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SPC Water Resource Center Webinar: If It Ain't Broke… It Still Needs Maintenance!

How to Effectively Maintain Blue/Green Infrastructure

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Daniel Wible, PE
Susan Beck, PE
Kate Austin

Water Resource Center
Southwestern Pennsylvania Commission

*Planning future workshop/webinar topics is currently underway! Please contact Erin Kepple-Adams, Water Resource Manager at **ekepple@spcregion.org** and let her know what your needs are. She is happy to try to accommodate your requests.*

Presentation Outline

- Background
  - What is blue/green infrastructure (BGI) and why does it matter?
  - Typical challenges / myths
- Maintenance Planning & Programming
  - Why is it important?
  - Barriers to success
  - Commitment and funding
  - Planning for success
- Design for Maintenance
- Case Study: City of Lancaster, PA
- Resources
- Q&A

Poll Question #1

Are you planning to implement BGI in the near future?

A. Yes, we have already implemented some type of BGI and are eager to do more.

B. Yes, we are planning to, but haven't done so before.

C. We are considering it as a possibility.

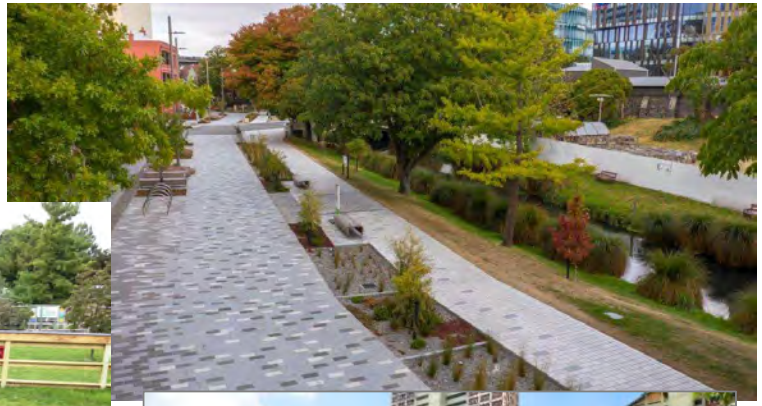
D. No, not unless we have to!

Background

What is blue/green infrastructure and why does it matter?

What is Blue/Green Infrastructure?

- **BI** (e.g., wet ponds and detention basins) temporarily **stores larger volumes** of stormwater without significant reliance on vegetation
- **GI** (e.g., bioretention and permeable pavement) typically uses **vegetation, soils, and/or rainwater harvesting** to treat and reduce **smaller, more frequent** stormwater flows
- **BGI** is a strategy that combines the **water quality and community enriching benefits** of "green" stormwater infrastructure (GI) coupled with the **flood reduction and climate resiliency benefits** of "blue" stormwater infrastructure (BI)



Why Does Blue/Green Infrastructure Matter?

- Responsive to drivers such as new/re-development stormwater regs, MS4, CSO, green building certifications, etc.
- Primary stormwater benefits: reduced volume, flow rate, and pollutants from stormwater runoff
- Many other benefits, including improved:
  - Groundwater recharge
  - Aesthetics, quality of life
  - Resiliency
  - Safety / walkability
  - Air quality, urban heat island
  - Property values
  - Localized flooding
  - Biodiversity / habitat
  - Social value / equity, jobs, etc.

Typical Challenges / Myths (for BGI implementation regionally and SW PA particularly)

- Won't work with clay soils and steep slopes
- There's not enough space
- There's too much rain / flooding
- Concerned about safety and mosquitos
- Won't last the winter
- Too many bad past experiences
- Utilities, utilities, and more utilities!
- NIMBY
- It's too expensive!!
- **Too hard to maintain…**

Common Failures / “Lessons Learned”

- “Seems about time we seal up that gravelly looking pavement”
- “What are those weeds doing in that planter?”
- “Looks like a good place to toss these old tires”
- “Relax, there’s a filter in that inlet, should be good for awhile”
- “Will I get ticketed if I park in this bioswale?”

