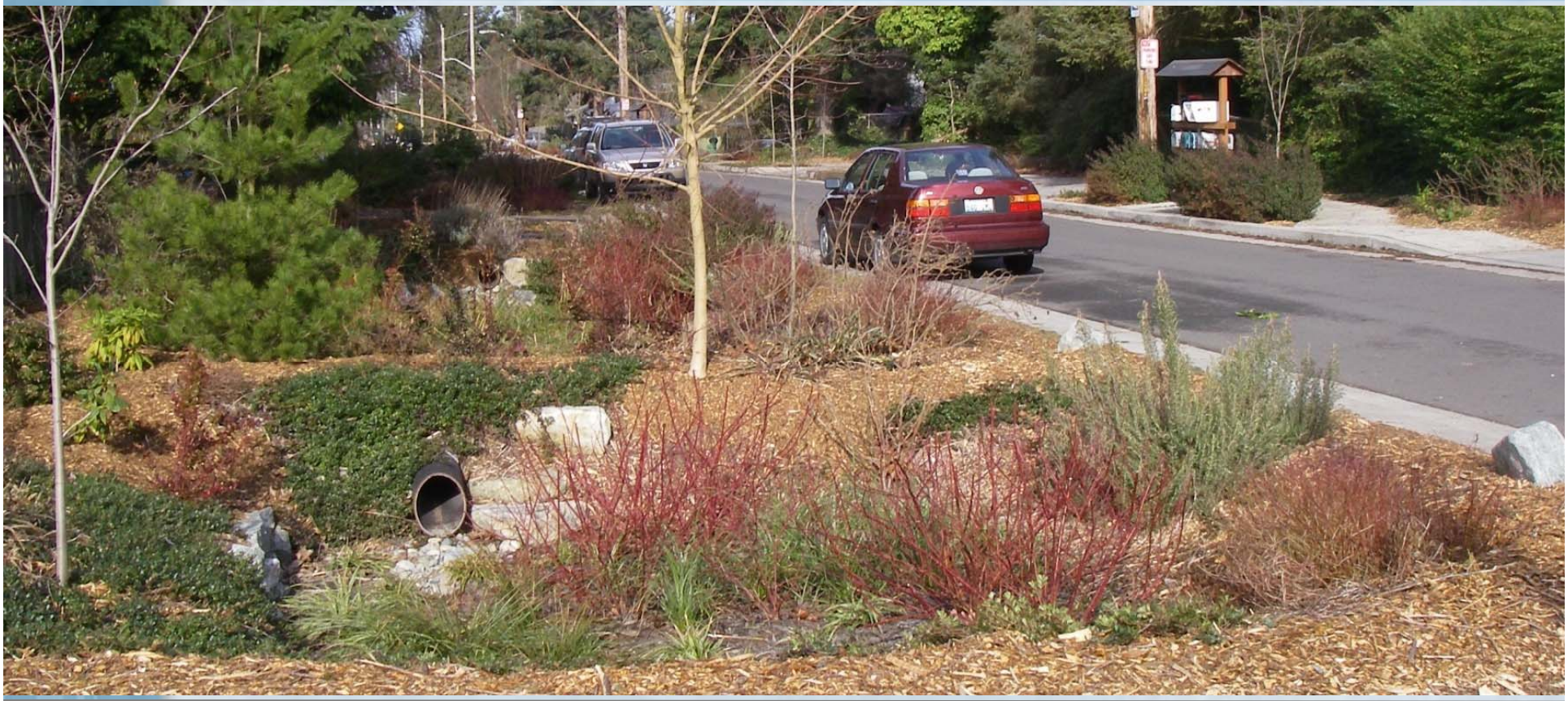
- Policy Resources
- Specs and Pre-approved Materials
- Inspections and Verification Procedures
- GSI Updates
- Other Resources

Policy Resources: DPD website

- Stormwater Code
- Stormwater Manual
- GSI to MEF Directors Rule
- Client Assistance Memos
  - Single Family: CAM 530-537
  - Rainwater Harvesting: CAM 520



GSI to MEF – Seattle's Mandated Evaluation Process



GSI BMPS Evaluation

Type	GSI BMPs
Runoff reduction methods	Retain Existing Trees
	Dispersion (downspout or sheet flow)
	Plant New Trees
Infiltrating and reuse facilities	Bioretention Cells (without underdrain)
	Rainwater Harvesting
	Permeable Pavement Facilities (with storage reservoir and overflow)
Impervious surface reduction methods	Green Roofs
	Permeable Pavement Surfaces
Non infiltrating facilities	Bioretention Planter
	Detention Cisterns with harvesting capacity (Single Family Parcels only)

GSI Calculator

- Fill out in combination with appendix B, Feasibility checklist

100% or feasibility restrictions documented

City of Seattle Green Stormwater Infrastructure Requirement Calculator (01-04-10)

Project Type →
Project Area → sf
New plus Replaced Impervious Area → sf
Area Requiring Mitigation → sf
(1,500 sf credit for SFR projects)

Runoff Reduction Methods		Facility Size			Credit		Area Mitigated
Retained Trees							
Existing Evergreen	# Trees	Total Canopy Area of Trees	sf	x	20% (or min 100 sf/tree)	=	sf
Existing Deciduous	# Trees	Total Canopy Area of Trees	sf	x	10% (or min 50 sf/tree)	=	sf
New Trees							
New Evergreen		# Trees		x	50 sf	=	sf
New Deciduous		# Trees		x	20 sf	=	sf
Dispersion [1]							
Downspout or Sheet Flow Dispersion		Dispersed Impervious Area	sf	x	86.0%	=	sf

