

Green Stormwater Infrastructure: Operations & Maintenance Program

Finding solutions to NPDES permit asset management requirements

Drainage Basin Type

Creek

Polluted stormwater runoff drains directly to urban creeks, untreated. Seattle's urban creeks are: Thornton Creek, Pipers Creek, Longfellow Creek, Taylor Creek, Fairview Creek, and Schmitz Creek.

Combined

Polluted stormwater runoff combines with sewage water in one pipe. Combined runoff and sewage can overflow directly into water bodies untreated during rain storms. In drier weather, water is treated by a wastewater treatment facility.

Partially Separated

Polluted stormwater runoff from roads and the roofs of older buildings drains to a "separated" stormwater pipe underground, and discharges into waterbodies like Puget Sound and Lake Washington.

Stormwater runoff from roofs of newer buildings drains to a "combined" sewer.

Fully Separated

Polluted stormwater from roads, roofs, and downspouts drains to a "separated" stormwater pipe underground and discharges into waterbodies like Puget Sound and Lake Washington.

All Basin Types



Management Goals

Kind of Storm to Manage

Sustain creek biology

Small - Medium

Preserve base flow
in summer

Small (frequent)

Improve water quality
in creek

Small (frequent)

Prevent combined sewer overflows
into Puget Sound, Lake Washington,
Salmon Bay & the Ship Canal, and
Longfellow Creek.

Small (frequent)

This can be achieved by preventing
stormwater volume from reaching the
combined pipe or by delaying the
flow until after the peak of the storm
has passed.

(We have combined
sewer overflows with
as little as 1" rain)

For runoff from roofs, refer
to combined system.

For runoff from roads and side
walks, refer to separated
system.

Clean and slow polluted
stormwater run-off before it is
discharged into receiving
water bodies like Puget Sound,
Lake Washington, or the
Duwamish River.

Small (frequent)

Preserve the finite capacity and
function of our existing underground
(pipe and pump) stormwater system so
that we can adapt well to changes in
precipitation and to new urban growth.

Small - Large

Avoid having to build new (expensive
and disruptive) underground facilities.

Small - Large

Convey stormwater runoff to protect
public health and safety, prevent
flooding and prevent damage to
public infrastructure.

