Going Green for Good: Long-Term Considerations for Operations and Maintenance of Green Infrastructure

Green Infrastructure Webcast Series

April 28, 2022

Housekeeping

- This presentation is being recorded and will be made available via https://www.epa.gov/green-infrastructure/green-infrastructure-webcast-series
- All participants are muted to minimize background noise.
- Technical issues or questions?
  - Contact us via the Q&A Box.

What is Green Infrastructure?

- Uses soils, vegetation, and other media to manage rainwater where it falls
- Treats stormwater before it could become a source of pollution
- Provides multiple benefits for communities

Water Infrastructure Improvement Act:
"the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest or reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters."
33 U.S.C. 1362(27)

Visit EPA's Green Infrastructure Website:
https://www.epa.gov/green-infrastructure/what-green-infrastructure

Green Infrastructure Operations and Maintenance

2022 Upcoming Green Infrastructure Webcasts

Research and Tools:

- May 18th: Ecosystem Benefits and Applications of Green Infrastructure
  - https://www.epa.gov/water-research/water-research-webinar-series
- June 2nd : Visualizing Ecosystem Land Management Assets (VELMA)
  - https://www.epa.gov/research-states/epa-tools-and-resources-training-webinar-series

Operations and Maintenance:

- Summer 2022: Green Infrastructure Asset Management
- Fall 2022: Green Infrastructure Jobs
- Recordings available online: https://www.epa.gov/green-infrastructure/green-infrastructure-webcast-series

Stay in touch: GreenStream List Serve

join-greenstream@lists.epa.gov

Today's Speakers

Dr. James Houle, Director of the University of New Hampshire Stormwater Center

Leslie Schehl, Stormwater Control Measures Maintenance Program Manager Metropolitan Sewer District of Greater Cincinnati

Peter Schultze-Allen, Senior Scientist at EOA, Inc.

University of New Hampshire

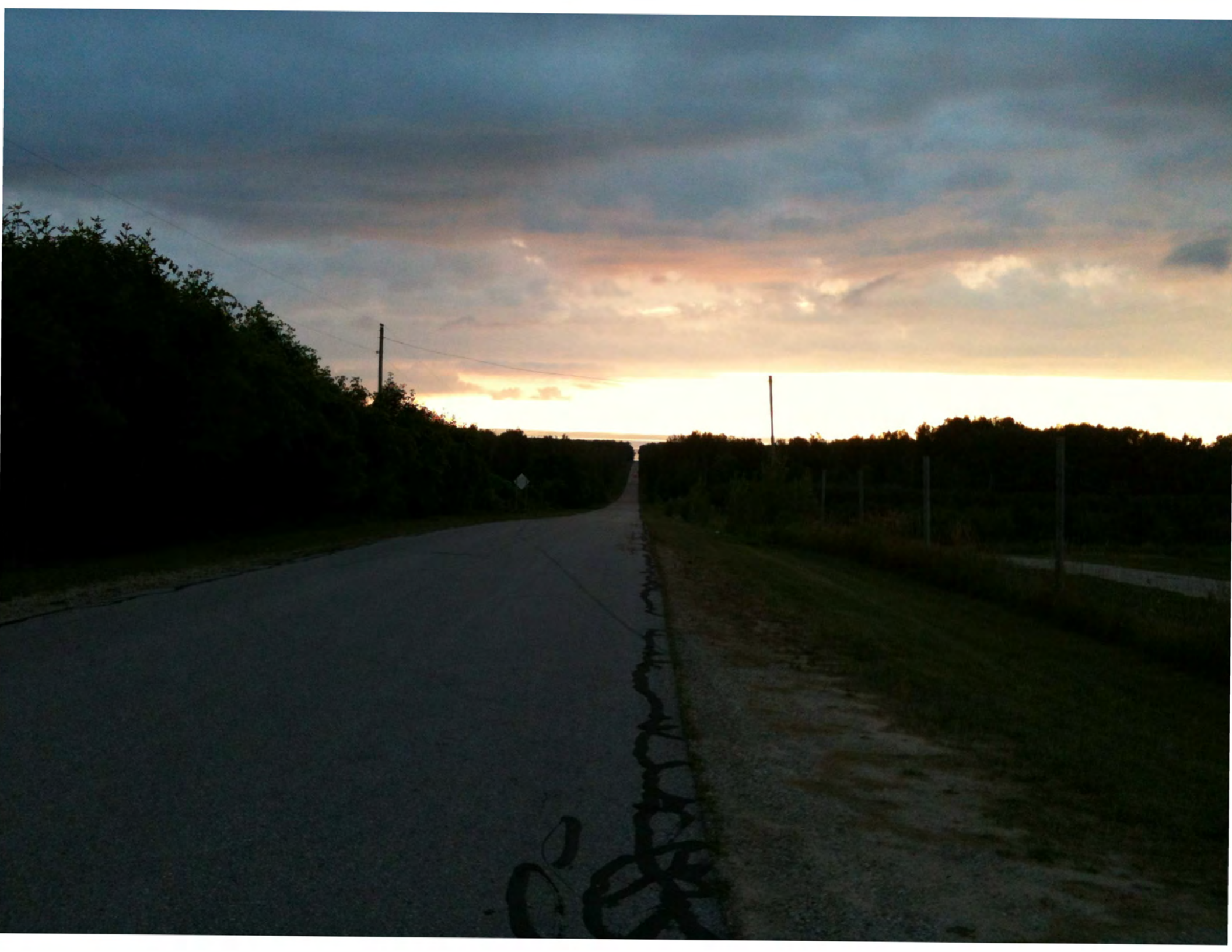
Green Infrastructure O&M Webcast, USEPA

James Houle, Ph.D, CPSWQ, CPESC

UNH Stormwater Center

April 28, 2022

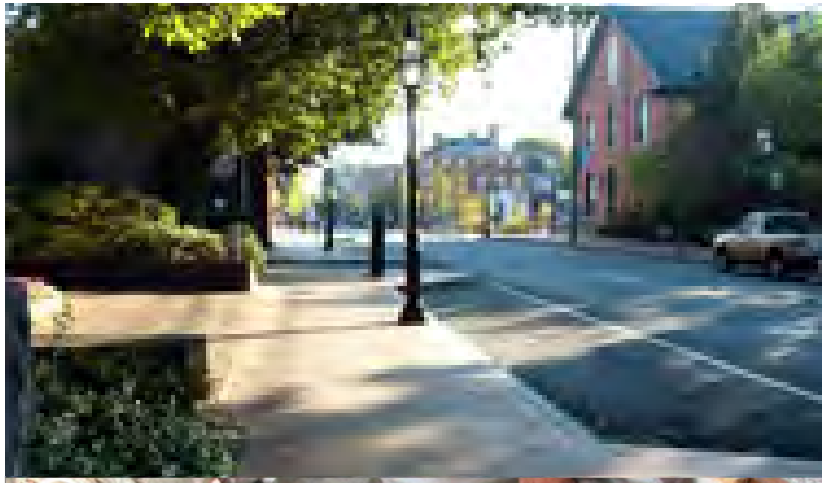


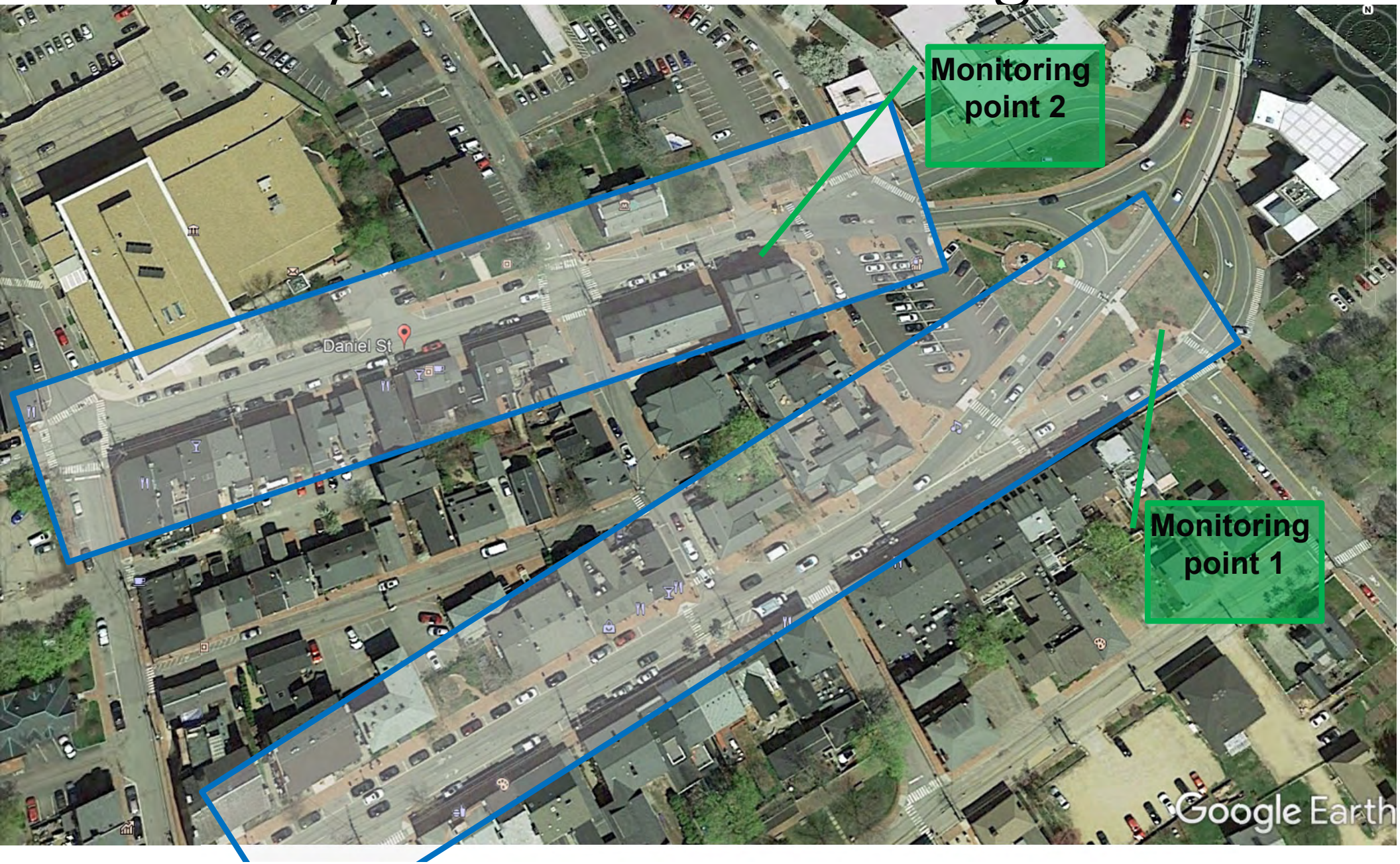

Brian

Outstanding Civil Engineering Achievement Award, 2010, American Society of Civil Engineers, NH Section