Infiltrating and Reuse Facilities		Facility Size			Sizing Factor		Area Mitigated
Infiltrating Facilities							
Bioretention Cell (without Underdrain)							
Ponding Depth	in	Bioretention Bottom Area	sf	÷	Select Depth	=	sf
Design Infiltration Rate	in/hr						
Permeable Pavement Facility (may receive run-on)							
Ponding Depth [2]	in	Permeable Pavement Area	sf	÷	Select Depth	=	sf
Design Infiltration Rate	in/hr						
Reuse Facilities [1]							
Rainwater Harvesting		Applicant must provide documentation of mitigation					sf

Impervious Surface Reduction Methods		Facility Size			Credit		Area Mitigated
Alternative Pavement Surfaces							
Permeable Pavement Surface (Subgrade Slope ≤2%)		Permeable Pavement Area	sf	x	100.0%	=	sf
Permeable Pavement Surface (Subgrade Slope 2-5%)		Permeable Pavement Area	sf	x	60.0%	=	sf
Alternative Roof Surfaces [1]							
Green Roof (Single-Course / 4" Growth Medium)		Green Roof Area	sf	x	59.0%	=	sf
Green Roof (Multi-Course / 4" Growth Medium)		Green Roof Area	sf	x	59.0%	=	sf
Green Roof (Multi-Course / 8" Growth Medium)		Green Roof Area	sf	x	70.0%	=	sf
Partial Infiltration [1]							
Bioretention Cell with Detention (without Underdrain)							
Contributing Area	sf						
Ponding Depth	in	Bioretention Bottom Area	sf		Select Depth	=	sf
Design Infiltration Rate	in/hr						

Non-Infiltrating Facilities		Facility Size			Sizing Factor/Credit		Area Mitigated
Non Infiltrating Facilities							
Bioretention Planter (with underdrain)							
Contributing Area	sf						
Ponding Depth	in	Bioretention Bottom Area	sf	÷	Select Depth	=	sf
Detention Cistern with Harvesting Capacity [3]							
Contributing Area	sf	Min Cistern Area	sf			=	sf
		Min Live Cistern Volume	gal				

Total Area Mitigated → 0 sf
Area Requiring Mitigation → sf
% Impervious Area Mitigated → %
GSI Requirement Achieved? →

Notes:
GSI - Green Stormwater Infrastructure; sf - square feet; in - inch; NA - not applicable; eqn - equation
min - minimum; ft - feet; in/hr - inch per hour; gal - gallons
1. Single family residential projects are not required to evaluate this BMP.
2. Average subsurface ponding depth in aggregate storage reservoir.
3. Cistern area must be rounded up to next commercially available product. Cistern need not have more than 3 feet of live storage volume above orifice.
This calculator does not provide conveyance flow calculations.
Applicant is responsible to ensure system overflow conveyance is provided per Section 4.2.5 of the Stormwater Manual Volume 3.

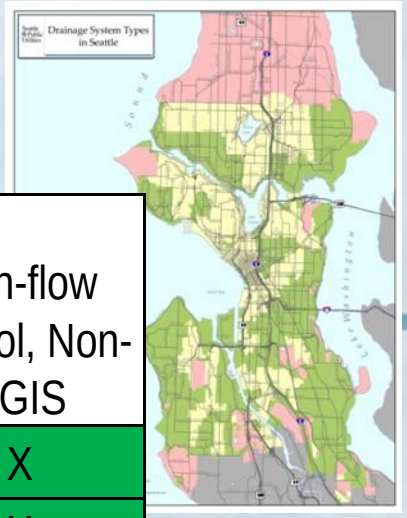
GSI to MEF Feasibility Checklist, (Appendix B of GSI to MEF Rule)

Table B.2. Feasibility Considerations for GSI Evaluation Category 2: Infiltrating and Reuse Facilities.

BMP	Feasibility Consideration	Additional information from applicant
All Infiltrating Facilities (including permeable paving facilities and bioretention without impermeable liner)	☐ Infiltration restrictions and setbacks per Stormwater Manual Vol. 3, Chapter 4.3 must be considered. Appendix C "Infiltration Feasibility Flowchart" is provided below for initial screening purposes. Infiltrating facilities may not be sited within: ☐ Landslide prone critical areas ☐ Setbacks from steep slope areas ☐ 100 feet of a known contaminated site or abandoned landfill ☐ Other setbacks presented in the Stormwater Manual Vol. 3 (e.g., setbacks from structures). ☐ The minimum vertical separation of one foot from the bottom of the facility to the underlying water table, bedrock, or other impermeable layer cannot be achieved. ☐ Geotechnical evaluation recommends infiltration NOT be used anywhere within the project area due to plausible concerns about erosion, slope failure, or other hazards (attach geotechnical report). ☐ Test Pits determined native soil infiltration rate to be less than 0.25inches/hr. ☐ Site design cannot avoid putting permeable pavement in areas likely to have excessive sediment contamination or in close proximity to areas that will be sanded.	
Bioretention Facilities (without impermeable liner)	☐ Site design cannot accommodate bioretention areas because sites longitudinal surface slopes cannot be graded to less than 7 percent.	