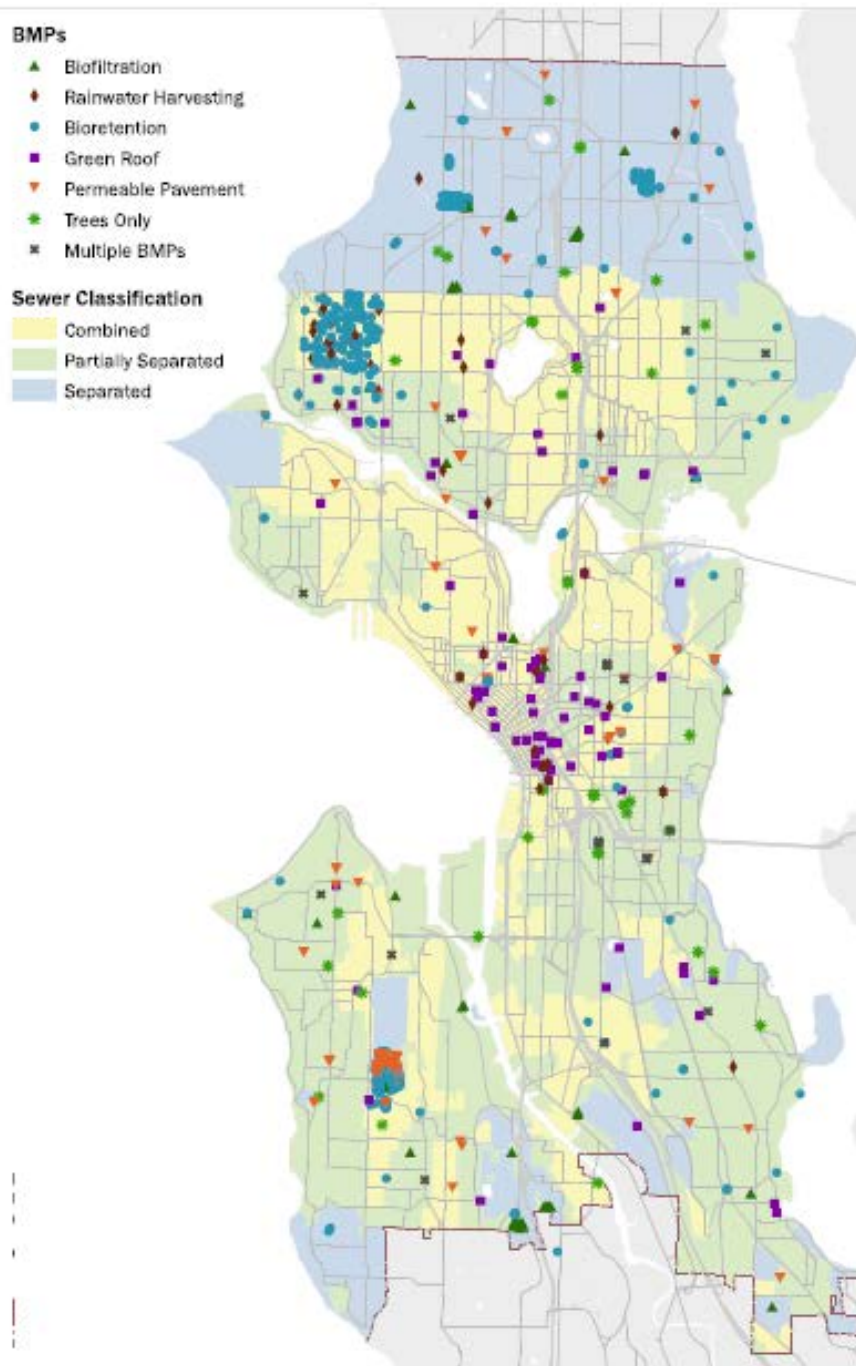
Medium - Large

BMPs

- ▲ Biofiltration
- ◆ Rainwater Harvesting
- Bioretention
- Green Roof
- ▼ Permeable Pavement
- ★ Trees Only
- ✱ Multiple BMPs

Sewer Classification

- Combined
- Partially Separated
- Separated



GSI Program Current and Forecasted



Current (2000-13):

- Approx 4 acres of vegetated area
- \$500K O&M budget

Forecasted: 2015-2020 (area managed):

- SPU: 42 acres
- SDOT: +/- 2.5 acres
- KCWTD: 442 acres
- Code Required: ~12 blks per year
- \$1.3M O&M budget

SPU/WTD's Practice Changes

- **Asset management tracking**
 1. Equipment #'s (EQ#'s) assigned and noted on CD level drawings
- **Design for major program maintenance**
 1. Improve standard design and specifications (ROW Improvement Manual and standard details)
 2. 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. (O&M vetted in design)
- **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

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

FOR INTERNAL DISCUSSION PURPOSES

SPU/WTG GSI Program Management SPU #C12-004
DRAFT Preliminary ROW GSI Components Checklist for O Assets
Date: May 5, 2014
SVR #12034



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

WORKING DRAFT 5-3-2014

This draft Bioretention focus -placeholders for others

Notes:

GSI Facility Asset / Component		CHECK		Asset or EQ# If available	NEW Type	ADDITIONAL INFO	APPROVED FOR USE		
		Is it defined in GSI Manual Vol V-Q&M? If no then go to NEW type column.	Meets SPU Standard?		Meets WTD Standard?	Tool, design, location, material etc	Reason for adding a new asset	Agency PM	O&M Mgr
▲ ▲ ▲ A. Facility Footprint ▲ ▲ ▲									
A1	Soils	COS Bioretention Mix							
		ECY Bioretention Mix							
		COS Mineral Aggregate Type 26							
		COS Mineral Aggregate Type 24							
		COS Mineral Aggregate Type 6 - sand							
A2	Check Dams	Rock							
A3	Weirs	Concrete							
		Wood or Composite							
		Boulder/stone							
		Segmental							
A4	Vertical Walls	Concrete							

Maintenance Management-Current

- Two crews
 - Hardscape: city crew
 - Landscape: contractor through 2020
- Semi annual inspections
 - pre fall
 - pre spring
- Post storm events