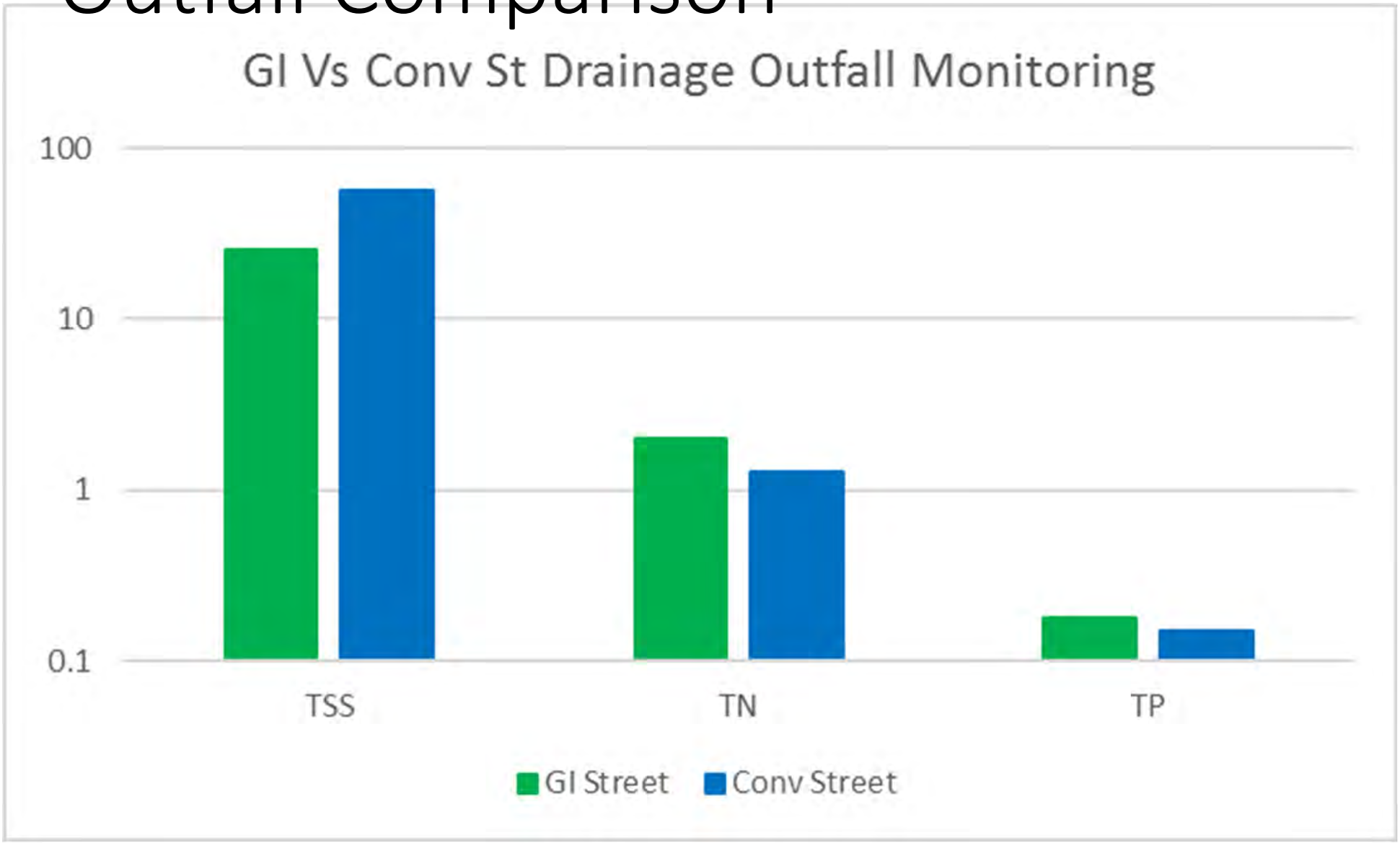
Complete reconstruction of utilities, including wastewater/stormwater separation and stormwater treatment, with construction of pedestrian- and business-friendly streetscape.



Side by side outfall investigation

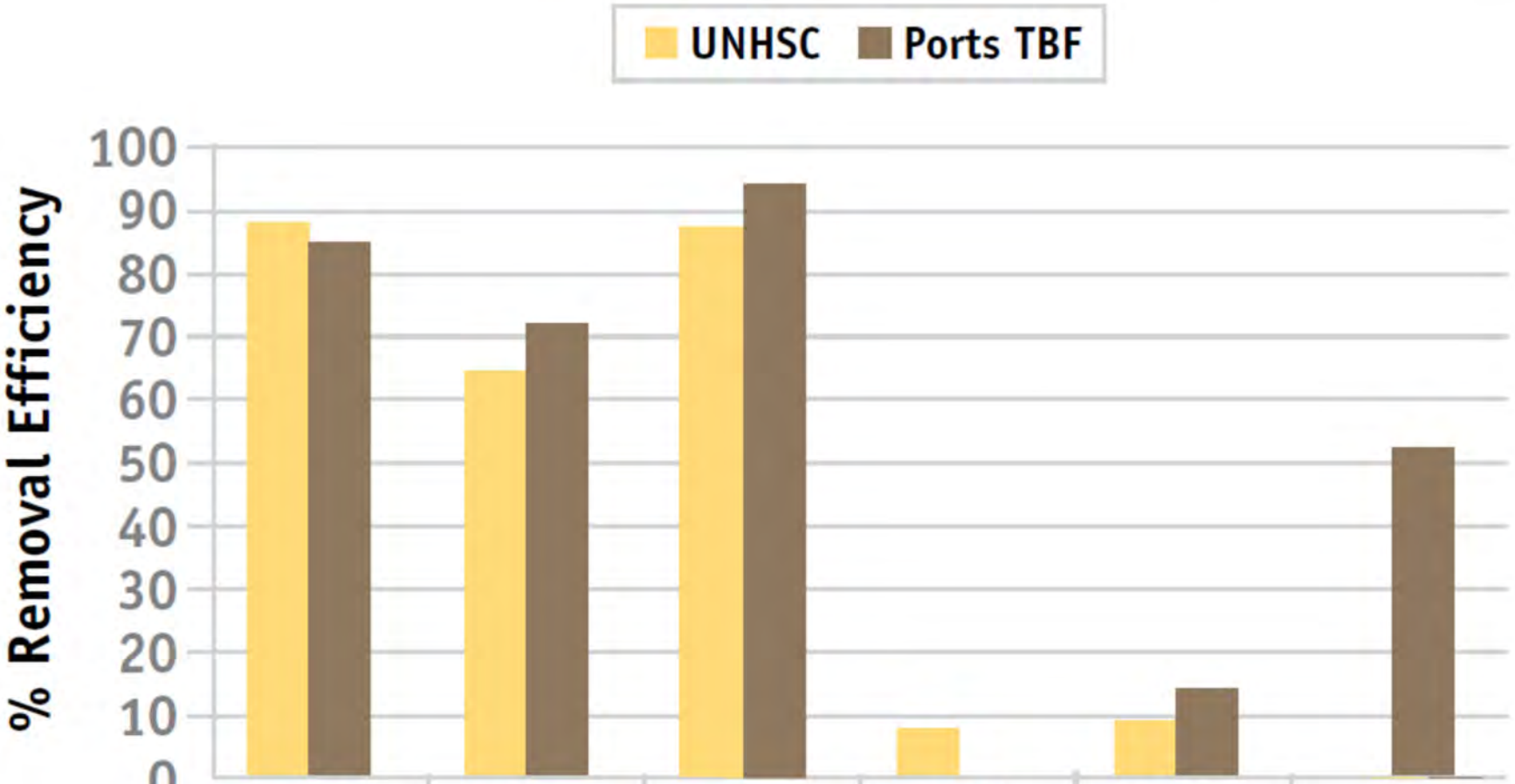


Outfall Comparison



- Location 1 = GI Location 2 = Conventional

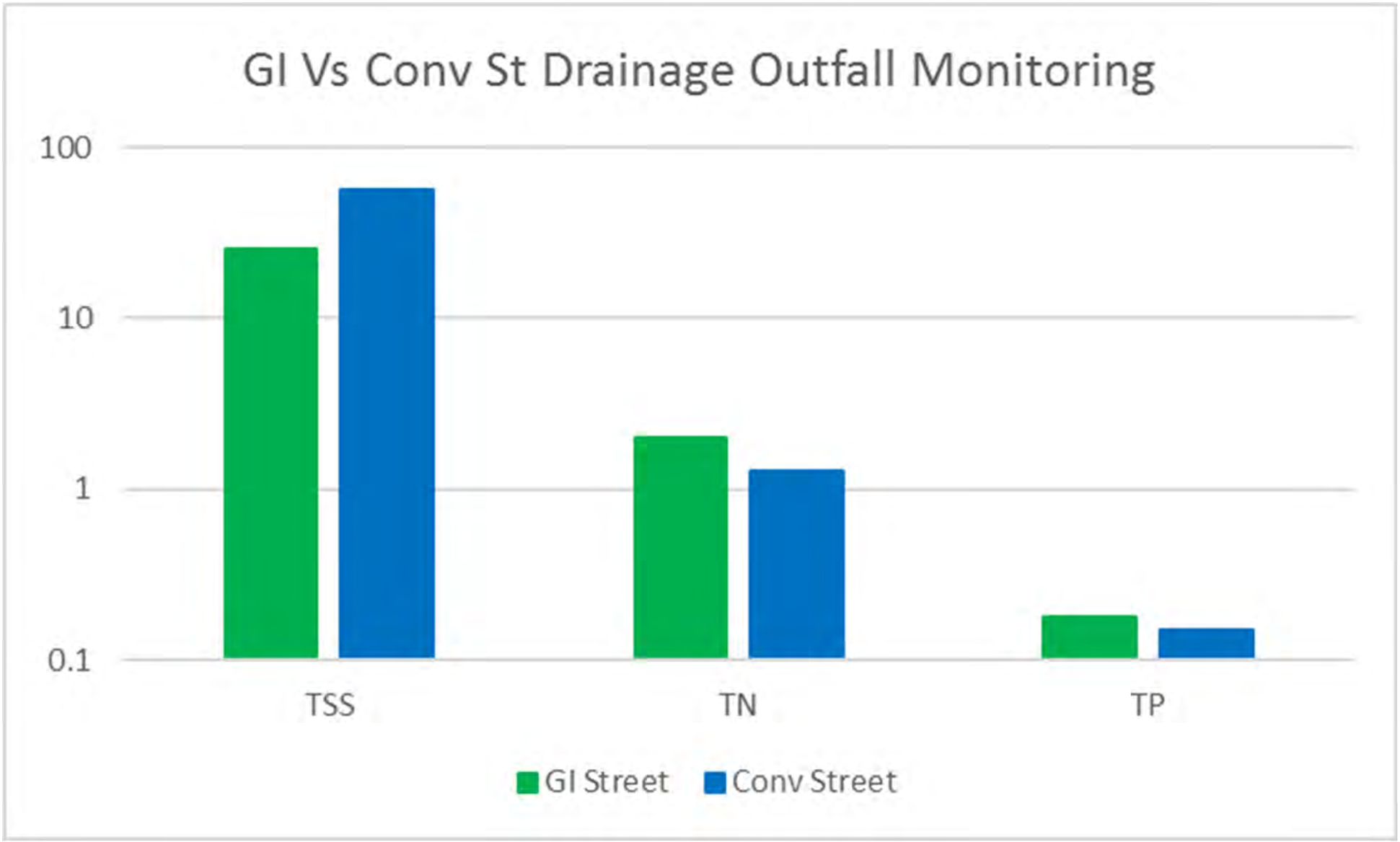
TREE FILTER PERFORMANCE



Median Annual Influent Event Mean Concentrations (EMC) in mg/L

	TSS	TPH-D	Zn	DIN	TN	TP
UNHSC	31	631	0.04	0.2	1.3	0.07
Ports TBF	39	520	0.10	0.2	1.5	0.21

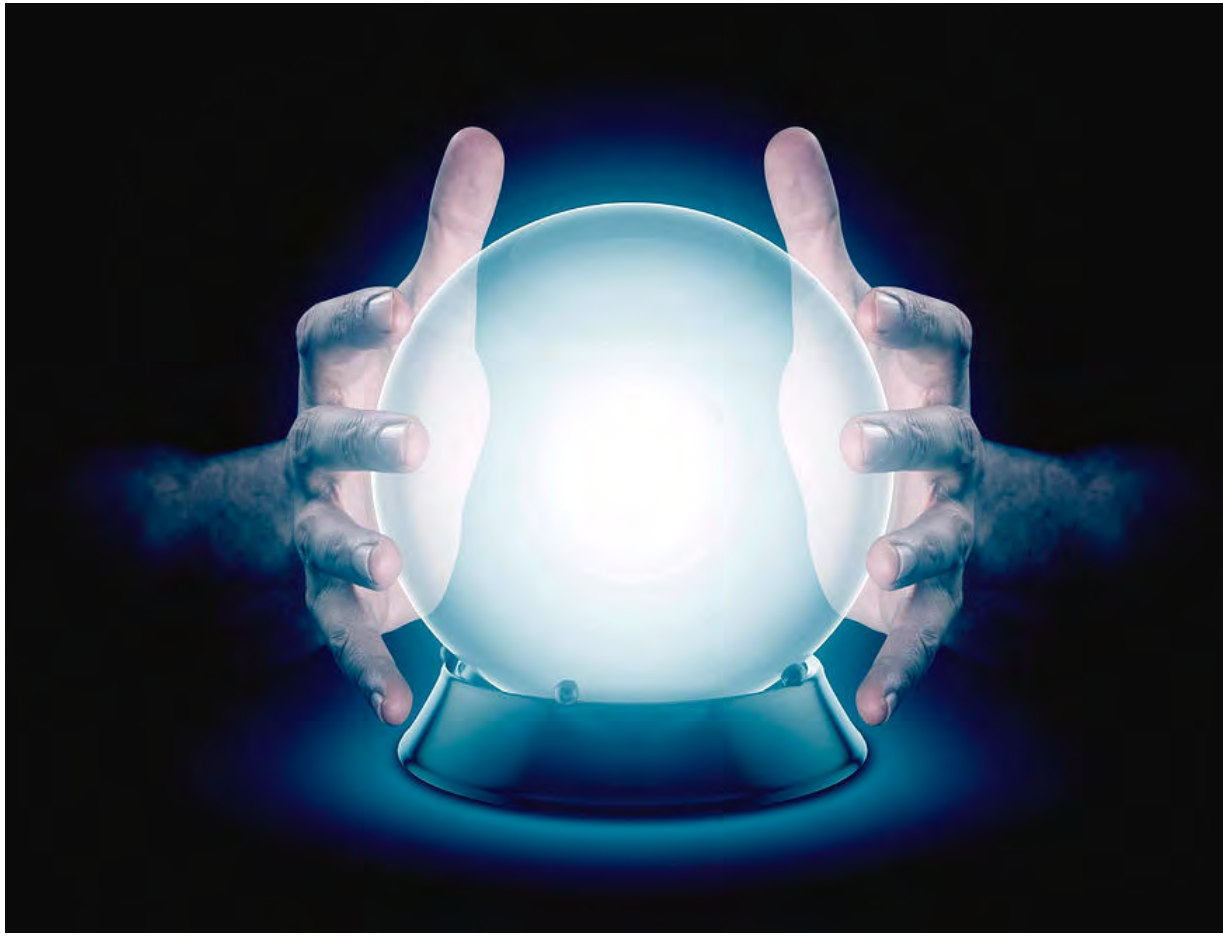
Outfall Comparison



- Location 1 = GI Location 2 = Conventional

Is this predictable?