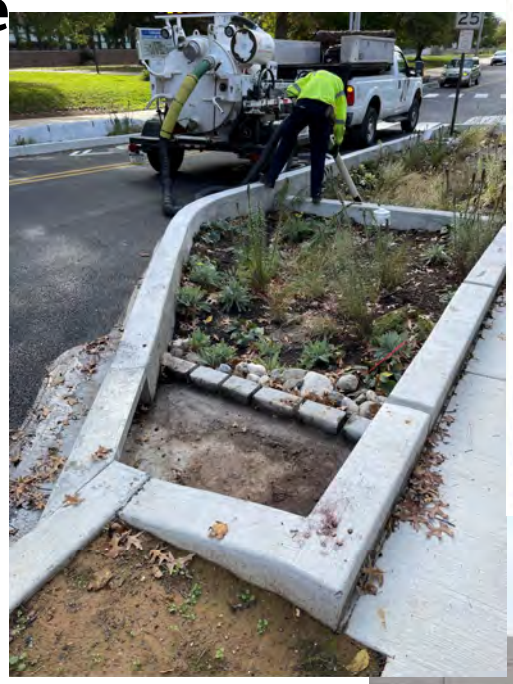
Why is Maintenance Critical?

- Ensure long term performance of *Blue/Green Infrastructure*
- Protect capital investments
- Important for aesthetics (landscaping trees)
- Meet regulatory requirements, public and private
- Public health issues
- Public/community perceptions

Barriers to Effective BGI Maintenance

- Lack of funding for operations and maintenance (resources)
  - Specialized equipment
  - Maintenance staffing requirements
- No training in specialized needs of green infrastructure
- Need for consistent inspection & maintenance procedures and enforcement policies
- Poor public awareness

How to integrate new and different O&M protocols into existing O&M programs and operating budgets???

