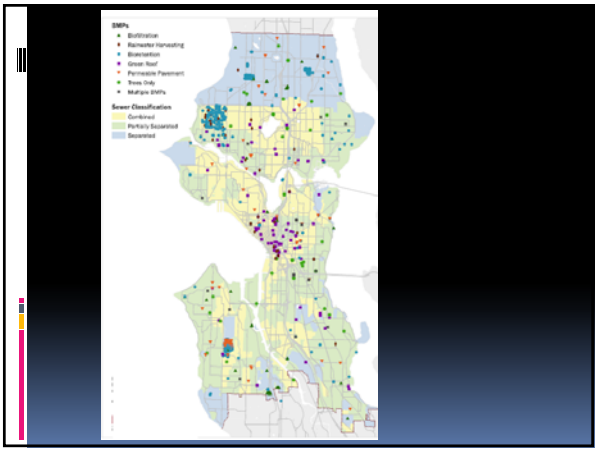


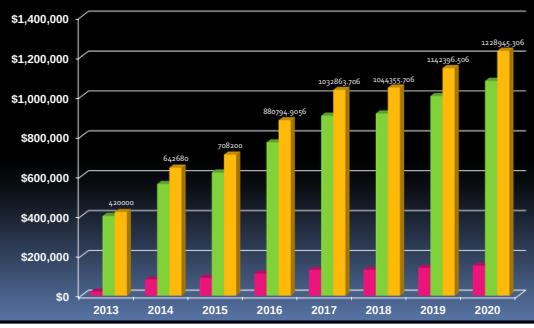
Operations and Maintenance

- O&M Maintenance Took Kit
  1. Landscape Maintenance Manual
  2. GSI/LID Maintenance Manual for ROW
  3. Identifiable and detailed levels of service
  4. Porous Pavement
  5. O&M Facility Checklists
  6. Key Performance Indicators
- Life Cycle Costs
- Maintenance Costs
- Additional Tools
- Risks/Lessons Learned

Current and Forecasted Bioretention

- Current (2000-14)
- 180K sq ft
- $500K budget
- 2014-2020
- SPU: 42 acres
- SDOT: +/- 2.5 acres
- King County: 442 acres
- $1.3M O&M budget

Strategic Business Plan - O&M Baseline Budget



SPU Tools

Homeowners Landscape Manual

- Landscape Maintenance Manual
- Maintenance personnel
- Homeowners living adjacent to systems

Restoration and Repair Manual

~ 10 Swales retrofitted
~ 4 possible failures 3-11
~ 2 possible infiltration failure 3-13

Maintenance Management

Two crews
- Hardscape: city crew
- Landscape: contractor through 2020

Scheduled by LOS –*not frequency!*

Semi annual inspections
- pre fall
- pre spring

GSI Manual Sections

Inspection/Checklist and Maintenance Activities

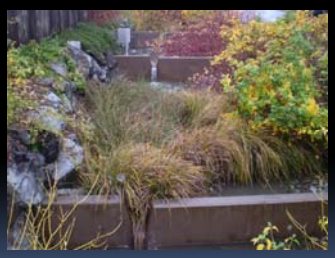
1. Vegetation and Landscaping
2. System Functionality
3. Hardscape and Infra-Structure
4. Infiltration Failure – Swale Ponding
5. Recommended Maintenance for Other Elements
6. Safety, Mobility, and Accessibility

Maintenance Manual

- Summary
  - Routine maintenance activities
  - Non-routine maintenance activities
  - Inspection/checklist
  - Scheduling and performing maintenance activities in the ROW
  - Images and descriptions

Program is currently designed

- Levels of Service
- LOS A – D
- Changing to meets NPDES requirements
- LOS to Acceptable/Unacceptable



SPU Practice Changes

- Asset management tracking
  - Equipment #'s (EQ#'s) assigned and noted on CD level drawings
- Design for major program maintenance
  - Improve standard design and specifications
  - GSI Design Phase Asset checklist
    - Non-standard elements require approval early in design process
    - Identifies in design potential long term cost issues of non standard elements

Changes and Improvements

- Third party inspection
  - Engineer of record
  - Landscape Architect of record
  - Geotechnical Engineer of record
- Clarity on acceptable maintenance
  - Compliance with NPDES
  - Communicating standard maintenance for function

Updated GSI O&M Manual for ROW

Summary of Topics

- Transition from construction and establishment
- Operations: Defining parameters and resources
- Bioretention surface maintenance
- Structures and subsurface maintenance
- Deep infiltration maintenance
- Permeable pavement maintenance
- Outsourcing and stewardship
- Storm events
- Inspection
- Public engagement
- Maintenance agreements