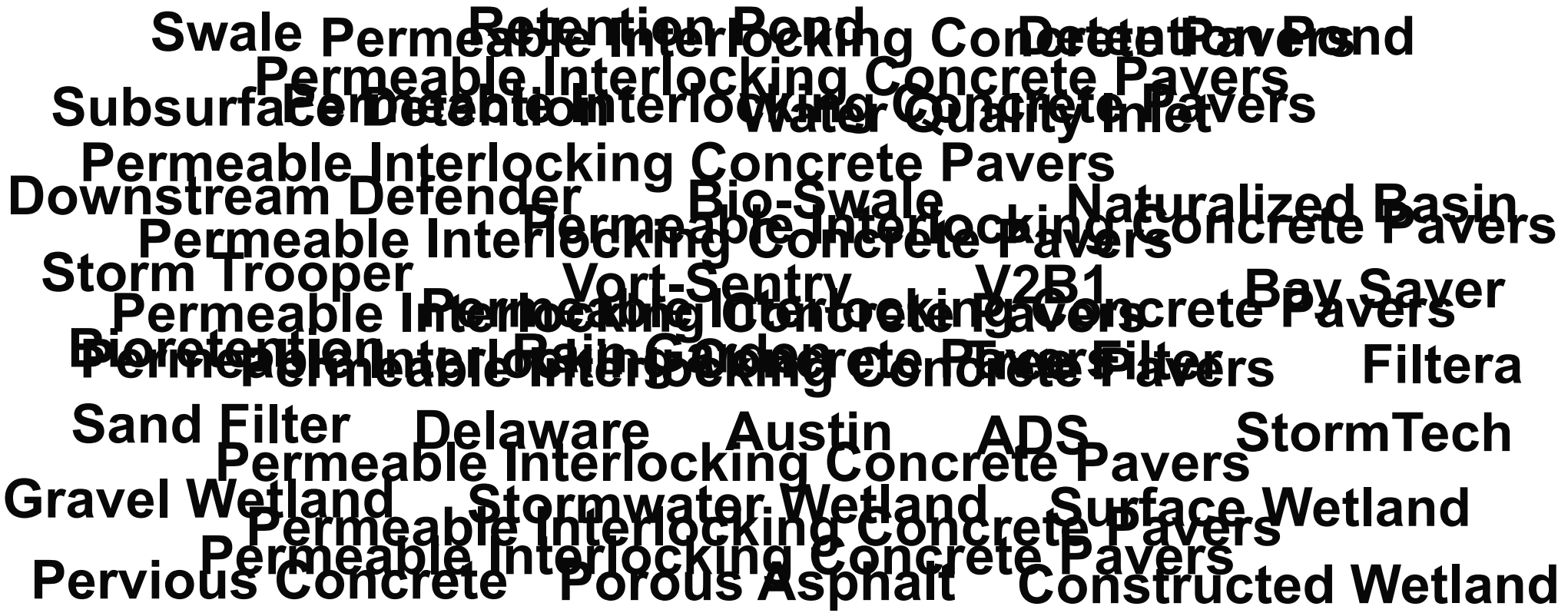
- Maintenance staff was not involved in the design,
- Little communication
- No co-development of solutions…



Maintenance December 2021

Stormwater Names Can Be Challenging

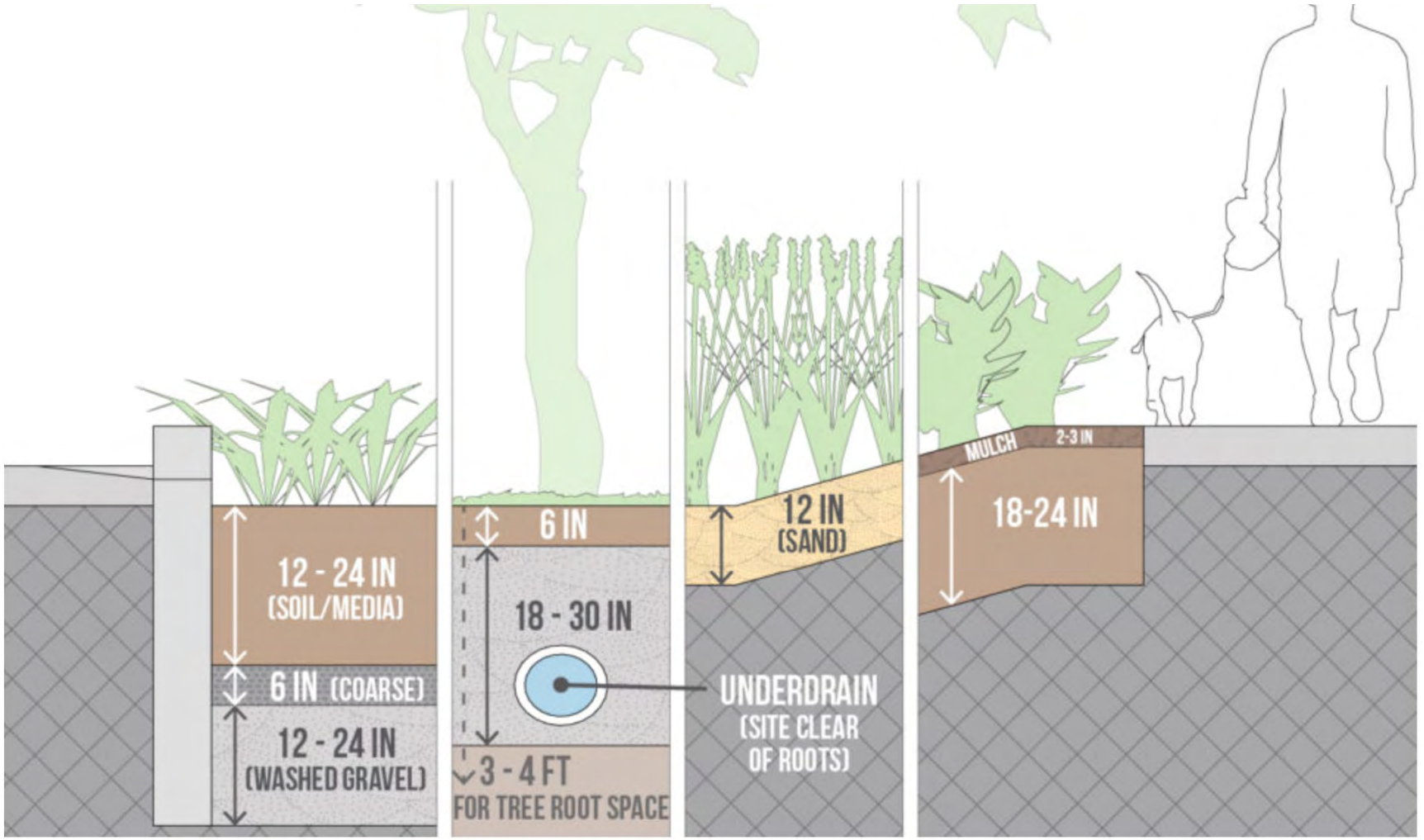
- Because we don't always speak the same language



Anatomy of a BMP

- System sizing – guided by local regulations, varies with respect to new development, re-development or retrofit.
- Inlet: Hydraulic contingencies, local code and maintenance preferences.
- Pretreatment: Maintenance contingencies, local code
- Outlet: Hydraulic contingencies, local code and maintenance preferences.
- Media and vegetation: Maintenance and aesthetic contingencies, local code

The “in-between”: flexible based on preference or opinion



https://nacto.org/publication/urban-street-stormwater-guide/stormwater-elements/bioretention-design-considerations/soil-media-plantings/