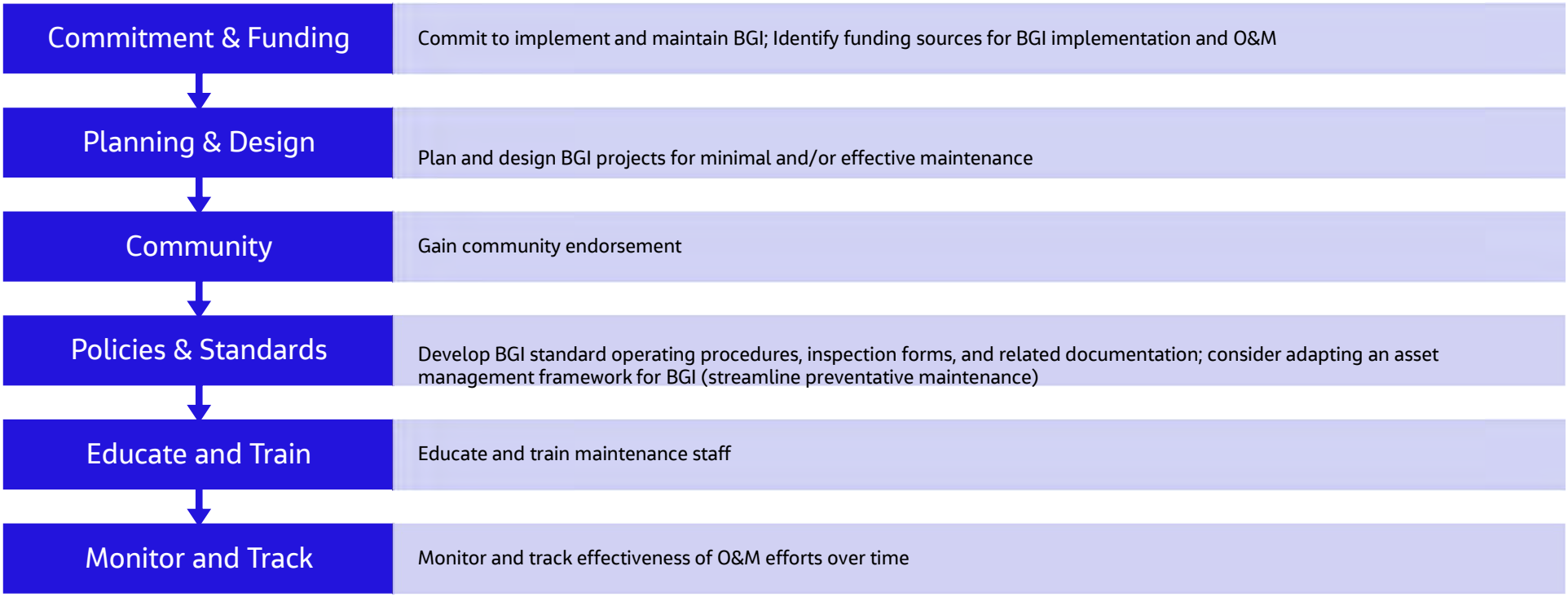


Maintenance Planning and Programming

Why is it important for green infrastructure and how can it be improved?

Source: Onondaga Earth Corps https://onondagaearthcorps.org/

Key Strategies for BGI O&M Planning & Programming

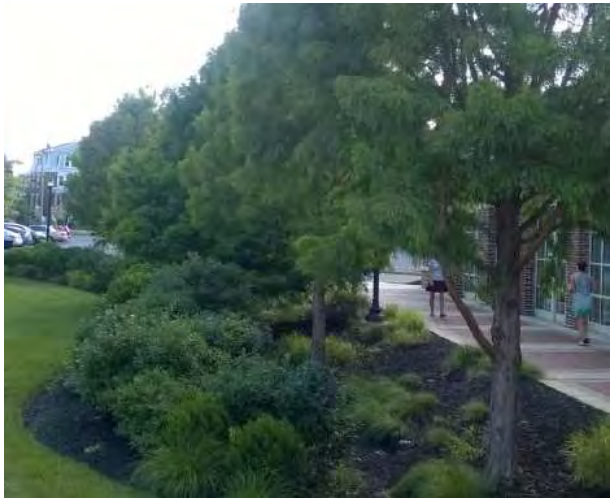


Commitment to BGI Maintenance

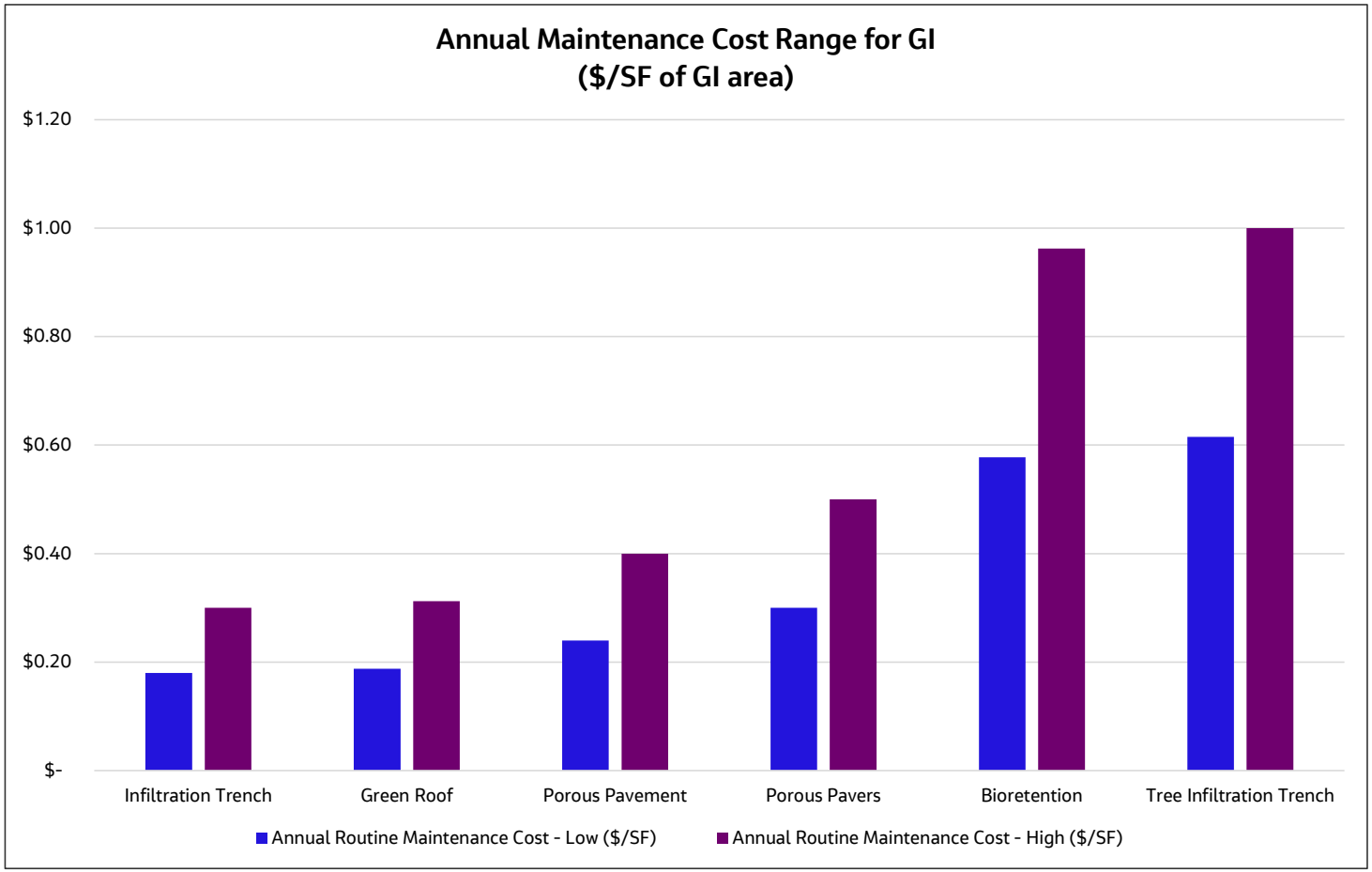
- Need institutional commitment for long-term success
  - Regulatory requirements
  - Adopt policies and enforcement (or education) procedures
- Establish responsible agency (staff) and provide adequate funding
- SW fees and credits can provide incentives and reinforce maintenance requirements
  - Offer financing or rebate for installation and maintenance of BGI on residential or commercial property