Maintenance Guidelines-Update

- Identify asset categories
- Tie to Washington State Ecology
- Priority for function and safety
- Key observation items
- Maintenance activity
- Frequency
- Performance standard
- Adaptable for *Maximo*
- Adaptable for Work Order contracting

Focus on Acceptable

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

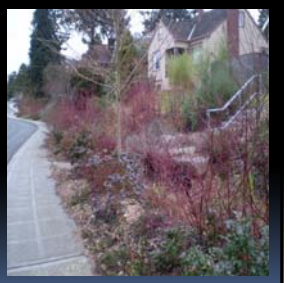
1-Vegetation and Landscape Maintenance

- **Inspection/checklist**
- Vegetation is mostly healthy
- Good appearance
- Small quantities of weeds
- Edges are loosely defined
- Grass encroaching on the swale (or vice versa)

Levels of Service B - Good

Levels of Service B - Good

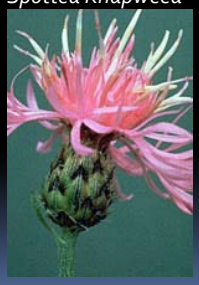
- **Inspection/checklist**
- Plants growing onto the street or sidewalk
- Mulch is present with occasional bare spots
- Erosion is likely unless maintenance is improved
- Some shoulder compaction adjacent to the swale
- Plant palette is mostly working for the facility



Noxious and Nuisance Weeds

- Special considerations need to be identified
- Provide link to jurisdiction's web site
- Photos
- Identification key
- Reporting requirements – *if applicable*

Spotted Knapweed



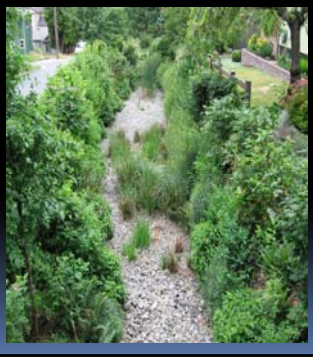
2-System Functionality

- Bioretention
- Biofiltration
- Bioretention and biofiltration
- Vegetation, soils, and substrate

Level of Service D

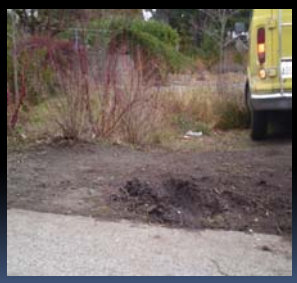
Inspection/checklist LOS C

- Bioretention and or biofiltration
  - for vegetation, soils and substrate
- 40% to 60% bottom covered
- Healthy vegetation
- Uniformed fine-stemmed at least 18 to 24 inches high



Continued….

- Soil is compacted
- Evidence of vehicle compaction
- Ponded water takes at least 72 hours to drain
- Many bare spots
- Significant level of sediment and debris accumulation

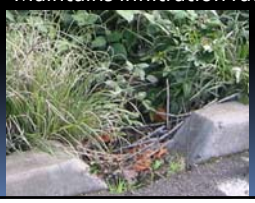


3-Hardscape and Infra-Structure

- Debris and sediment removal
- Clearing and cleaning

Hardscape and Infra-Structure – Long Term Maintenance

- Every fifteen years
- Remove and replace top two inches of sediment
- Prevent swale clogging
- Maintains infiltration rates



All Levels of Service-Meet permit requirements

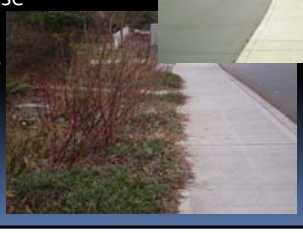
- Stormwater sedimentation structures are less than ½ full or in accordance with NPDES requirements

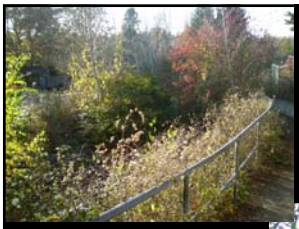
4-Infiltration Failure

- Evidence of a cell holding water for more than 24 hours needs to be reported
- Operations and Maintenance Asset Manager
- Monitor swale for ponding water
- Retrofit swale

5-Recommended Maintenance for Other Elements

- Pest control
- Spill prevention and response
- Permeable pavements
- Irrigation systems