Traditional Approach

KEY	QUANTITY	NAME
	50	TUSSOCK SEDGE *(Carex stricta)*
	75	COMMON RUSH *(Juncus effusus)*
	350	SWITCHGRASS *(Panicum virqatum)*
	15	BLUE FLAB *(Iris versicolor)*
	50	JOE PYE WEED *(Eupatorium maculatum)*
	20	BLUE CARDINAL FLOWER *(Lobelia siphilitica)*
	100	FOX SEDGE *(Carex Vulpinoidea)*
	15	NEW YORK ASTER *(Aster novi-belgii)*
	20	NEW YORK ASTER *(Aster novi-belgii)*
	40	BLUE CARDINAL FLOWER *(Lobelia siphilitica)*
	50	NEW YORK IRONWEED *(Vernonia noveboracensis)*
	50	NEW ENGLAND ASTER *(Aster novae-angliae)*
	150	BITTER PANICGRASS *(Panicum amarum)*
	40	BLUE CARDINAL FLOWER *(Lobelia siphilitica)*
	35	BLUE FLAB *(Iris versicolor)*
	75	COMMON RUSH *(Juncus effusus)*
	50	NEW YORK IRONWEED *(Vernonia noveboracensis)*
	15	NEW YORK ASTER *(Aster novi-belgii)*
	15	SWITCHGRASS *(Panicum virqatum)*
	20	BLUE CARDINAL FLOWER *(Lobelia siphilitica)*
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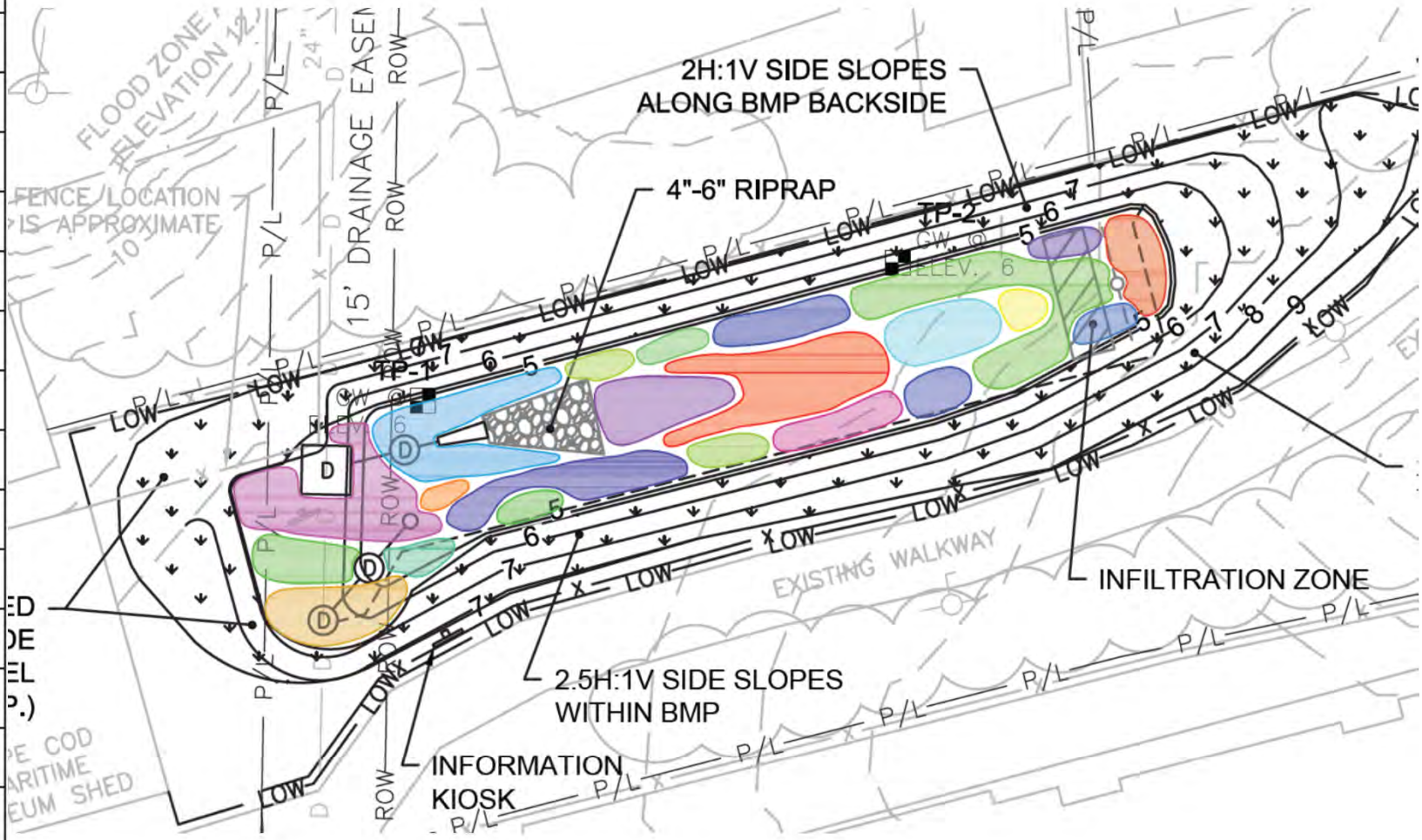
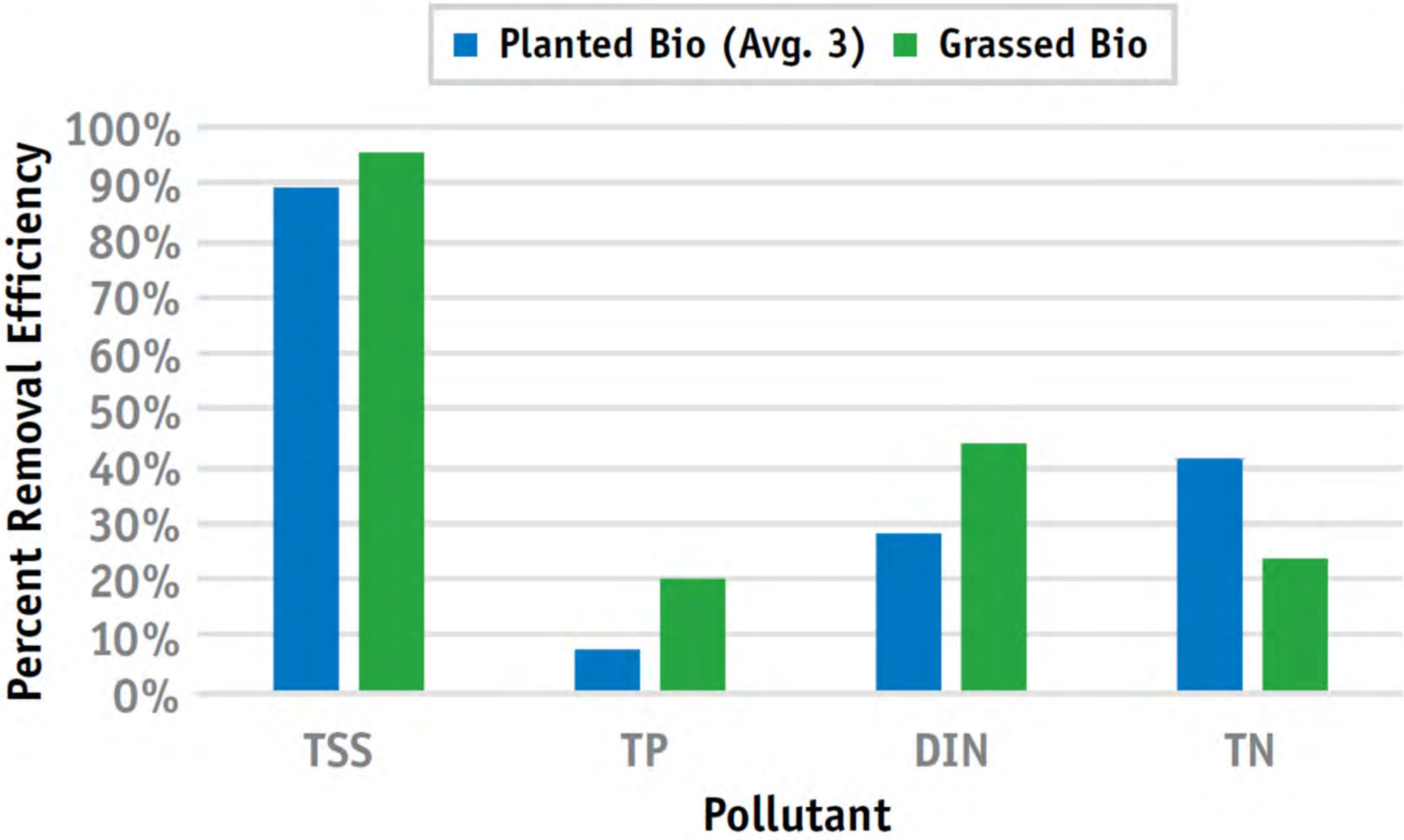


The Site Today

The tale of two raingardens …

Comparison of Pollutant Removal Efficiency
Planted vs Grassed Bioretention



CHECKLIST FOR INSPECTION OF BIORETENTION SYSTEM / TREE FILTERS

Location:
Inspector:
Date:
Time:
Site Conditions:
Days Since Last Rain Event:

Inspection Items	Satisfactory (S) or Unsatisfactory (U)	Comments/Corrective Action
1. Initial Inspection After Planting		
Plants are stable, roots not exposed	S U	
Surface is at design level, no evidence of preferential flow/shoving	S U	
Inlet and outlet/bypass are functional	S U	
2. Debris Cleanup (1 time/year minimum, Spring/Fall)		
Litter, leaves, and dead vegetation removed from the system	S U	
Prune/mow vegetation	S U	
3. Standing Water (1 time/year and/or after large storm events)		
No evidence of standing water after 24-48 hours since rainfall	S U	
4. Vegetation Condition and Coverage		
Vegetation condition good with good coverage (typically > 75%)	S U	
5. Other Issues		
Note any additional issues not previously covered.	S U	
Corrective Action Needed		**Due Date**
1.		
2.		
3.		
Inspector Signature		**Date**

CHECKLIST FOR INSPECTION OF BIORETENTION SYSTEM / TREE FILTERS

Location:
Inspector:
Date:
Time:
Site Conditions:
Days Since Last Rain Event:

Visual Indicators	Satisfactory (S) or Unsatisfactory (U)	Comments/Corrective Action
1. Vegetation		
Plants are stable, no evidence of erosion	S U	
2. Appearance (1 time/year minimum, Spring/Fall)		
Evidence of trach or debris	S U	
3. Inlet and Outlet Condition (1 time/year and/or after large storm events)		
No obstructions, no standing water after 24-48 hours since rainfall	S U	
4. Other Issues		
Note any additional issues not previously covered.	S U	
Inspector Signature		**Date**

Stormwater BMP Inspection Checklist

Visual Indicators

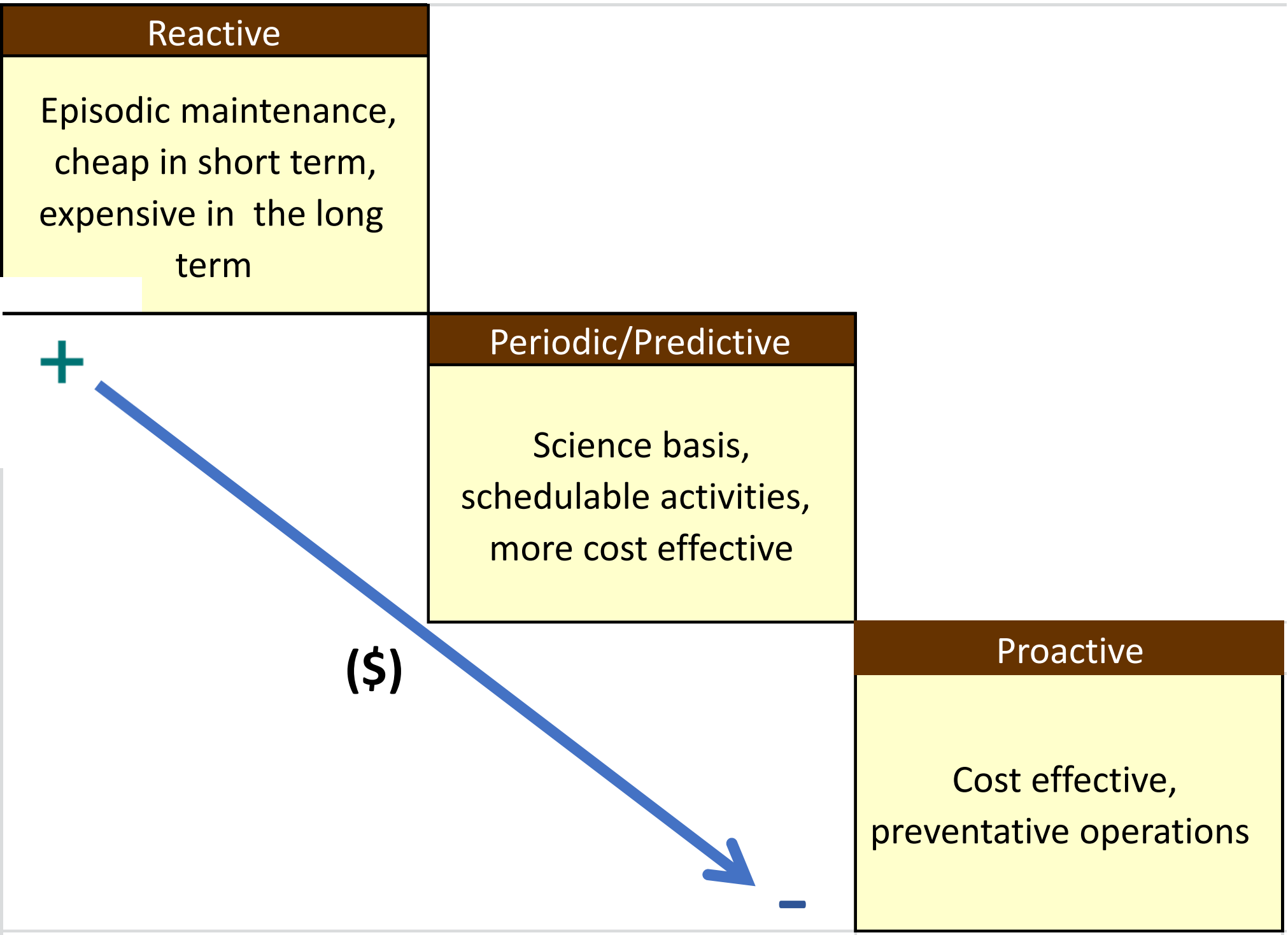
Pass	Fail	
☐	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☐	☐	System Operability: Does the system appear to be operating as designed?
☐	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☐	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

- https://www.unh.edu/unhsc/maintenance

Maintenance Complexity is defined as:

Minimal	Simple
Stormwater Professional or Consultant is seldom needed	Stormwater Professional or Consultant is occasionally needed
Moderate	**Complicated**
Stormwater Professional or Consultant is needed half the time	Stormwater Professional or Consultant is always needed

Erickson, et al, 2010



Adapted from Reese, A.J., Presler, H.H., 2005

MEMORANDUM

DATE: February 20, 2016

TO: Opti-Tool TAC

FROM: Karen Mateleska, EPA Region- I

SUBJECT: **Methodology for developing cost estimates for Opti-Tool**

Table 3: Maintenance Costs ($) and Hours per year for select BMPs – From UNHSC

BMP	Maintenance Cost ($) per year	Annual Maintenance Hours
Bioretention	$1,890.00	20.7
Chamber System	Not Assessed	Not Assessed
Detention Pond	$2,380.00	24.0
Gravel Wetland	$2,138.33	21.7
Porous Asphalt	$1,080.00	6.0
Pervious Concrete	$1,080.00	6.0
Retention Pond	$3,060.00	28.0
Sand Filter	$2,807.50	28.5

*Note: initial costs based on cost of maintenance per year per acre of IC treated

Economics of Installation vs Maintenance Costs, normalized by area

Parameter	Vegetated Swale	Wet Pond	Dry Pond	Sand Filter	Gravel Wetland	Bioretention	Porous Asphalt
Capital Cost ($)	12,000	13,500	13,500	12,500	22,500	21,550	21,800
Inflated 2012 Capital Cost	14,600	16,500	16,500	15,200	27,400	25,600	26,600
Maintenance and Capital Cost Comparison	17.8	5.4	6.9	5.4	12.8	13.5	24.6
Personnel (hr/yr)	9.5	28.0	24.0	28.5	21.7	20.7	6.0
Personnel ($/yr)	823	3,060	2,380	2,808	2,138	1,890	380
Subcontractor Cost ($/yr)	0	0	0	0		0	700
Total Operational Cost ($/yr)	823	3,060	2,380	2,808	2,138	1,890	1,080
Operation/Capital Cost (%)	6%	19%	14%	18%	8%	8%	4%