- Appendix B – summarizes technical feasilbity, pre-identified site and financial feasibility

GSI BMPs Evaluation Required



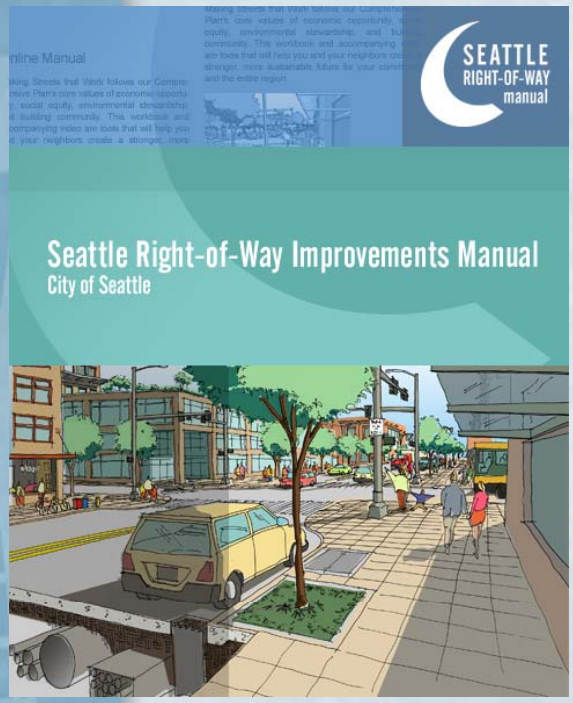
GSI BMPs	Flow Control Basins (Creeks and Capacity Constrained)	Non-flow control basins, PGIS	Non-flow control, Non-PGIS
Retain Existing Trees	X	X	X
Dispersion (downspout or sheet flow)	X	X	X
Plant New Trees	X	X	X
Bioretention Cells (without underdrain)	X	X	X
Rainwater Harvesting	X	NA	-
Permeable Pavement Facilities	X	X	-
Green Roofs	X	NA	-
Permeable Pavement Surfaces	X	X	-
Bioretention Planter	X	X	X
Detention Cisterns	X	NA	X

Feasibility Checklist: Practical Considerations of Engineering Design

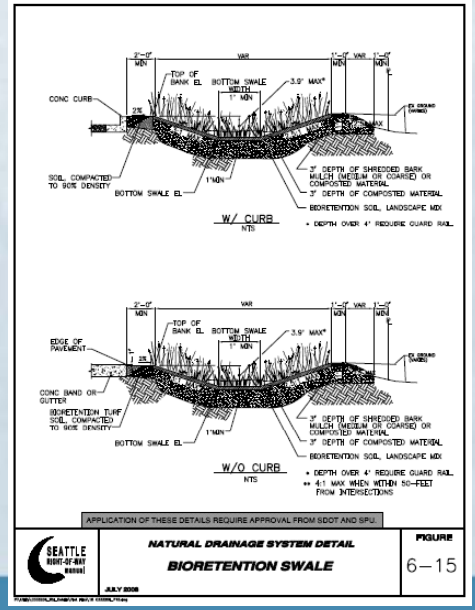
- Technical Limitations, defined as "not feasible" in Stormwater Manual
  - Eg. Infiltration facilities – steep slopes, contaminated soils, setbacks, etc
  - Note: native soil infiltration rate by PIT test <0.25"/hr infiltration BMP evaluation NOT required and if used NOT credited toward stormwater goals

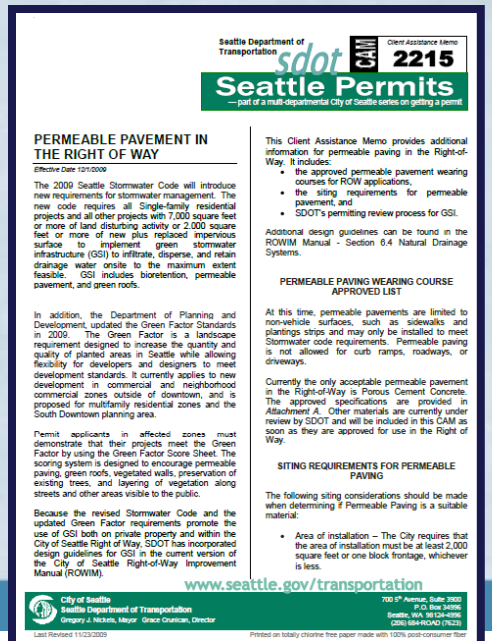
All information compiled into "GSI to MEF Directors Rule" Appendix B

Feasibility Checklist: Physical Limitations of the Site / “Competing Needs for space use”



- Reflects the multiple demands on public space: UGA density goals, historical designation, vehicular and pedestrian access, intended use of the right-of-way (including bike/ped mobility goals), urban design elements, etc





Feasibility: Reasonable Considerations of Financial Cost and Environmental Benefit

- Eliminated requirement to evaluate some BMPs.
  - Eg. Green Roofs and Rainwater harvesting evaluation only required on projects with >5,000sf new plus replaced roof surface
- Defined data to be provided by applicants claiming economic infeasibility
- Rule of thumb – high priority but premature to develop. Priority for greenroofs and rainwater harvesting. Currently using team approach and collecting information.
- Creek watersheds, non-SFR: Considering no economic feasibility for bioretention

GSI to MEF Feasibility Checklist, (Appendix B of GSI to MEF Rule)

Table B.2. Feasibility Considerations for GSI Evaluation Category 2: Infiltrating and Reuse Facilities.