Section 6: Safety

Accessibility

ADA

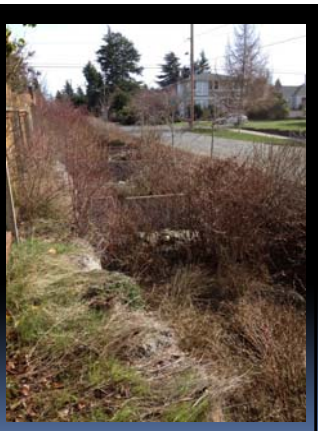
Right plant for right place

Simplified plant pallet

Maintenance access

Checklists

- Condensed version of manual
- Developed for each section of the manual
- Reduce maintenance activities to a summary
- Eliminate photos
- Identify key performance indicators
  - monitoring and reporting

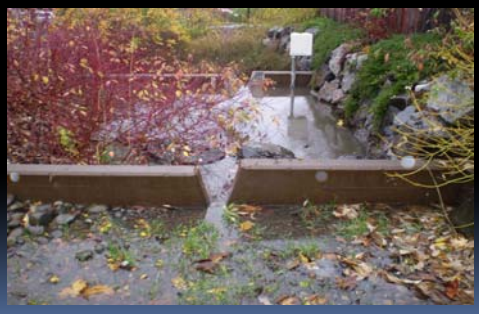


Key Performance Indicators (KPI's)

- Data includes
  - Project location
  - Drainage area
  - Maintenance target
  - Reporting of maintenance LOS achieved
- Provides
  - Accountability
  - Reporting method
- Excellent asset management tool for management


NDS KPI Reporting Form
UBM Urban Watersheds

Life Cycle Costs



Life Cycle Costs - Pinehurst

- Present value of O&M + construction costs
- LCC for Pinehurst (47,290 ft²)
  - $1.2M+ $5.2M = $6.4M
- Initial estimates
  - $4.8 million construction cost
- Comparable project to retrofit $8.9 million
- Total project cost 453K for 660 ft blk
  - Includes all design, project management, const. cost
- Present value of O&M costs compared to traditional systems is significantly less

Construction Costs

- $280,000 for 660' block
- 42% Stormwater elements (including soil)
- 45% Street improvements (road, curb, sidewalk)
- 13% Landscaping

Maintenance Costs

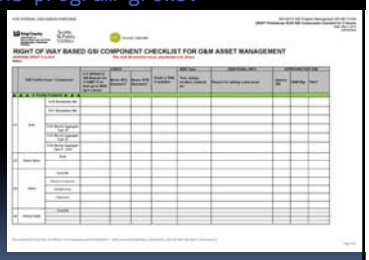
Total Maintenance Cost

- Total $$ = Vegetation + Hardscape
- Initial Vegetation – 3 years
  - SPU cost: $2.21
  - Watering method and frequency increase cost up to 4X
- Established Vegetation – 4 plus
  - SPU cost: $1.66
  - 25% reduction
- Replacement costs - $0.50 per sq. ft.
- Hardscape - $0.31 per sq. ft.

Additional tools and resources

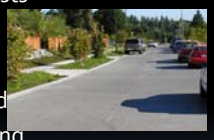
Example: Design Phase GSI ROW Checklist for O&M Asset Management to ensure consistency in approach as the program grows.

A. Facility Footprint
B. Inlets/Outlets/Pipes – Surface
C. Inlets/Outlets/Pipes – Subsurface
D. Vegetation
E. Mulch
F. Watering
G. Deep Infiltration (over 6 feet)
H. Permeable Pavement Facility
I. Hardscape/ Specialty Elements


RIGHT OF WAY BASED GSI COMPONENT CHECKLIST FOR O&M ASSET MANAGEMENT

Porous Pavement

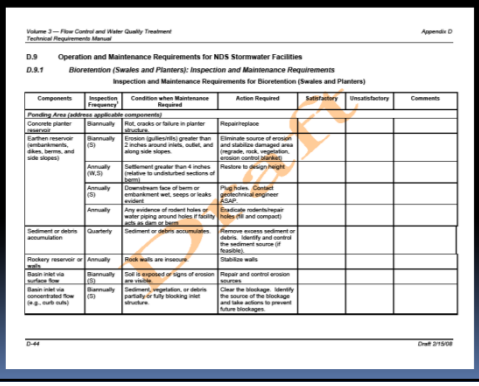
- SPU porous pavement spec
- Inspector and installer checklists
- BMP's
- Levels of services
- Frequency schedule & method
- Standardized infiltration testing
- Recommended maintenance activities
- Technical Report -available