Additional Resources

- EPA Region 1 has developed a cost estimation tool that calculates maintenance hours for typical BMPs the method is documented here: https://https://www.unh.edu/unhsc/sites/default/files/media/epa-cost-memo_0.pdf
- This is also included in the performance stormwater calculator: https://www.unh.edu/unhsc/ms4-resources
- International Stormwater BMP Database is continuing to develop resources for implementers and has expanded the database to track BMP costs: https://bmpdatabase.org/urban-bmp-cost
- NCSU BAE is finalizing a cost calculator for BMP maintenance, when available the tool will be located here: https://stormwater.bae.ncsu.edu/resources/

Questions

Going Green for Good:

Long Term Considerations for the Operations and Maintenance of Green Infrastructure

Stormwater Control Measures O&M Program

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI

April 28, 2022

Agenda

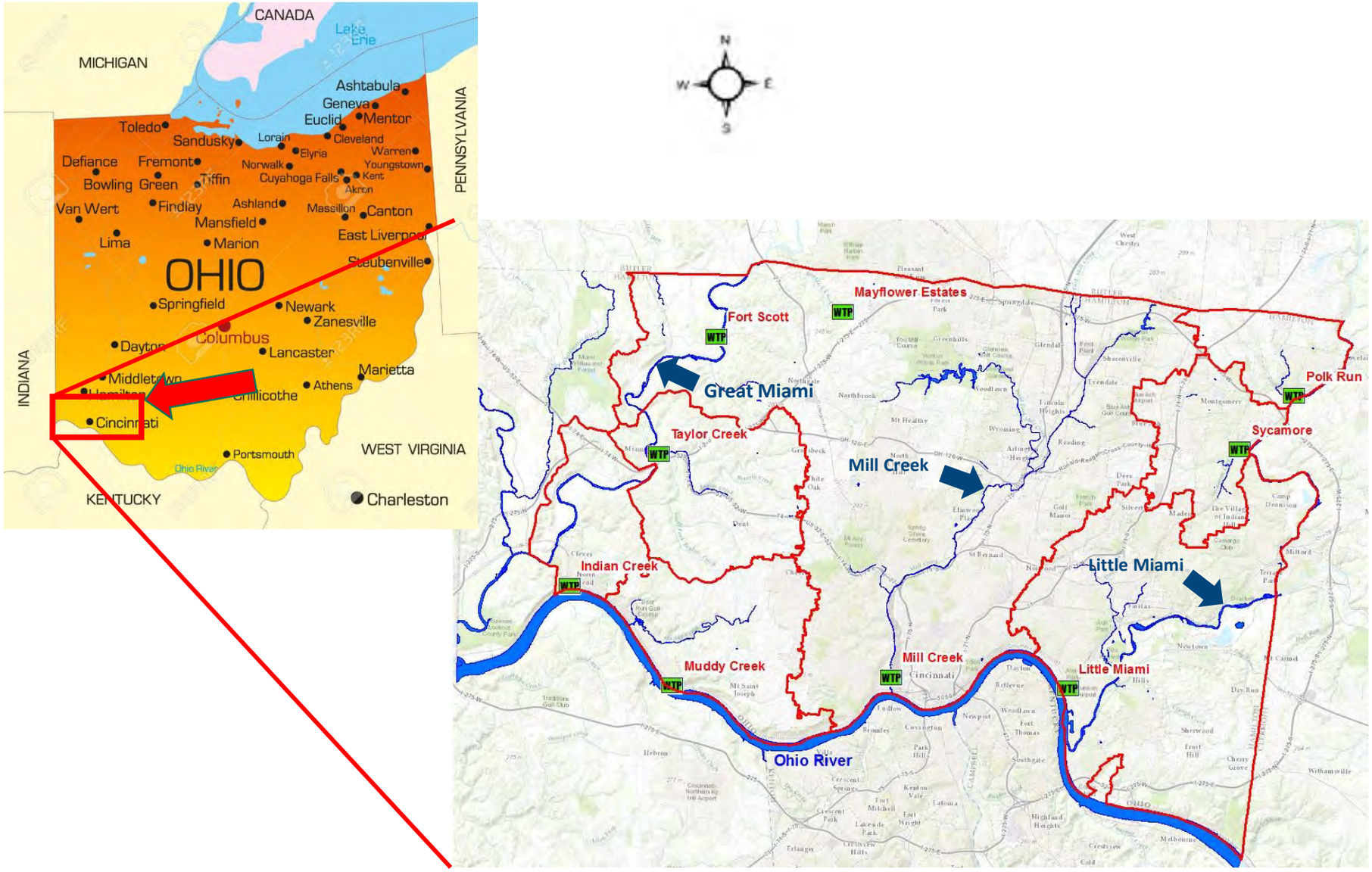
- Background
- Green Infrastructure Program
- SCM Inspection Program Evolution
- SCM Maintenance Program Evolution
- Lessons Learned

It’s All About Clean Water

MSD collects, treats, and manages wastewater from Greater Cincinnati communities, protecting the environment and public health by returning clean water to local rivers and streams.

METROPOLITAN SEWER DISTRICT
OF GREATER CINCINNATI

MSD At A Glance



MSD At A Glance

MSD treats 190 million gallons of wastewater a day

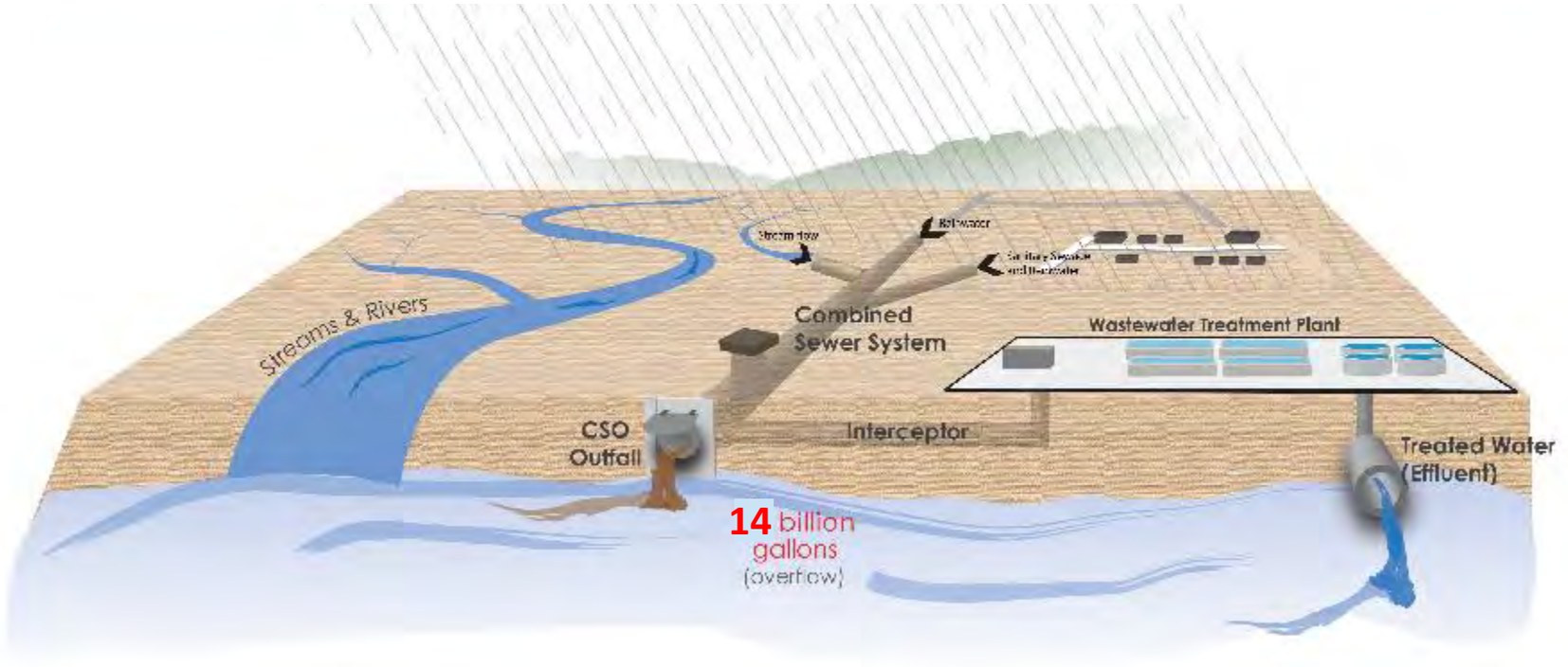
MSD has 9 treatment plants and other assets

MSD maintains more than 3,000 miles of sewer pipe

MSD serves >225,000 residential, commercial and industrial customers

Wet Weather Program

- MSD is under a federal mandate to reduce <u>combined sewer overflows</u> into local rivers and streams.
    - ~800 communities across the U.S. are also under consent decrees for “CSOs”



Status of Our Weather Program

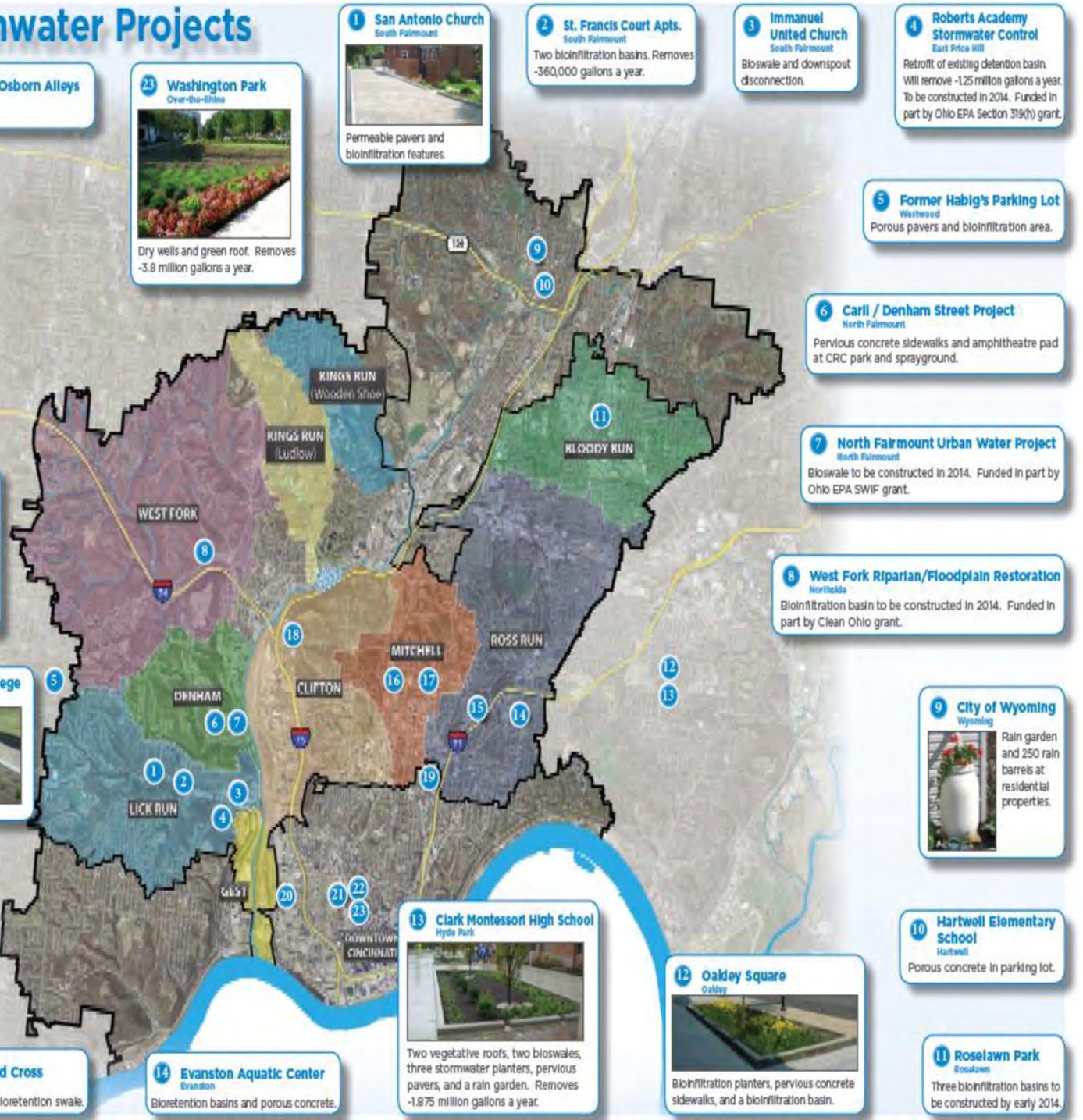
- Completed 1st phase in 2020; entire program will take **many decades to complete**
- To date, eliminated **6 billion gallons** of sewer overflows a year (from 14 billion to 8 billion)
- Invested **more than $1 billion** in infrastructure improvements
- Evaluating and implementing **green infrastructure** as one of the solutions to **reduce overflows** and **improve water quality** in local creeks and rivers.