BMP	Feasibility Consideration	Additional information from applicant
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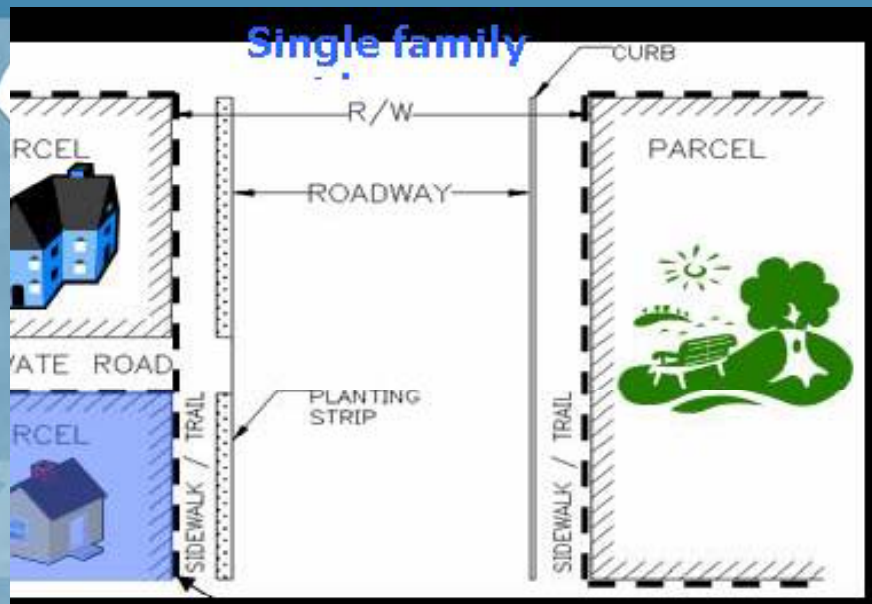
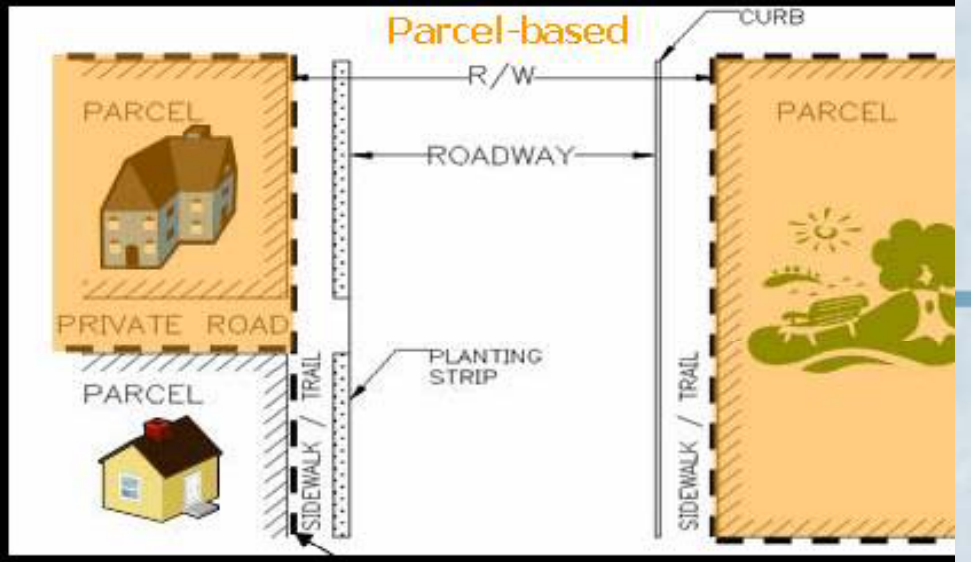
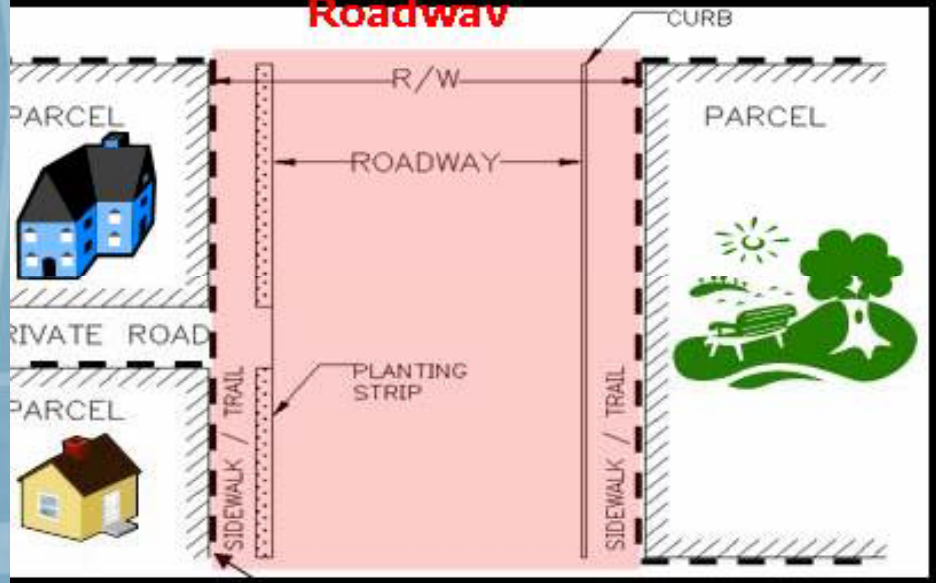
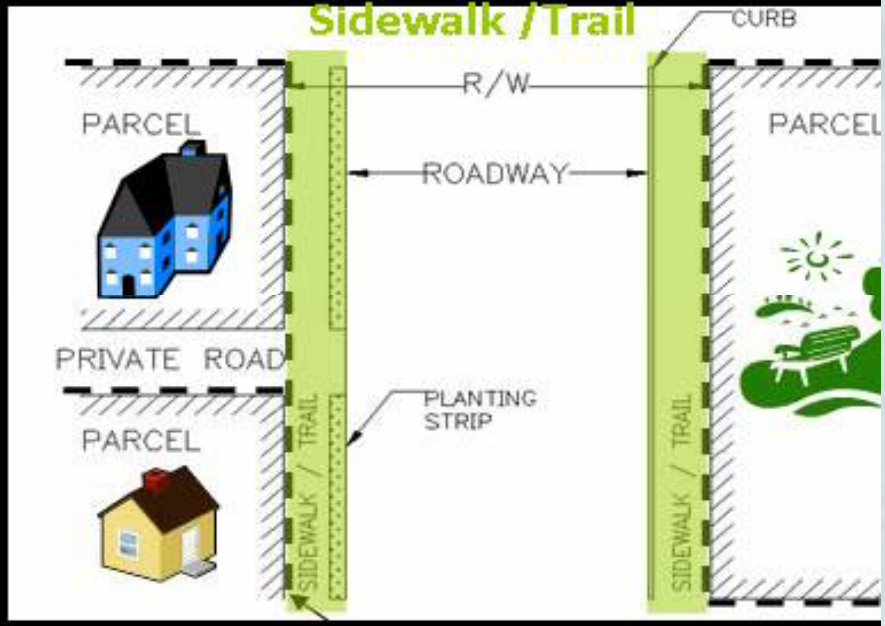
Bioretention Facilities (without impermeable liner)	☐ Site design cannot accommodate bioretention areas because sites longitudinal surface slopes cannot be graded to less than 7 percent.	