Operations and Maintenance- Future

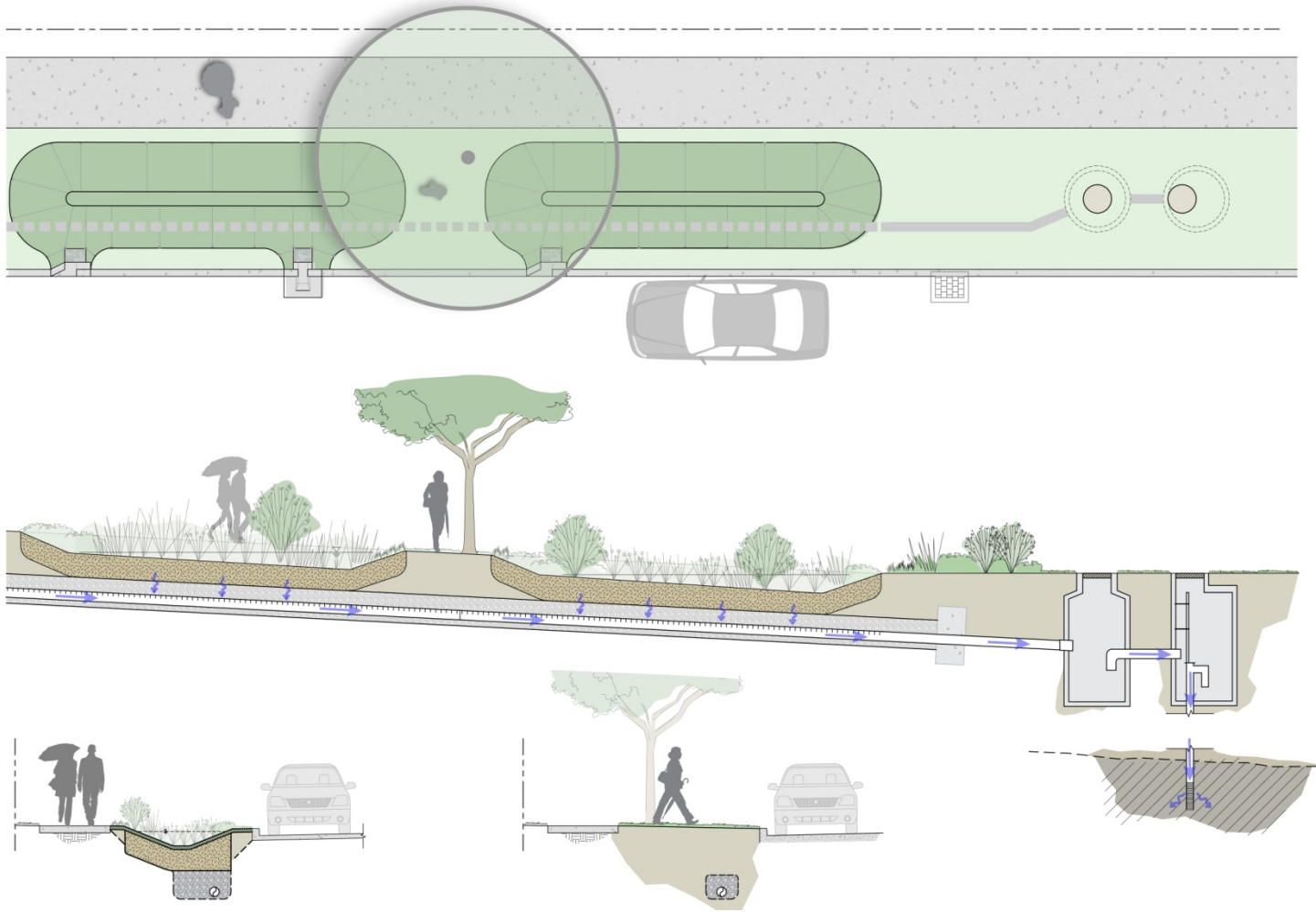
- **Operations and Maintenance Manual Update**
 1. Landscape Maintenance (Acceptable/Unacceptable)
 2. Hardscape Maintenance
 3. Structure Maintenance UIC's
 4. O&M Facility Checklists
- **Maintenance Costs**
 1. Staffing and outsourcing
 2. Equipment & Materials
 3. Communications (engagement, notice, reporting)
- **GIS- assess based tracking**

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



Right of Way Context- Typical Elements



Focus on Acceptable

ACCEPTABLE MAINTENANCE



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

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

Acceptable Meets Permit Requirements

- Ex: Stormwater sedimentation structures are less than ½ full or in accordance with NPDES requirements
- Annual reporting for documenting achievement of minimum requirement for SPU Management & WA ECY



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



ROUTINE MAINTENANCE GUIDELINES FOR ESTABLISHED (1-3 YEARS AF
INTERNAL WORKING DRAFT 4-30-2014 This draft Bioretention Only

Notes:

1. The following table for SPU/WTG GSI program for bioretention (in City ROW) is based on the "Guidance Document: Western Washington Low Impact Development (LID) Op
2. Click on the photos to link to an enlarged image and description. Click on the enlarged image to return to the table.