Green Infrastructure Program

Enabled Impact Program

- About 50 million gallons per year of stormwater removed from the combined system from 30+ Green Demonstration projects.
    - 290,000 square feet of bioinfiltration practices;
    - 168,000 square feet of vegetative (green) roofs;
    - 155,000 square feet of porous/pervious paving;
    - 125,000 gallons of rainwater storage for reuse;
    - 2,040 linear feet of storm sewer separation; and
    - 5 large capacity stormwater dry wells.

Sustainable Stormwater Projects



1 San Antonio Church
South Fairmount

Permeable pavers and bioinfiltration features.

2 St. Francis Court Apts.
South Fairmount

Two bioinfiltration basins. Removes ~360,000 gallons a year.

3 Immanuel United Church
South Fairmount

Bioswale and downspout disconnection.

4 Roberts Academy Stormwater Control
East Price Hill

Retrofit of existing detention basin. Will remove ~1.25 million gallons a year. To be constructed in 2014. Funded in part by Ohio EPA Section 319(h) grant.

5 Former Habig's Parking Lot
Westwood

Porous pavers and bioinfiltration area.

6 Carll / Denham Street Project
North Fairmount

Pervious concrete sidewalks and amphitheatre pad at CRC park and sprayground.

7 North Fairmount Urban Water Project
North Fairmount

Bioswale to be constructed in 2014. Funded in part by Ohio EPA SWIF grant.

8 West Fork Riparian/Floodplain Restoration
Northside

Bioinfiltration basin to be constructed in 2014. Funded in part by Clean Ohio grant.

9 City of Wyoming
Wyoming

Rain garden and 250 rain barrels at residential properties.

10 Hartwell Elementary School
Hartwell

Porous concrete in parking lot.

11 Roselawn Park
Roselawn

Three bioinfiltration basins to be constructed by early 2014.

12 Oakley Square
Oakley

Bioinfiltration planters, pervious concrete sidewalks, and a bioinfiltration basin.

13 Clark Montessori High School
Hyde Park

Two vegetative roofs, two bioswales, three stormwater planters, pervious pavers, and a rain garden. Removes ~1.875 million gallons a year.

14 Evanston Aquatic Center
Evanston

Bioretention basins and porous concrete.

15 American Red Cross
Norwood

Vegetative roof and bioretention swale.

16 North Avondale Montessori
North Avondale

Vegetative roof.

17 Cincinnati Zoo & Botanical Garden
Avondale

African Savannah: Enhanced turf, porous paving, and storm sewer separation. Removes ~15.6 million gallons a year.

Main Entrance: Pervious pavers and rainwater storage tank.

18 Cincinnati State Technical and Community College
Clifton

Bioretention pond; infiltration chamber; level spreader; permeable parking lots; 10 rain gardens; and two cisterns. Removes ~12.6 million gallons a year.

19 Civic Garden Center's Green Learning Station
Corryville

Permeable pavers, porous asphalt and concrete, green roofs, bioswales, and cistern.

20 Cincinnati Museum Center
Queensgate

Vegetative roof.

21 Taft IT High School
West End

Vegetative roof and bioinfiltration basin.

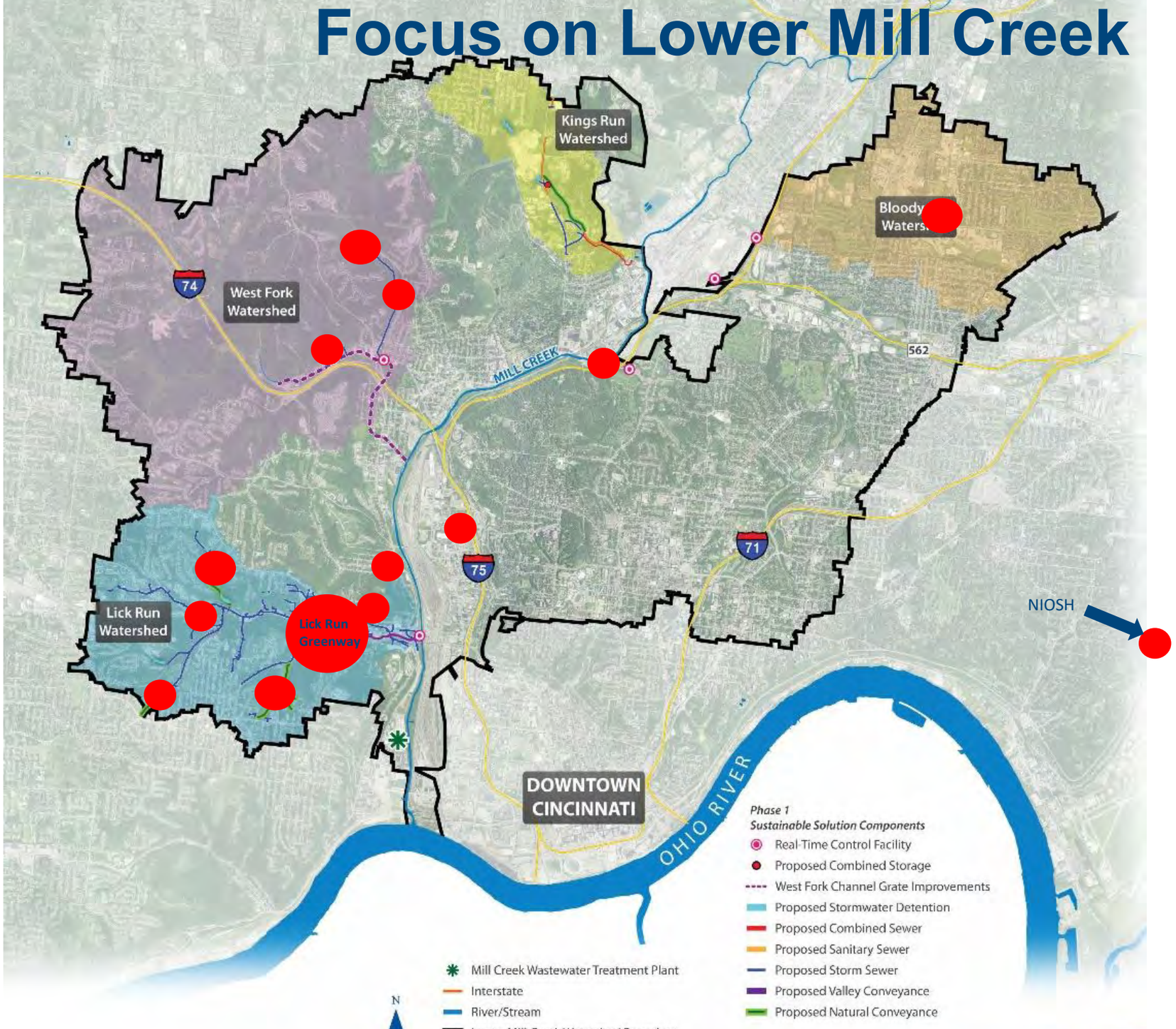
22 Comer and Osborn Alleys
Over-the-Rhine

Permeable pavers.

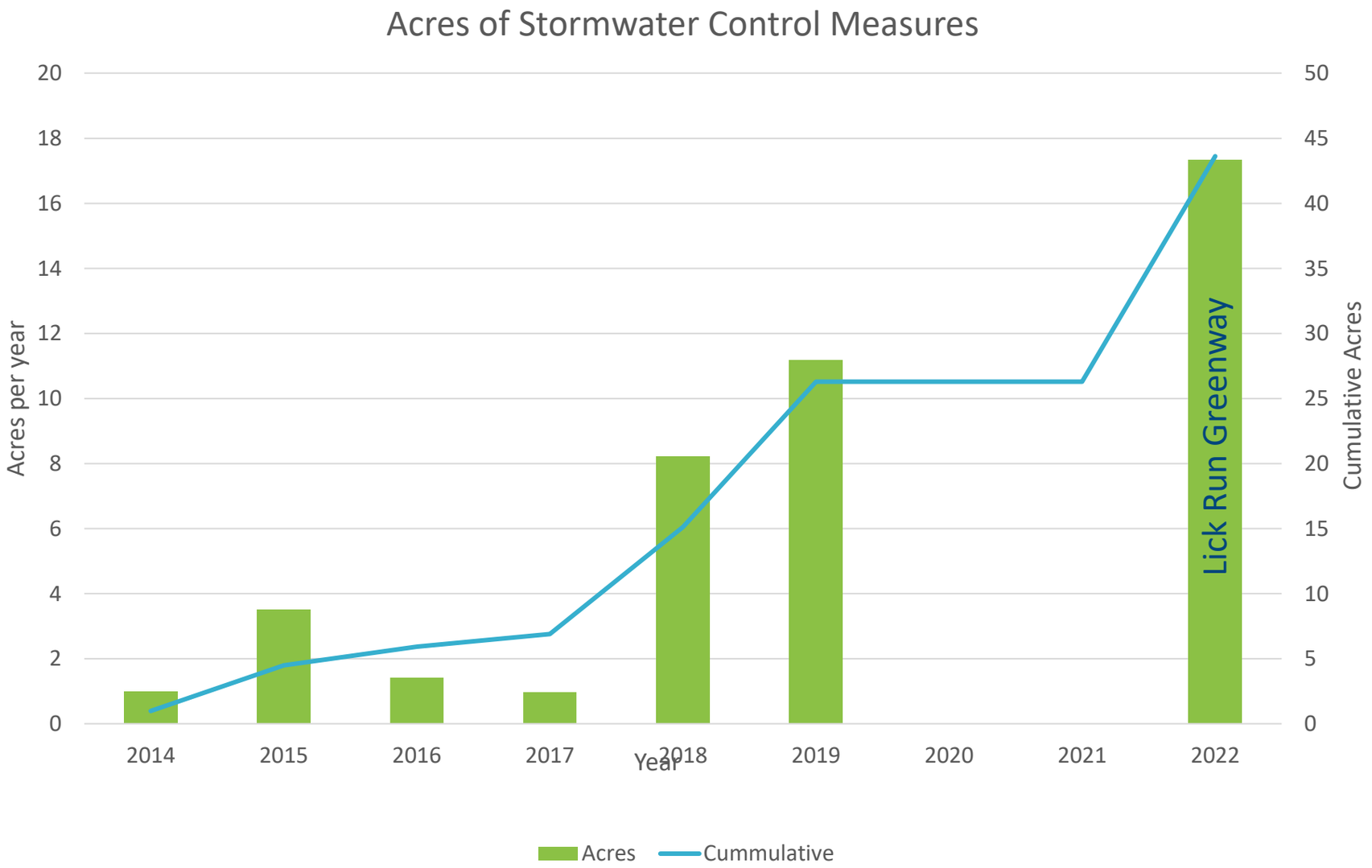
23 Washington Park
Over-the-Rhine

Dry wells and green roof. Removes ~3.8 million gallons a year.

Focus on Lower Mill Creek



By the Numbers



SCM Inspection and Maintenance Program Goals

Goals for sites…

- Function
- Safe
- Aesthetically acceptable

Lick Run Greenway

Programmatic Goals …

- Data to flow seamlessly from inspection to maintenance
- Inspection and maintenance to be data driven
- Eliminate all paper forms
- Skilled labor at all levels

Inspection Program

Inspection Program

You've probably heard this before….

Inspection is the key to keeping SCM's functioning at peak performance.