Client Assistance Memo's

- Mostly for Private Facilities
- Post Construction Soil Management
- Bioretention Cells (Rain Gardens)
- Permeable Pavement Surfaces and Facilities
- Tree Planting
- Green Roofs
- Bioretention Planters

Private Property O&M



Volume 3 — Flow Control and Water Quality Treatment Technical Requirements Manual *Appendix D*

D.9 Operation and Maintenance Requirements for NDS Stormwater Facilities

D.9.1 Bioretention (Swales and Planters): Inspection and Maintenance Requirements

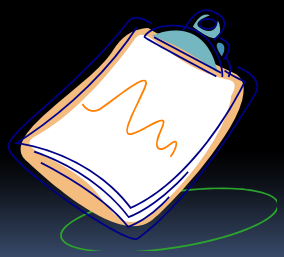
Inspection and Maintenance Requirements for Bioretention (Swales and Planters)

Components	Inspection Frequency	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Ponding Area (address applicable components)						
Concrete planter reservoir	Biannually	Pot, cracks or failure in planter structure.	Repair/replace			
Earthen reservoir (embankments, dikes, berms, and side slopes)	Biannually (S)	Erosion (gullies/rills) greater than 2 inches around inlets, outlet, and along side slopes.	Eliminate source of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control blanket).			
	Annually (W,S)	Settlement greater than 4 inches (relative to undisturbed sections of berm)	Restore to design height			
	Annually (S)	Downstream face of berm or embankment wet, seeps or leaks evident	Plug holes. Contact geotechnical engineer ASAP.			
	Annually	Any evidence of rodent holes or water piping around holes if facility acts as dam or berm	Eradicate rodents/repair holes (fill and compact)			
Sediment or debris accumulation	Quarterly	Sediment or debris accumulates.	Remove excess sediment or debris. Identify and control the sediment source (if feasible).			
Rockery reservoir or walls	Annually	Rock walls are insecure.	Stabilize walls			
Basin inlet via surface flow	Biannually (S)	Soil is exposed or signs of erosion are visible.	Repair and control erosion sources.			
Basin inlet via concentrated flow (e.g., curb cuts)	Biannually (S)	Sediment, vegetation, or debris partially or fully blocking inlet structure.	Clear the blockage. Identify the source of the blockage and take actions to prevent future blockages.			

D-44 *Draft 3/15/09*

ROW Facilities - documentation

- Construction and installation checklist
- Plan review checklist for bioretention
- Plan review checklist for permeable pavements
- GSI Restoration and Repair Manual



SPU Specifications:

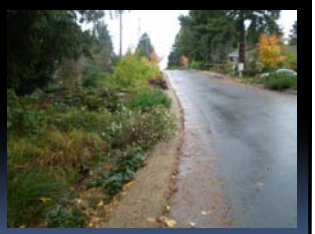
- Bioretention infiltration testing
- Porous pavement infiltration testing
- Bioretention soil
- Permeable/porous pavement
- Weir installation

Inspection Processes and Protocols

Successful liner installation

Evolving Systems

- Work, work, work with field or contracting crews
- Update photos to continue refining doc.
- Document learned
- Include BMP's




Minimal maintenance – Functioning system
•Erosion control during plant establishment (3yr)
•Tree canopy (leaf litter)
•Plant pallet (bushes shade swale bottom)


•Planting season
•Plants available
•Interim?

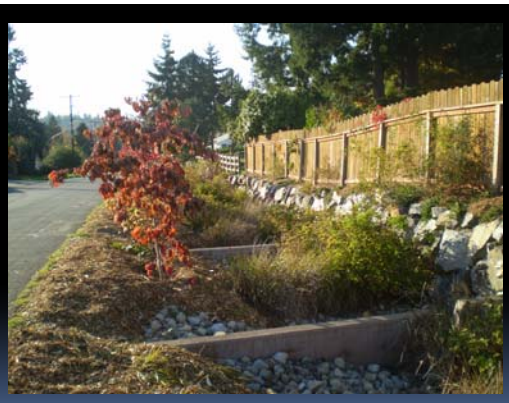

Maintenance can be overwhelming


Acceptable? Still functions


•Invasives
•Aesthetically unpleasing
•Neighborhood nuisance
•Still functions


Street edge parking?
Erosion
Compaction


•Street Edge
•Parking
•Access to vehicle
•Erosion control
•Vegetation/bushes
•Rock?
•Vegetation/ground cover?
•sheet flow
•Mulch?



www.seattle.gov/util/naturalsystems