- Appendix B – summarizes technical feasibility, pre-identified site and financial feasibility


Single family
CURB
R/W
ROADWAY
PARCEL
PLANTING STRIP
SIDEWALK / TRAIL
SIDEWALK / TRAIL


Parcel-based
CURB
R/W
ROADWAY
PARCEL
PRIVATE ROAD
PARCEL
PLANTING STRIP
SIDEWALK / TRAIL
SIDEWALK / TRAIL


Roadway
CURB
R/W
ROADWAY
PARCEL
PARCEL
PLANTING STRIP
SIDEWALK / TRAIL
SIDEWALK / TRAIL


Sidewalk / Trail
CURB
R/W
ROADWAY
PARCEL
PARCEL
PRIVATE ROAD
PARCEL
PLANTING STRIP
SIDEWALK / TRAIL
SIDEWALK / TRAIL

More to the Process

Reviewer Process

- Review TIR
- Review GSI Requirement Calculator and Feasibility Evaluation
- Review Hydrostats report if applicable
- Follow Reviewer Checklist

Construction Inspection

Longterm inspection protocol

NOV 20 2009

Questions?

Seattle.gov/util/greeninfrastructure

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GSI Program Manager

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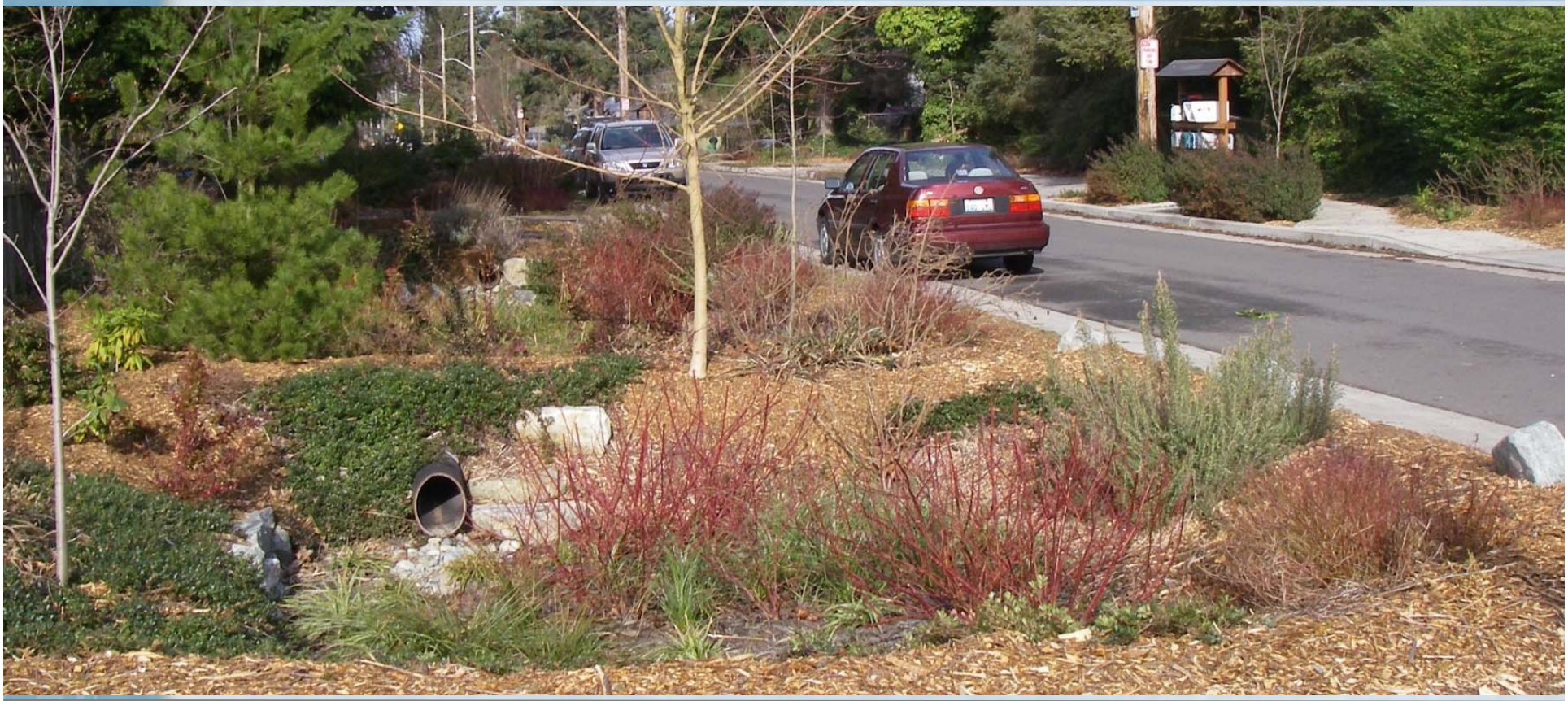
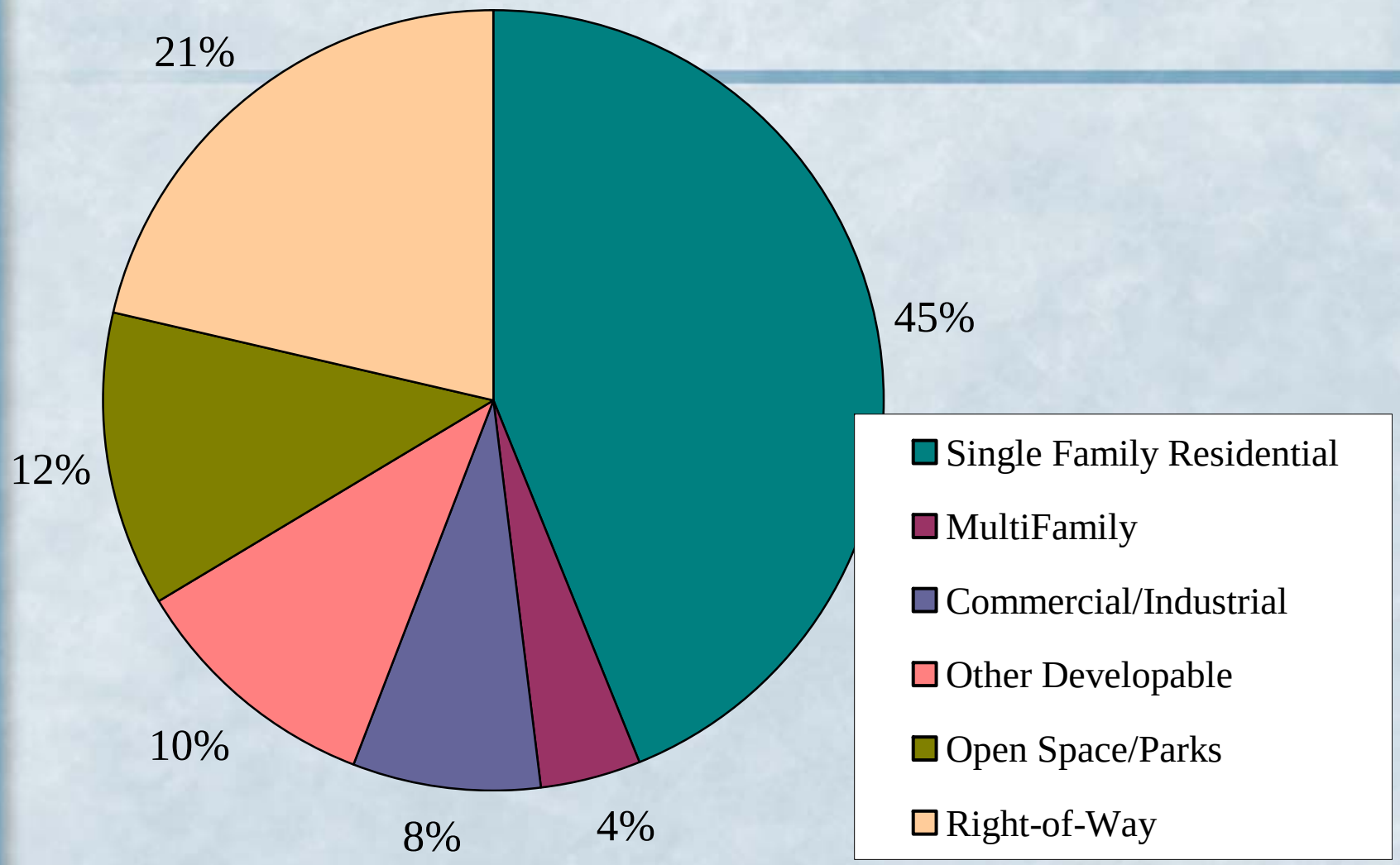