What MSDGC <u>WAS</u> doing:

- Inspect each asset monthly
- Borrowed internal labor
- Used paper forms and separate photos
- Information manually transferred to CMMS

Rapid Run Park

Performance Indicators

Visual aspects of GI that provide information on the health and function of that asset

Vegetated systems

- Structure clogging
- Standing water
- Plant viability
- Erosion
- Sediment
- Trash
- Infestation

Non-vegetated systems

- Structure clogging
- Structure failure

Vegetated Systems Bioretention Systems			
Indications of Poor Function	**Evidence**	**Remedies**	**Consequences of Inaction**
Excessive Sediment at inlet	• Sediment buildup immediately downstream of inlet (at splash pad, level spreader, etc.) • Sediment upstream of inlet (e.g., in gutter) is evidence of flow into bioretention system being blocked or slowed down which allows sediment to settle out prior to entering bioretention system. • Sediment deposition depth should not be greater than 20% of the design freeboard depth (distance between top of bioretention system and surface of mulch).	• Perform regular maintenance so that sediment does not build up to an excessive amount at, upstream, or downstream of inlet. • Install sediment trap to keep sediment from impairing performance of bioretention system between regularly scheduled maintenance.	• Drowning hazard due to flooding • A blocked inlet will keep flow from entering bioretention system and cause a loss of storage volume capacity and water quality improvement • Sediment buildup at the level spreader or energy dissipater will counteract erosion controls • Street flooding or flooding of adjacent property • Loss of desired plants due to sediment buildup within bioretention system • Repair and replacement cost • Poor aesthetics
Invasive plants	• Invasive species coverage greater than 30% of the bioretention system by area • Common invasive species include reed canary grass, common reed, purple loosestrife, and cattails	• Removal of invasive species and replanting of deeply rooted native species, particularly during establishment period. • Invasive species shall be eradicated within one month of discovery to prevent further spreading. • If design species continue to fail to become dominant, soil pH, soil permeability, hydrology, or salt content may be incorrect for the selected species. Consult designer for plant material adjustment and implement soil testing.	• Invasive species outcompete deeply rooted native species which maintain proper infiltration • Increase in flooding and standing water due to loss of infiltration • Loss of storage volume and/or water quality improvement due to loss of infiltration • Repair and replacement cost • Poor aesthetics
Damage by vehicles/plows	• Chipped or broken curb • Tire marks on curb • Tire tracks within bioretention system • Crushed structures, piping, cleanouts	• Add reflective signage or stakes within the asset near areas of frequent strikes. • Stakes shall be of sufficient height to be visible above banked snow. • Redesign or retrofit as necessary to reduce vehicle strikes.	• Inlet blockage due to curb breaks • Damage to soils, underdrains, overflow grates, structures, and vegetation • Damage to private and public property • Repair and replacement cost • Poor aesthetics
Blockage to outlet (e.g., downstream curb cut, overflow grate, or underdrain)	• Flow from the bioretention system is partially or completely obstructed by sediment, debris, or vegetation	• Remove blockage. • Remove or relocate vegetation near the outlet. • Remedies to excessive sediment at the inlet and erosion problems will limit sediment build up at the outlet.	• Increases flooding or standing water which limits volume capacity and water quality improvement • Loss of desired plants • Repair and replacement cost • Poor aesthetics

**Major storm event is equal to or more intense than 0.75 inches of rainfall in 24 hours*

WILLIAMS CREEK CONSULTING

METROPOLITAN SEWER DISTRICT of greater CINCINNATI

Inspection Program

What MSDGC IS doing:

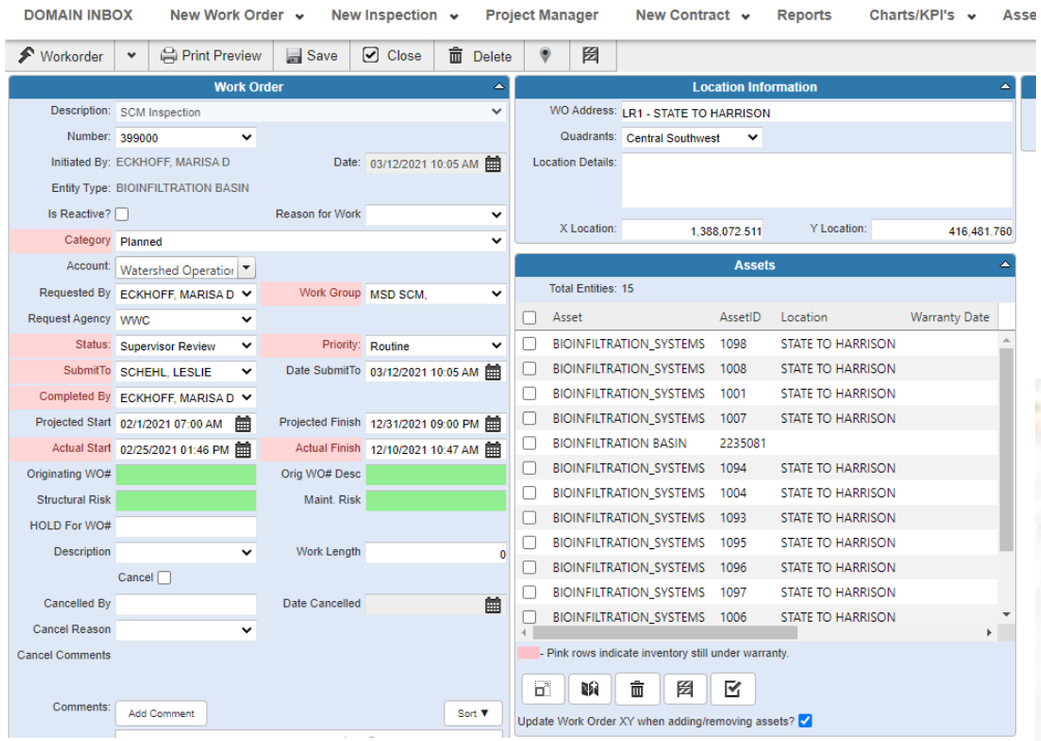
- Inspect each asset monthly
- Use own internal labor
- Utilize CMMS for scheduling
- Use an app that pushes info directly to network and a monthly workorder

Harrison Street Planter

Tracking Data

Inspection

- Yearly WO created in the CMMS
- WO info sent to FF Inspection app
- Internal staff complete inspections in FF
- Report sent back to CMMS WO
- WO closed out for the year



Maintenance Program

Maintenance Program

How MSDGC is getting it done:

- Frequency/tasks are outlined in maintenance manual; re-evaluated yearly
- **MOST** labor is contracted (seasonal, on demand)
  - Create the schedule
  - Assigned sites
  - Use maintenance app in the field
- Manually enter labor and materials
- Tracked in CMMS
  - Routine v. Non-routine $$$
  - Hot spots

Lick Run Greenway Headwaters

Maintenance Program

Maintenance Program for GI used existing MSDGC Collection Division processes/procedures for work order creation/tracking.

But…

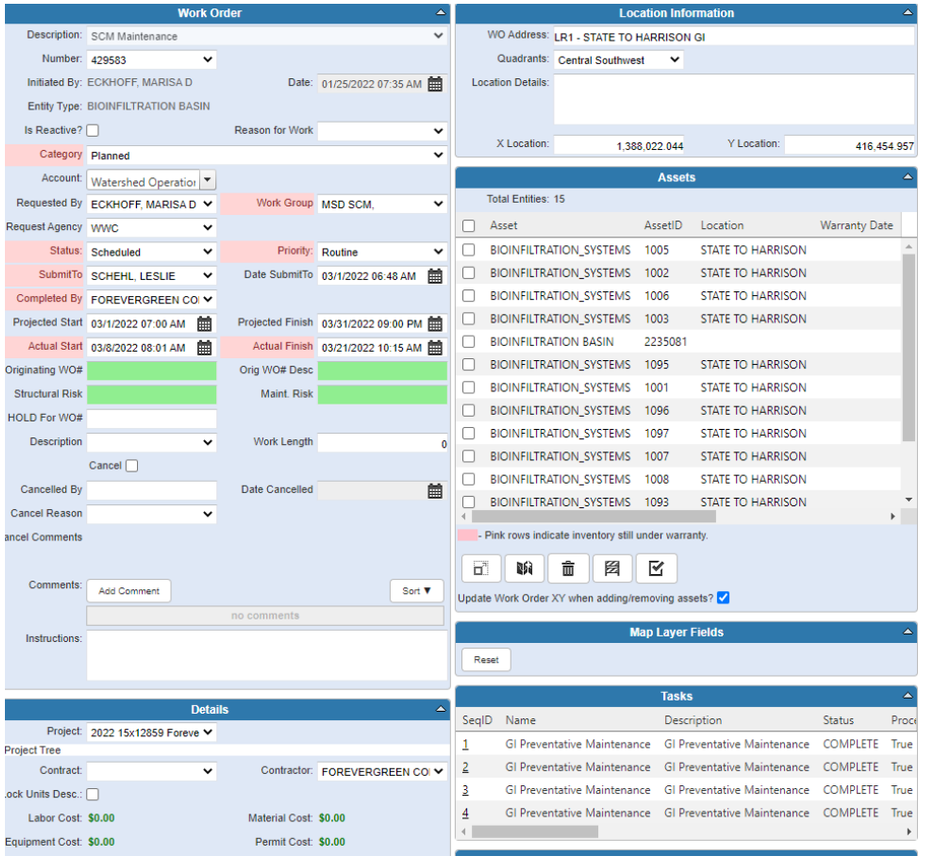
It's still different!

- Tasks
- GIS Depiction
- Tools
- Materials

Tracking Data

Work Orders

- Monthly WO created in CMMS
- WO info sent to FF WO app
- Vendor track tasks and resources in FF WO app
- Task info sent back to CMMS
- Tasks, hours, resources in FF and CMMS are checked against invoice
- WO closed out for the month



Lessons Learned

Lessons Learned

- Asset Management
  - Criticality and risk
  - Proper condition assessments
  - Levels of service
    - Tracking the right data
- Workforce
- Technology

NIOSH Basin

When nothing is going right, go left.

Lick Run Greenway

For more information:

Leslie Schehl
leslie.schehl@cincinnati-oh.gov

www.youtube.com/user/CincinnatiMSD

www.projectgroundwork.org/lickrun/

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Going Green for Good: Long-Term Considerations for Operation & Maintenance of Green Infrastructure

EPA Webcast: April 28, 2022

Healthy Plants for Better Bioretention Performance: An Approach from the San Francisco Bay Area

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EOA, Inc.
Santa Clara Valley Urban Runoff Pollution Prevention Program
(SCVURPPP)

Presentation Outline

- Regenerative Landscaping Principles and Bioretention Measures
- Plant Groups in Bioretention Measures
- Mulch for Bioretention Measures
- San Francisco Bay Area GSI and Bioretention Measure Maintenance Resources

Regenerative Landscaping in Bioretention Measures

ReScape California

ReScape California's holistic and regenerative landscaping principles include:

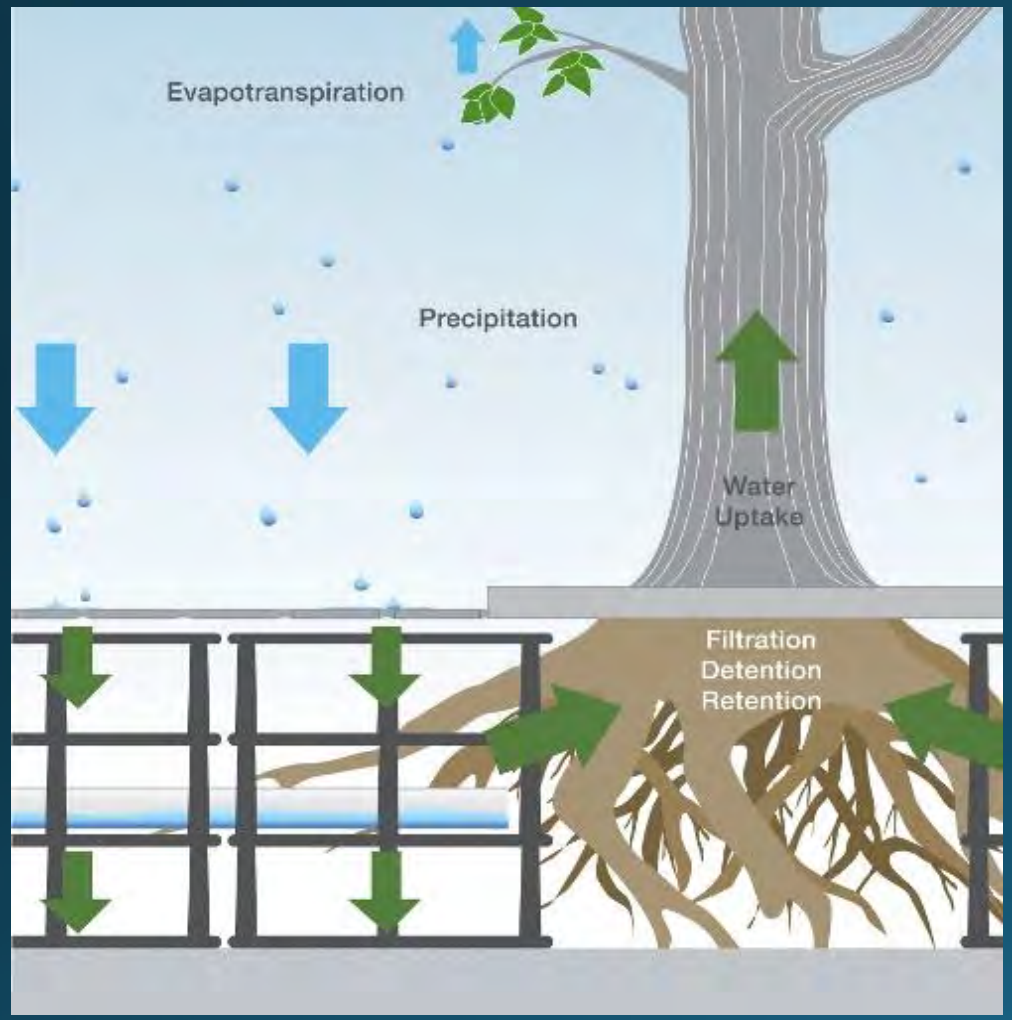
- Using climate-appropriate vegetation and minimizing planting of intensive-resource landscapes such as turfgrass
- Using compost and mulch enhances fertility, soil structure, and improves nutrient and water retention; they inoculate the soil with beneficial organisms, and provide other benefits
- More information at: www.rescapeca.org