^a Frequency Code




R = Routine Visits (March, July, September and October - Adjust fall visits to follow tree leaf drop)

M=Monthly

A = Annual visit in September (unless otherwise noted)

W= Weekly

B = Biannual visits in March and September (unless otherwise noted)

GSI Facility Asset / Component		Priority for Function or Safety	INSPECTION Observation or Troubleshooting (Note 1. See also Long Term Table)	C O D E ^a	Frequency	Est. Crew Hrs	Maintenance Activity (Crew)	C O D E ^a
◆ ◆ ◆ Major Storm or Weather Events ◆ ◆ ◆								
	Curb Cuts, Catch Basins (CB), and Weirs	HIGH PRIORITY	<input type="checkbox"/> Blockage	–	<input type="checkbox"/> Before Storm/Notification of Storm Event <input type="checkbox"/> After Storm Event <input type="checkbox"/> After CSO Notification		<input type="checkbox"/> Remove at a minimum blockages/leaves from drain curb cuts at presetting zones, from the curb cut at the first cell after presetting and from the curb cut at the low point or corner. Remove blockages from all curb cuts if time allows. <input type="checkbox"/> Remove blockages from weirs and last CB	–
	Street Surface	HIGH PRIORITY	<input type="checkbox"/> Sand or salt	–	<input type="checkbox"/> After snow storm		<input type="checkbox"/> Sweep if sand or salt is used during a snow event and the City does not sweep	–
	Extreme drought/ Water Restrictions	HIGH PRIORITY	<input type="checkbox"/> Extreme Drought <input type="checkbox"/> Water restrictions	–	<input type="checkbox"/> Water restrictions		<input type="checkbox"/> Water facility bottom area vegetation first. <input type="checkbox"/> Limit water to remaining planted areas.	–
▲ ▲ ▲ A. Facility Footprint ▲ ▲ ▲								
A1	Soils	  	<input type="checkbox"/> Soil protection during maintenance	–	–		<input type="checkbox"/> When possible, perform maintenance work when soils are dry to prevent compaction and damage to soil structure.	–
			<input type="checkbox"/> Erosion and washouts	B	March September		<input type="checkbox"/> Fill in erosion gullies and clean up washouts <input type="checkbox"/> Install temporary erosion control measures until permanent repairs are made <input type="checkbox"/> Identify and remedy what is causing erosion and/or or washouts <input type="checkbox"/> Place cobbles or other erosion protection measure where concentrated water flows	R
			<input type="checkbox"/> Settlement	B	March September		<input type="checkbox"/> Add mulch when settlement is less than 4 inches	R
			<input type="checkbox"/> Vegetative cover	B	March September		<input type="checkbox"/> Observe and report if plant coverage is less than 75% at bottom zone	B
			<input type="checkbox"/> Water is not draining ¹ <input type="checkbox"/> Sediment accumulation	B	March September		<input type="checkbox"/> Report non-draining swales <input type="checkbox"/> Remove sediment <input type="checkbox"/> Attempt to identify and remedy source of sediment	R
A2	Check Dams		<input type="checkbox"/> Blockage <input type="checkbox"/> Backed up water <input type="checkbox"/> Undercutting ¹	A	September		<input type="checkbox"/> Remove surface blockages, debris, sediment & fall leaf litter	R
A3	Weirs	HIGH PRIORITY	<input type="checkbox"/> Blockage <input type="checkbox"/> Backed up water <input type="checkbox"/> Undercutting ¹	B	March September		<input type="checkbox"/> Remove surface blockages, debris, sediment & fall leaf litter	R

Example: Infiltration Failure

Function & Safety Unacceptable

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



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.

Permeable Pavements

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



Additional Tools and Resources

- Internal-Inter Departmental Team
 1. Reviews next practices
 2. Integration with Standard Details and Specifications
 3. Right of Way Improvement Update
- External- Partnership with King County Waste Water Treatment Division
 1. Joint program
 2. Common GSI Manual
 3. Community engagement- consistent messaging
 4. Staffing resource – adds expertise
- Common Community Engagement Plan
- Permeable pavements
- Client Assistance memos or TIP's

Client Assistance Memos

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

GIS Integration



GIS Integration & Role in GSI Asset Management

- Map/Model GSI infrastructure and provide a spatial inventory of GSI assets
- Allow synchronization between GIS and internal business systems
 - DWW GIS staff maintained tables
 - Maximo asset management system
 - User tables updated by GSI subject matter experts (data stewards)
- Publish GSI presentation data to users and provide tools for research and investigation