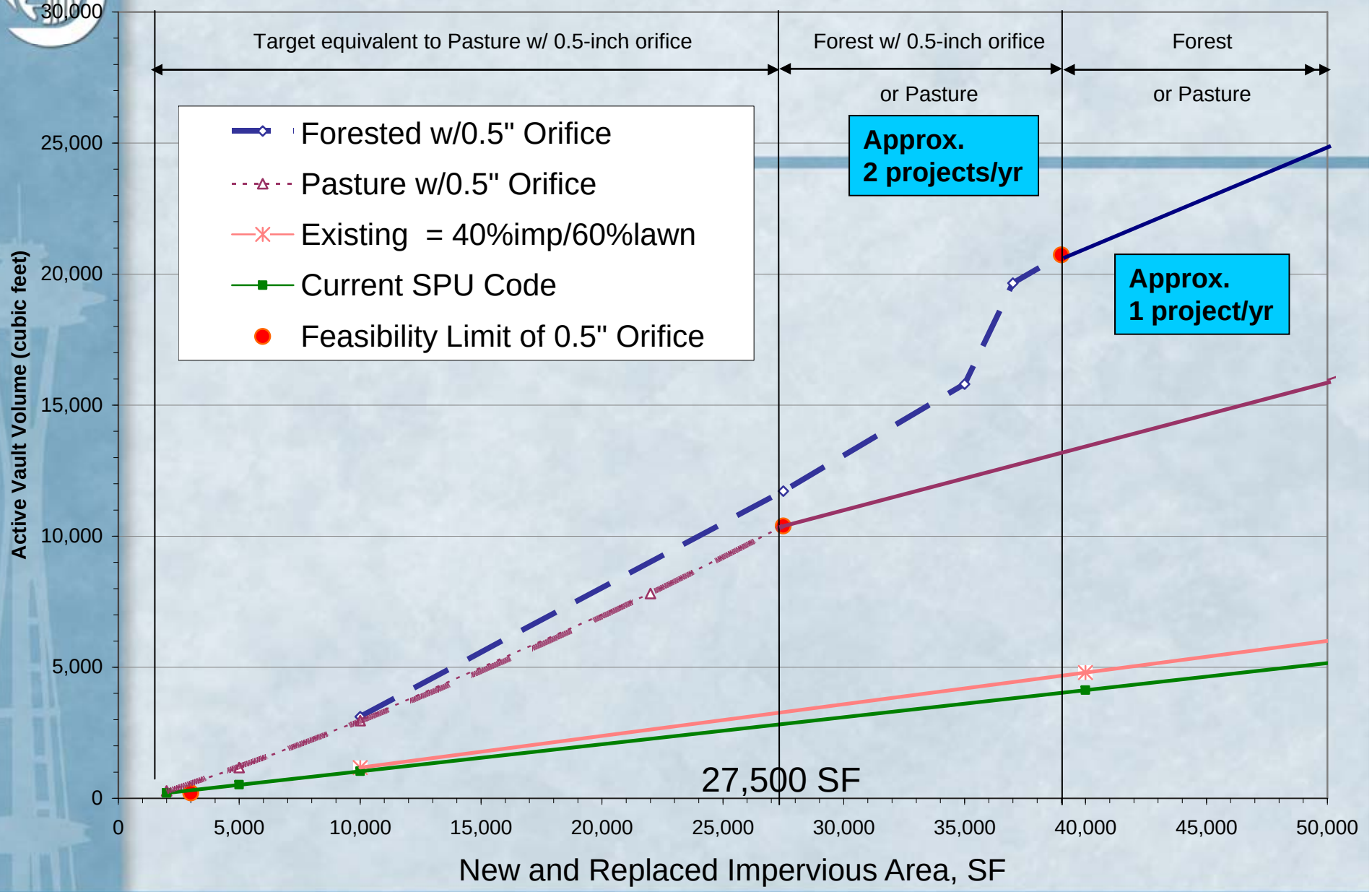
City of Seattle
Seattle Pubic Utilities
Ray Hoffman, Acting Director