Regenerative Bioretention Measure Maintenance Practices

- Know your plants
  - Identify the plant or at least know how its maintained
  - Right plant in the right place reduces pruning and waste
  - Know your weeds and what they are telling you
- Avoid pesticides and synthetic fertilizers
  - Can kill beneficial insects and soil life
  - Can impact water quality discharges
- Use compost and wood mulch
  - Improve soils, reduce water consumption and weeds
  - Inoculate soil and improve plant health

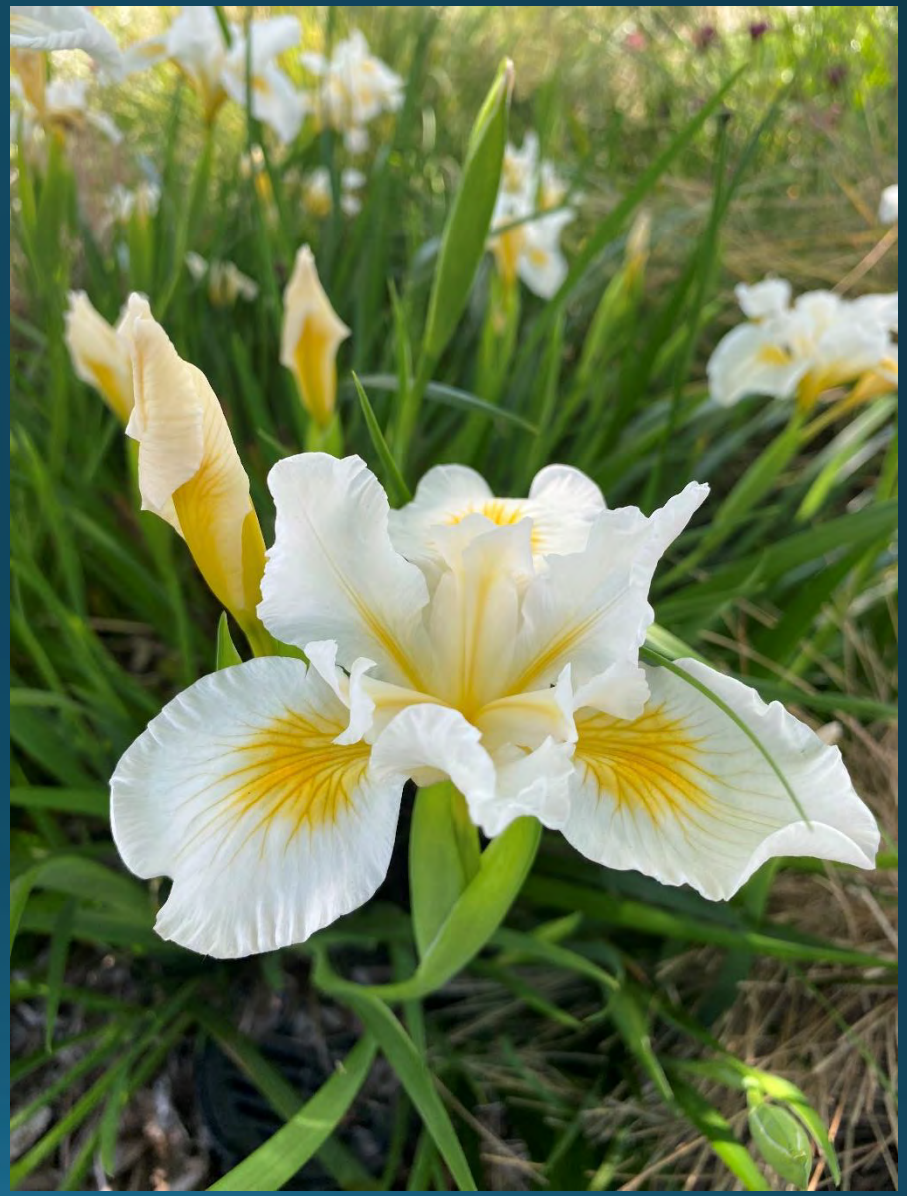
Bioretention Measure Examples

Tree Well Filter Example



Plant Maintenance Tips/Questions

- Plant spacing and coverage:
  - How large will it grow?
  - How long will it take to grow to full size?
  - Are plants too close together?
  - Are more plants needed?
- How much water and sunlight does it need?
- When does it flower?
- Is it a “weed” or a desired plant?
- What time of year is best to prune?
- Does it really need to be pruned?
- Should it be divided and replanted?
- How long does it live?
- Is it dormant or dead?



Iris douglasiana – Pacific Coast Iris

GSI Maintenance Field Guide - San José

Plant Density

4 Excellent Condition

- 100% plant coverage at plant maturity*
- Plants are appropriately spaced
- No obstruction of inlets, overflow, or irrigation infrastructure

*Newly planted systems may not have full coverage, but systems must have full coverage after plant establishment and maturity

3 Good Condition

- At least 90% plant coverage at maturity*
- Some sporadic bare spots present (0-10%)
- Most plants are appropriately spaced
- Partial obstruction of one or more inlet, overflow, or irrigation system

2 Moderate Condition

- At least 50% plant coverage at maturity*
- Moderate number of small bare spots with no large, continuous bare spots (10-20%)
- Significant obstruction of one or more inlets, overflows, or irrigation systems

1 Poor Condition

- Less than 50% plant coverage at maturity*
- Significant number of bare spots or large, continuous bare spots (more than 20%)
- Full obstruction of one or more inlets, overflows, or irrigation systems

Images courtesy of the City of San José, a member of SCVURPPP

Why Plant Identification Matters

- If you don't know your plant, you might kill it!
- Three plant "maintenance groups":
  - Rushes
  - Sedges/grasses
  - "Flowers"*

Calamagrostis x acutiflora – Reed Grass

*Botanically speaking, all three of these groups of plants have flowers, but for the purposes of our three "maintenance groups", we are using "Flowers" to mean the group with large, very noticeable flowers.

Plant “Maintenance Groups”

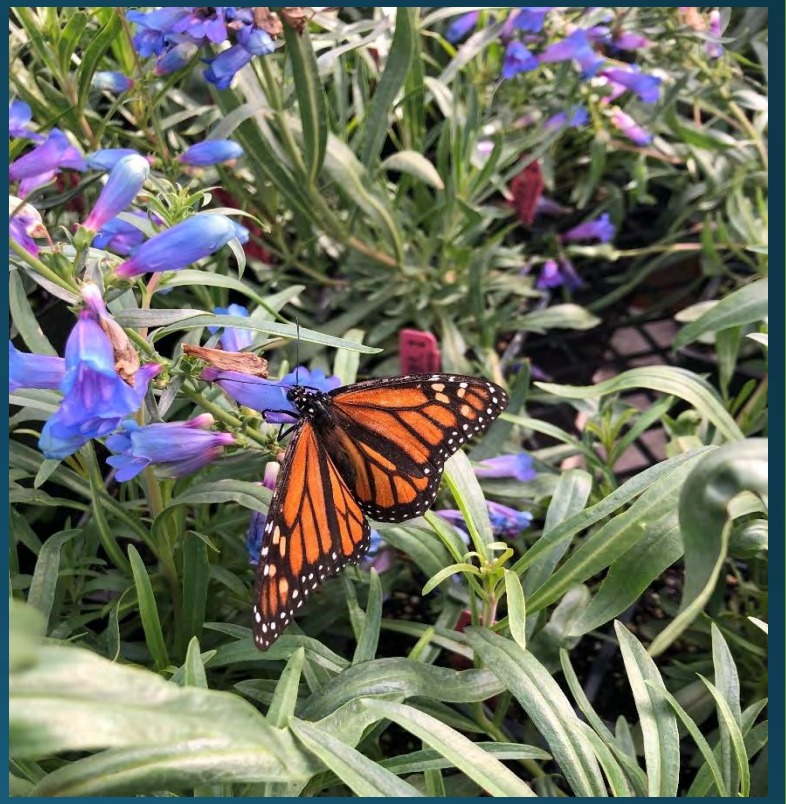
Rushes

Rush stems are round and solid

Sedges/Grasses

Sedges have edges, grass stems are hollow – both have flat leaves; sedges and grasses can have shorter lifespans; some can turn brown in summer if not irrigated; and some grasses are colorful

Flowers



Flowers are broadleaved or long-stemmed and often have larger, more colorful flowers than the other two groups of plants.

Rushes

Chondropetulum tectorum – Cape Rush

Juncus patens – California Gray Rush

If possible, do not prune at all!

Care: Remove dead stems only - dethatch by hand with textured rubber gloves. If live growth needs pruning, remove only tips (top 4-6 inches)

Sedges/Grasses

Carex tumulicola – Berkeley Sedge

Muhlenbergia capillaris – Pink Muhly Grass

Care: Dethatch with rubber gloves; divide larger plants in fall; will be greener with more water – can turn brown in summer without irrigation.

Flowers

Penstemon heterophyllus Foothill Penstemon

Carpenteria californica Bush Anemone

Care: Deadhead spent flowers and remove dead growth

Plant Pruning Example

A newly installed bioretention measure with two types of rushes

Improper Pruning of Rushes

One year later, improper and unnecessary pruning of rushes leads to poor plant health issues

Results of Improper Rush Pruning

Two years later, repeated pruning has led to almost complete plant failure

Mulch Topics

- Purpose of mulch
  - Reduces weed growth
  - Conserves water by minimizing soil dehydration
  - Keeps soil cool
  - Reduces soil erosion
- Depth of mulch
  - 3 inches is required in California for water-efficient landscaping and conservation
- Mulch considerations
  - Depends on site and design
  - Wood mulch
    - Improves soil
    - Holds moisture
    - Needs periodic replacement
  - Rock mulch
    - Prevents erosion
    - Can heat up soil
    - Doesn’t improve soil
    - Can make weeding difficult
    - Potential vandalism (cobble)

Mulch Types

- Wood Mulch (recommended):
  - Uncomposted Wood Mulch
  - Composted Wood Mulch
- Rock Mulch (only when really needed):
  - Gravel (small)
  - Medium-sized rock
  - Cobble (large)
- Combination
  - Rock mulch can be used in the flow line with wood mulch on the sloped sides
  - Jute netting can also be used to temporarily hold the mulch in place until plants are established

The Bioretention Measure Design Affects the Mulch Choice

Off-line design with trench drains & wood mulch

In-line design with Splash Apron and Cobbles

Combination Wood and Rock Mulch Design

Where space allows and when you have sloped sides, a combination of rock mulch in the flow line and wood mulch on the sides can be used

Composted Wood Mulch Benefits

The composting process provides benefits:

- Inoculates mulch and soil media with beneficial organisms
- Holds more water
- Floats less (heavier and less resinous)
- Less flammable
- Reduces pathogens that might be in the mulch like Sudden Oak Death (Phytopthora ramorum)

The Biotreatment Wood Mulch (BWM) Specification can be downloaded from the SCVURPPP website:

https://scvurppp.org/2021/07/01/biotreatment-soil-media-supplier-list/

Uncomposted Wood Mulch

Composted Wood Mulch (BWM)

Gravel Rock Mulch (Small)

Medium-sized Rock Mulch and Cobble (Large)

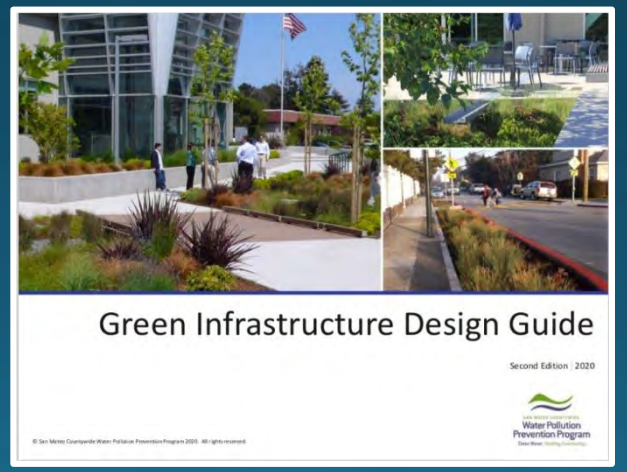
SF Bay Area Bioretention Resources

SCVURPPP GSI Handbook (2019)
https://scvurppp.org/2019/09/01/scvurppp-green-stormwater-infrastructure-handbook/

City of San José GSI Maintenance Field Guide (2019)
www.sanjoseca.gov/home/showdocument?id=40709

SMCWPPP GI Design Guide (2020)
https://www.flowstobay.org/data-resources/resources/green-infrastructure-design-guide/

San Francisco GI Maintenance Guide Book (2018)
https://sfpuc.sharefile.com/share/view/sb83923c24cb4298a



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Mimulus aurantiacus – Sticky Monkey Flower