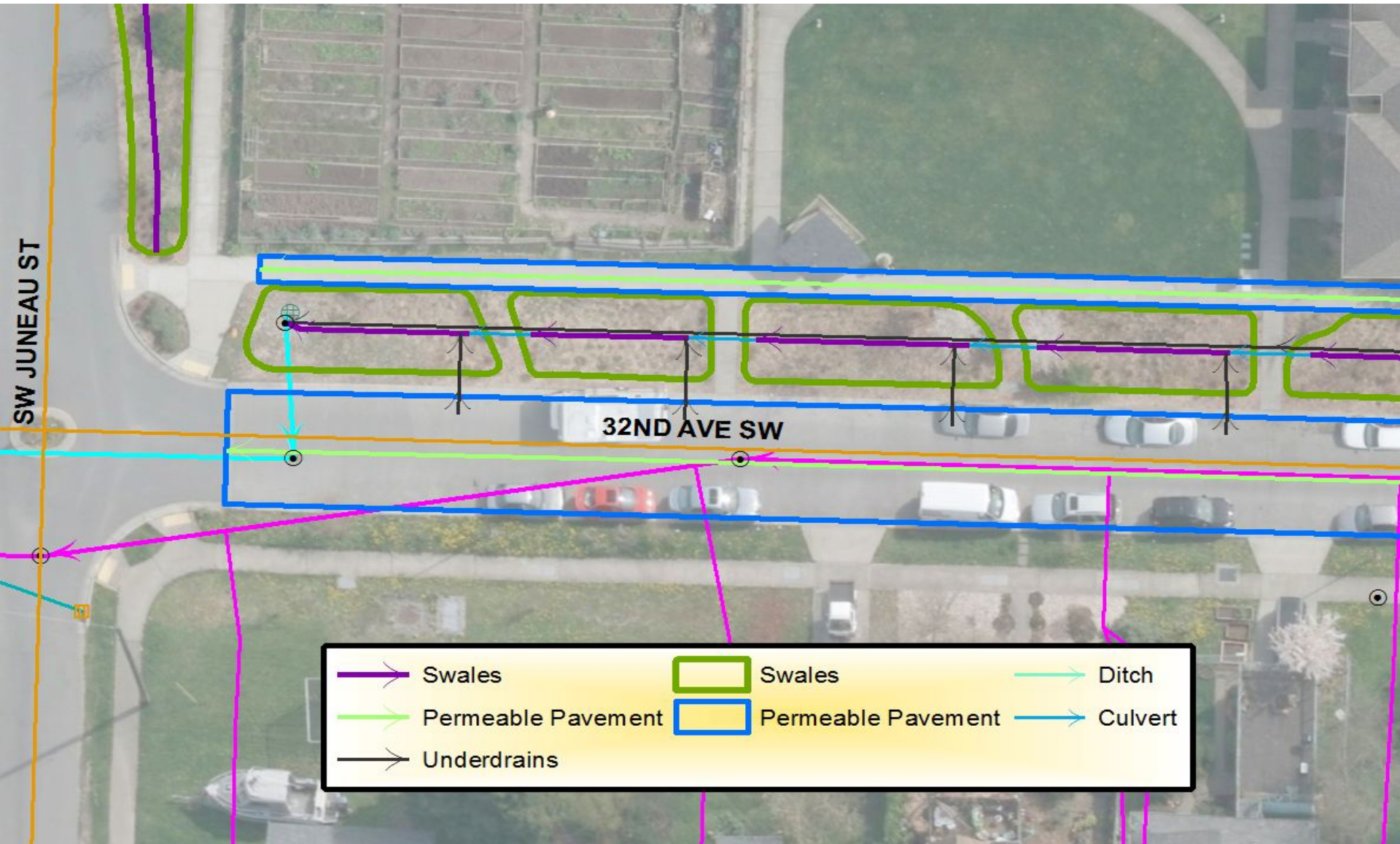
- Source Document – Engineering Drawing

SEE SHEET C3.01

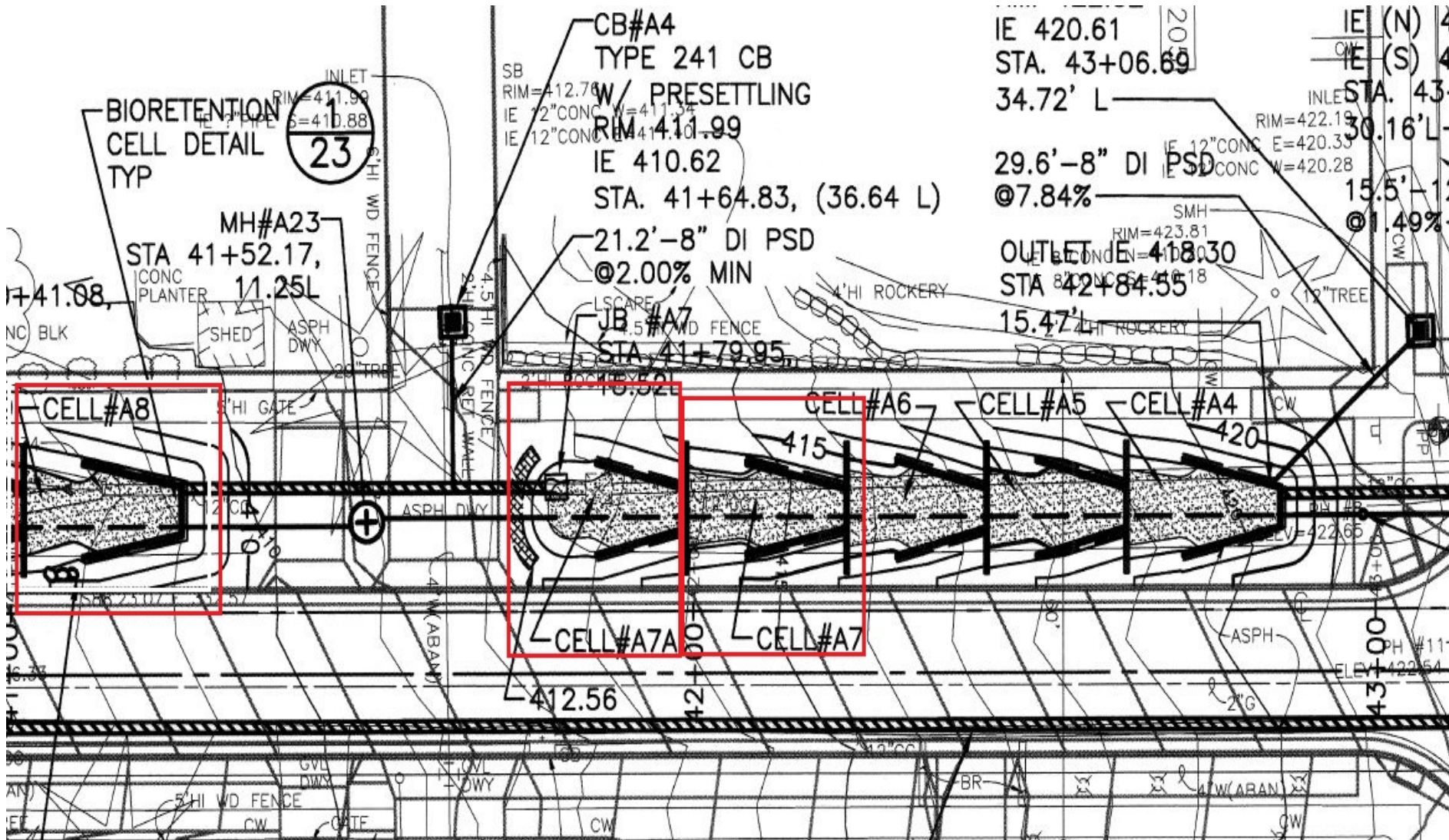
This engineering plan view illustrates a stormwater management system located along SW Juneau St. The system consists of four primary detention cells, labeled CELL 1a-1 through CELL 1a-4, which are highlighted by red rectangular boxes. Each cell contains a series of parallel, rounded structures designed for water storage and sedimentation.

- Cell Details:**
 - CELL 1a-1:** Includes a "PSDMH 12.30" inlet structure at station 14+00.
 - CELL 1a-2:** Located between stations 14+00 and 15+00.
 - CELL 1a-3:** Located between stations 15+00 and 16+00.
 - CELL 1a-4:** Located between stations 16+00 and 17+00.
- Inlet Structure:** A "UTILITY TRENCH DAM" is shown at station 12+00, leading into the first cell. It is constructed from "26 LF 12\" CORRUGATED HDPE (PSD) @ 4.6%".
- Swale Features:**
 - "TOP OF SWALE EDGE" and "BOTTOM OF SWALE EDGE" are indicated along the length of the system.
 - Slopes are specified as "2:1 MAX (TYP)" and "3:1 MAX (TYP)".
 - A "CLEANOUT (TYP)" is shown at the end of the fourth cell.
- Infrastructure and Notes:**
 - The system runs parallel to SW Juneau St, which has an asphalt surface.
 - Stationing is marked along the alignment: 14+00, 15+00, 16+00, and 17+00.
 - A note indicates to "CONNECT TO EX PSDMH AND RECHANNEL MH" near station 15+00.
 - Another note refers to "CHECK DAMS PER SHEET C2.32".
 - Other features include "6\" PSS (R)", "6' Board Fence", and "5' OLF".