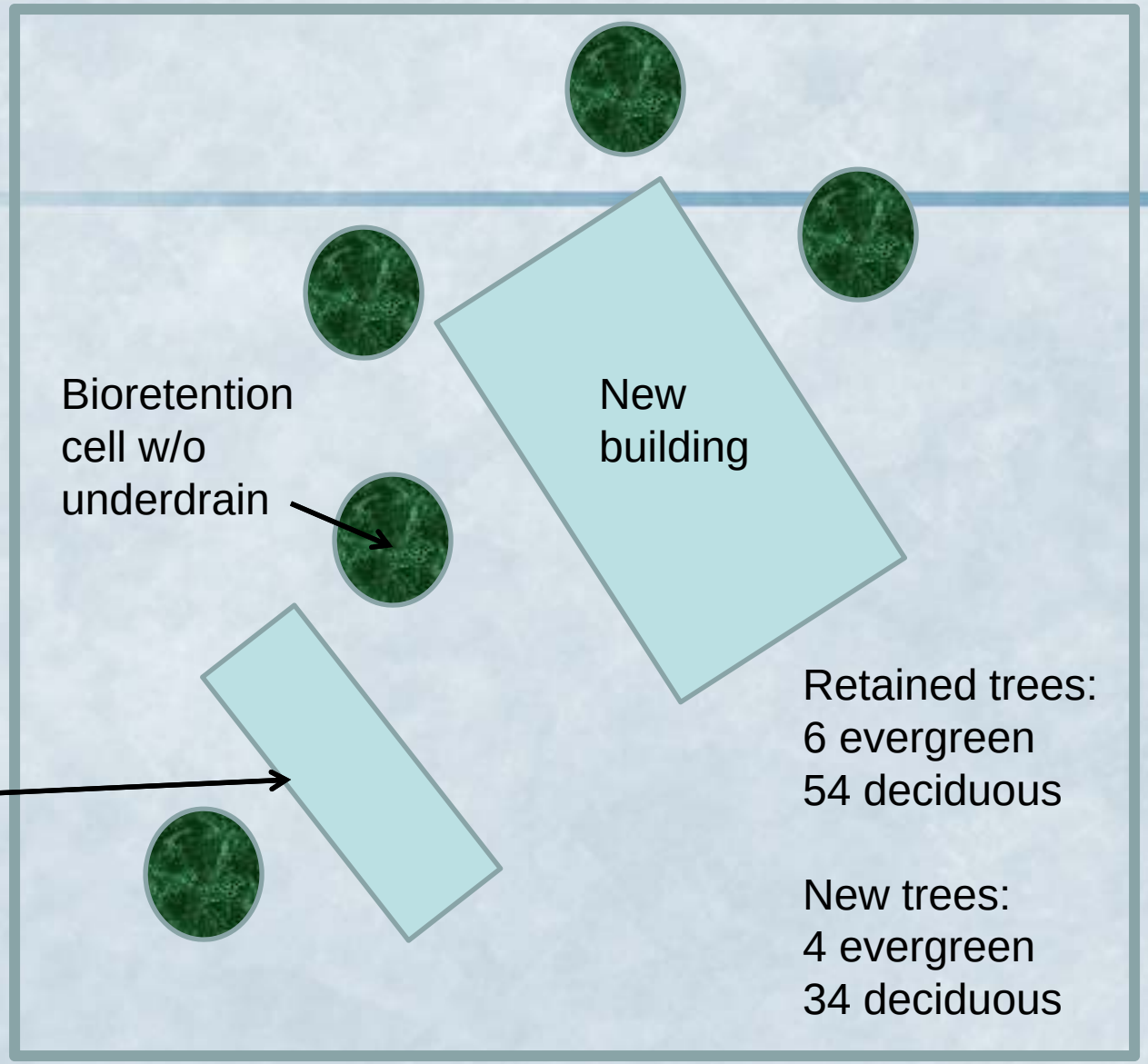
Creek Basins by Land Use



Overview

Detention Vault Volume by Impervious Area




Bioretention cell w/o underdrain
New building
New parking lot with permeable pavement parking spaces
Retained trees:
6 evergreen
54 deciduous
New trees:
4 evergreen
34 deciduous

Parcel Project Example

- Project type – Parcel
- Project area – 330,000 sf
- New plus replaced impervious surface – 55,000 sf
- Area requiring mitigation – 55,000 sf
- # retained trees – 6 evergreen, 1815 total canopy; 54 deciduous,16,200 sf total canopy area
- # new trees – 4 evergreen, 34 deciduous
- Permeable pavement surface (slope <2%) – 12,000 sf
- Bioretention with 6 inch ponding – 2,000 sf
- Assume 0.25 in/hr infiltration rate

City of Seattle Green Stormwater Infrastructure Requirement Calculator (01-04-10)

Project Type → _____

Project Area → _____ sf

New plus Replaced Impervious Area → _____ sf

Area Requiring Mitigation → _____ sf
(1,500 sf credit for SFR projects)

Runoff Reduction Methods			Facility Size				Credit		Area Mitigated
Retained Trees									
Existing Evergreen	# Trees		Total Canopy Area of Trees		sf	x	20% (or min 100 sf/tree)	=	sf
Existing Deciduous	# Trees		Total Canopy Area of Trees		sf	x	10% (or min 50 sf/tree)	=	sf
New Trees									
New Evergreen			# Trees			x	50 sf	=	sf
New Deciduous			# Trees			x	20 sf	=	sf
Dispersion [1]									
Downspout or Sheet Flow Dispersion			Dispersed Impervious Area		sf	x	86.0%	=	sf

Infiltrating and Reuse Facilities			Facility Size				Sizing Factor		Area Mitigated
Infiltrating Facilities									
Bioretention Cell (without Underdrain)									
Ponding Depth		in	Bioretention Bottom Area		sf	÷	Select Depth	=	sf
Design Infiltration Rate		in/hr							
Permeable Pavement Facility (may receive run-on)									
Ponding Depth [2]		in	Permeable Pavement Area		sf	÷	Select Depth	=	sf
Design Infiltration Rate		in/hr							
Reuse Facilities [1]									
Rainwater Harvesting			Applicant must provide documentation of mitigation						sf

Impervious Surface Reduction Methods	Facility Size				Credit		Area Mitigated
Alternative Pavement Surfaces							
Permeable Pavement Surface (Subgrade Slope ≤2%)	Permeable Pavement Area		sf	x	100.0%	=	sf
Permeable Pavement Surface (Subgrade Slope 2-5%)	Permeable Pavement Area		sf	x	60.0%	=	sf
Alternative Roof Surfaces [1]							
Green Roof (Single-Course / 4" Growth Medium)	Green Roof Area		sf	x	59.0%	=	sf
Green Roof (Multi-Course / 4" Growth Medium)	Green Roof Area		sf	x	59.0%	=	sf
Green Roof (Multi-Course / 8" Growth Medium)	Green Roof Area		sf	x	70.0%	=	sf
Partial Infiltration [1]							
Bioretention Cell with Detention (without Underdrain)							
Contributing Area		sf					
Ponding Depth		in	Bioretention Bottom Area	_____ sf	Select Depth	=	sf
Design Infiltration Rate		in/hr					

Non-Infiltrating Facilities			Facility Size				Sizing Factor/Credit		Area Mitigated
Non Infiltrating Facilities									
Bioretention Planter (with underdrain)									
Contributing Area		sf							
Ponding Depth		in	Bioretention Bottom Area	_____	sf	÷	Select Depth	=	sf
Detention Cistern with Harvesting Capacity [3]									
Contributing Area		sf	Min Cistern Area	_____	sf			=	sf
			Min Live Cistern Volume	_____	gal				

Total Area Mitigated → 0 sf

Area Requiring Mitigation → _____ sf

% Impervious Area Mitigated → _____ %

GSI Requirement Achieved? → _____

Notes:

GSI - Green Stormwater Infrastructure | sf - square feet | in - inch | NA - not applicable | eqn - equation
min - minimum | ft - feet | in/hr - inch per hour | gal - gallons

1. Single family residential projects are not required to evaluate this BMP.
2. Average subsurface ponding depth in aggregate storage reservoir.
3. Cistern area must be rounded up to next commercially available product. Cistern need not have more than 3 feet of live storage volume above orifice.

This calculator does not provide conveyance flow calculations.