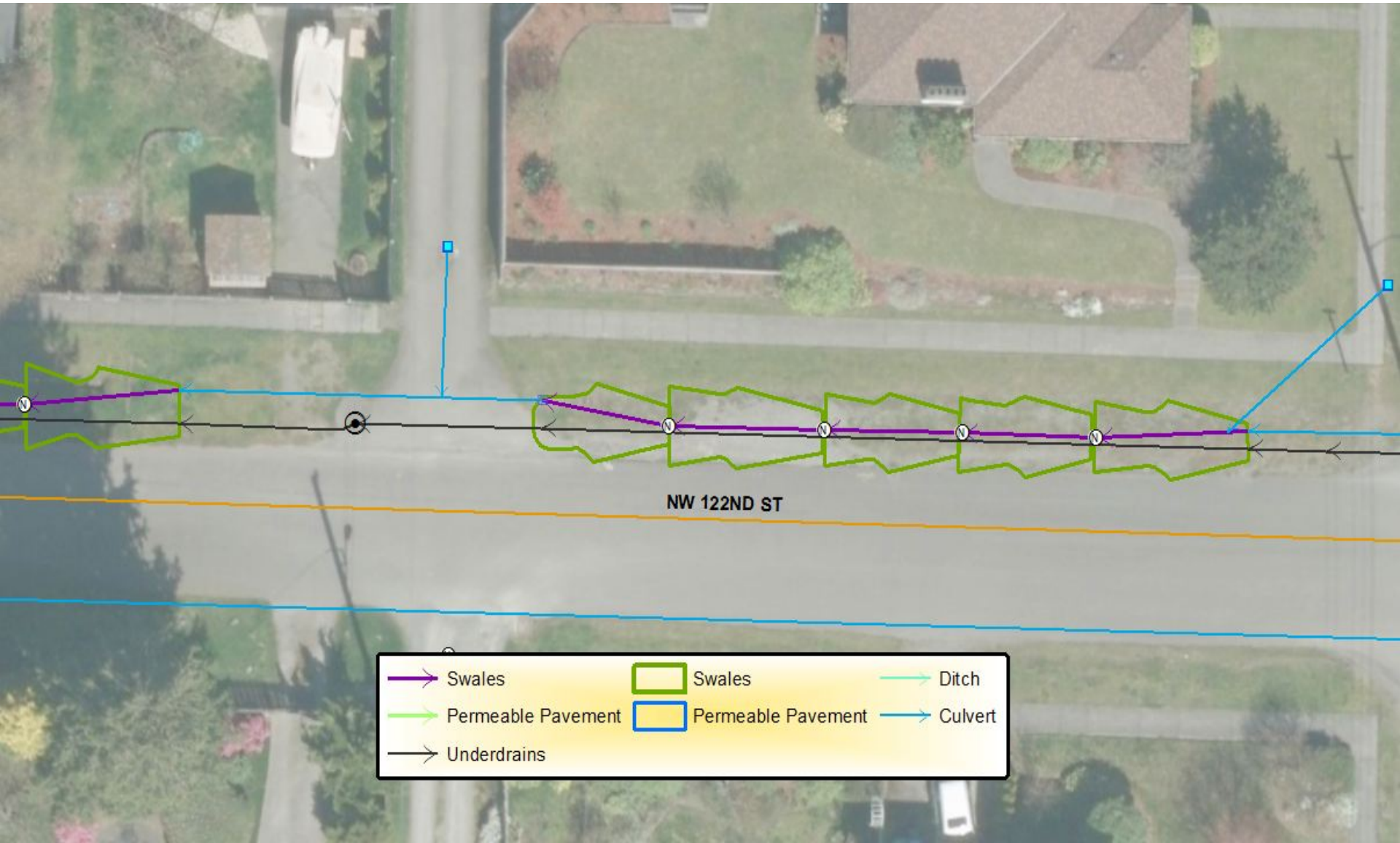
GIS Representation – High Point



Source Document - Engineering Drawing



GIS Representation – Venema Natural Drainage



Maximo Asset Management System Integration

- All assets in GIS are assigned a unique feature key
- Weekly synchronization process between Maximo and GIS creates a relationship between the GIS feature key and Maximo asset number
- Enables GIS to be used as a tool for work order creation
- Child asset mapping – relationship allows us to map assets that don't actually live in GIS (i.e. hydrobrakes, weirs, sluice gates)

GSI Data Steward Integration

- Generic Table Editor (GTE)

The screenshot displays the Generic Table Editor (GTE) application window. The title bar reads "Generic Table Editor (SPUGISP)".

Tables: DWW.BIORETENTION_SWALE

Target Layers: DWW Ditches, Culverts, Surface Drainage

Buttons: Query, Find, Sort, Refresh, Export

	CELL WARRANTY SERVICE LEVEL	CELL WARRANTY RESPONSIBILITY	ROUTINE MAIN START MM/DD/YYYY	CELL ROUTINE MAIN SERVICE LEVEL	CELL ROUTINE MAIN RESPONSIBLE	DRAINAGE AREA SQUARE FEET	NEW REPLACE SURFACE AREA SQ
▶	Service Level B	Private		Service Level B	Private		
	Service Level B	Private		Service Level B	Seattle Public Utilities	5662800	
	Service Level B	Private		Service Level B	Seattle Public Utilities	5662800	

Navigation: 1 of 187

☒ Edit Table

Buttons: Add, Undo, Redo, Commit, Delete, Undo All, Redo All, Exit

Layers:

- ☐ DWW Proposed Green Storm Infrastr
- ☒ Addresses
- ☐ Orthophoto - 2012, Color, Service Ar
- ☒ DWW Swales
- ☐ DWW Side Sewer & Laterals
- ☒ DWW Ditches, Culverts, Surface Drain
- ☒ JUNCTION POINT
- ☒ DWW Mainlines
- ☒ Streets
- ☐ DWW Catch Basins
- ☐ DWW Ditches and Culverts
- ☐ DWW Mainlines (Probable Flow)
- ☐ 2009 Aerial Photos

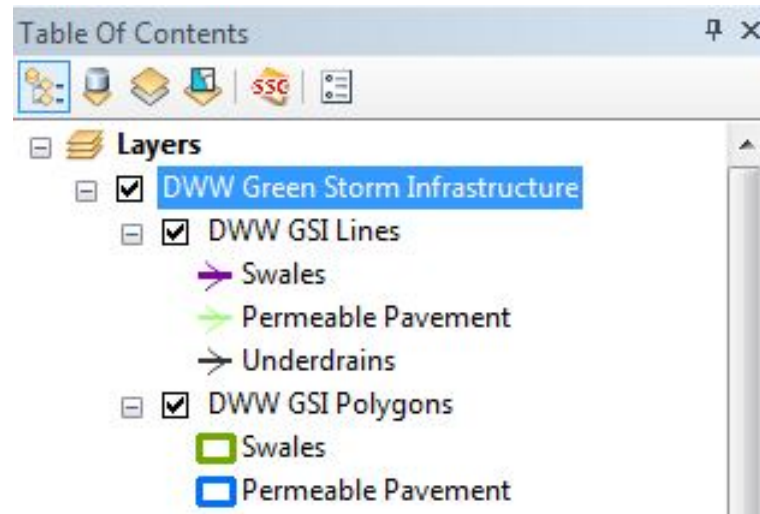
Map View: 1:255 scale. Labels include "MS SEWER SW", "Swale - High Point Revitalization", "Perm Pave - High Point Revitalization", and "Swale - High Point Revitalization".

GSI Data Steward Integration

- **Bioretention Swale Table & GSI Project Table**
 - Allows subject matter experts to enter information/attributes critical to asset management, maintenance, and compliance into a stand-alone table
 - This information is easily appended to the GIS presentation data
 - GSI projects are treated as systems with regard to preventative maintenance (PM) scheduling in Maximo
 - Enables users to link GIS assets that “live” in a particular project area to a unique project number (i.e. GSI007 = High Point Revitalization)
 - Linkage between asset and project is easily pushed to Maximo for PM work order creation

GSI Presentation Data

- “DWW Green Storm Infrastructure” layer



- Available for users of UtiliView or ArcMap
- Dataset compiled with input from DWW GIS staff, Maximo, and subject matter experts

Research Tool

Clear Research Tool Results		Export
Virtual Vault	Maximo	Side Sewer Cards CCTV

^ Catch Basins

^ Catch Basin [Asset Num = 564979] [ADDRESS = SWC MINOR AVE/MARION ST] [MAP AREA = 040]

^ Asset Info

^ Preventive Maintenance(s)

^ PM Number: 92116, Activity: Condition Based Maintenance

^ PM Number: 92115, Activity: Condition Based Maintenance

^ PM Number: 92114, Activity: Condition Based Maintenance

^ PM Number: 92113, Activity:

^ Work Order(s)

^ Work Order 2184522, Classification: CB/SB/JB/INLET INVESTIGATION, Job Plan: 2286, Report Date: 1/4/2010

Equipment Number = 564979

Equipment = CATCH BASIN - SWC MINOR AVE/MARION ST

[Work Order Number = 2184522](#)

Work Type = Reactive Maintenance

Work Group = DWRC

Priority = Public service interruption, regulatory violations, time-sensitive.

Description = INLET - MINOR AVE / MARION ST

Call Reason =

Cause = LEAVES

Problem = INLET MALFUNCTION

Remedy = CLEANED

Completed = 1/4/2010

Report Date = 1/4/2010

Target Start = 1/4/2010

Target Finish = Unknown

Address = MINOR AVE / MARION ST

Address Location = SWC MINOR AVE/MARION ST

Project = DRAINAGE INSPECTION

Assigned Person = SANTOSE

Actual Loaded Labor = \$54.68

Actual Material Cost = \$0.00

Actual Tool Cost = \$7.85

Summary:

ROW Facilities Documentation

- Design for O&M
- Asset management
- Construction and installation checklist
- Third party inspection checklist for construction closeout



Evolving Systems

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





Questions?

www.seattle.gov/util/naturalsystems