Typical BGI O&M Cost Considerations

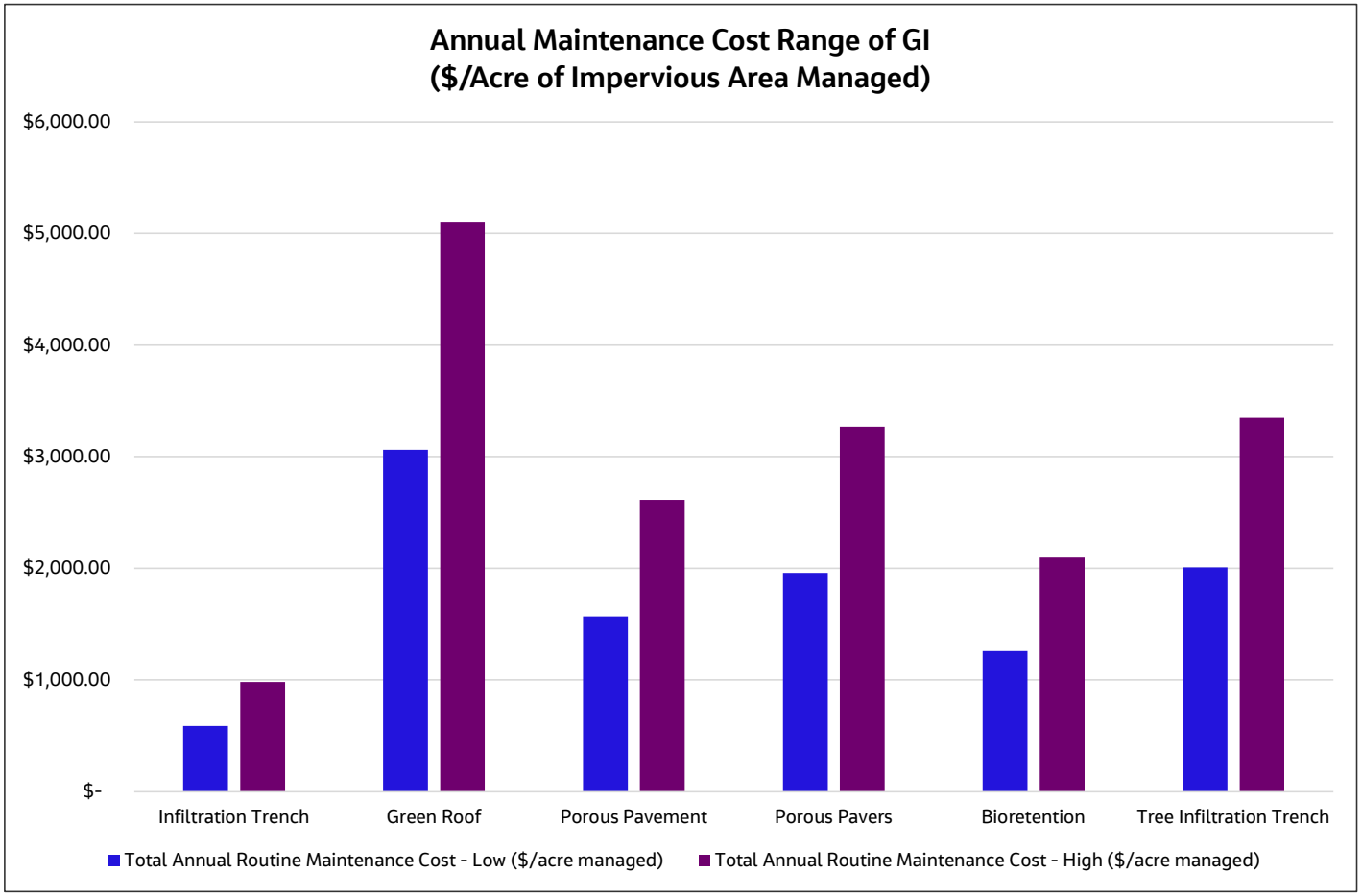
- Establish a business case - consider the incremental costs of maintaining BGI compared to conventional infrastructure or landscape maintenance.
- Economies of Scale – the ability to keep maintenance crews busy full time are more efficient.
- Size, design complexity, location, public visibility, system age, etc. **– maintenance costs can vary dramatically!**
- **Very little reliable cost data available!**



Typical GI O&M Costs per SF of GI



Typical GI O & M Costs per Acre of IA Managed



Paying for BGI Maintenance

- Stormwater Utilities to Fund O&M
  - Provide a stable revenue source
  - Equitable approach that bases fees on impact
  - Incentivize private investment through credit programs that reduce fees

- Alternative Financing Strategies
  - Public-private partnerships
    - In Lancaster, PA, private recipients of (partial) funding for GI projects must agree to 40 years of O&M

Funding Maintenance for a Large-Scale GI Program: Onondaga County, Syracuse, NY

- O&M funding through combination of strategies
- Integration of GI O&M into existing infrastructure maintenance regime and CMMS tracking system
- Utilization of large-scale O&M contracts (permeable pavements, landscaping, etc.)
- Community partnerships to provide low-cost O&M and provide entry-level jobs and training
- Establishment of incentive program to offset costs through private implementation (10-year maintenance agreement)

Visit: SaveTheRain.us

Onondaga Earth Corps

NEWS

Summer 2012

www.onondagaearthcorps.org

This summer, OEC expanded its youth development and employment program to include a young adult crew that is responsible for leadership of the summer youth program as well as for management and leadership of OEC's growing fee-for-service program. This summer the crew was responsible for education and outreach to thousands of neighborhood residents and children, maintenance of City and County-owned green infrastrucutre parking lots and a number of other exciting projects, including the installation of rain gardens and food gardens.

Special thanks to the Allyn Foundation for supporting our capacity building efforts which enabled us to purchase our first pickup truck. Thank you!

Save the Rain

OEC summer activities were made possible by funding from Onondaga County's Save the Rain campaign. Thank you Onondaga County!

The Onondaga Earth Corps summer activities were made possible in part by funding from Onondaga County's Save the Rain campaign, Onondaga Lake Partnership, NYS DEC, and CNY Works Summer Youth Employment Program.

Summer Program Orientation

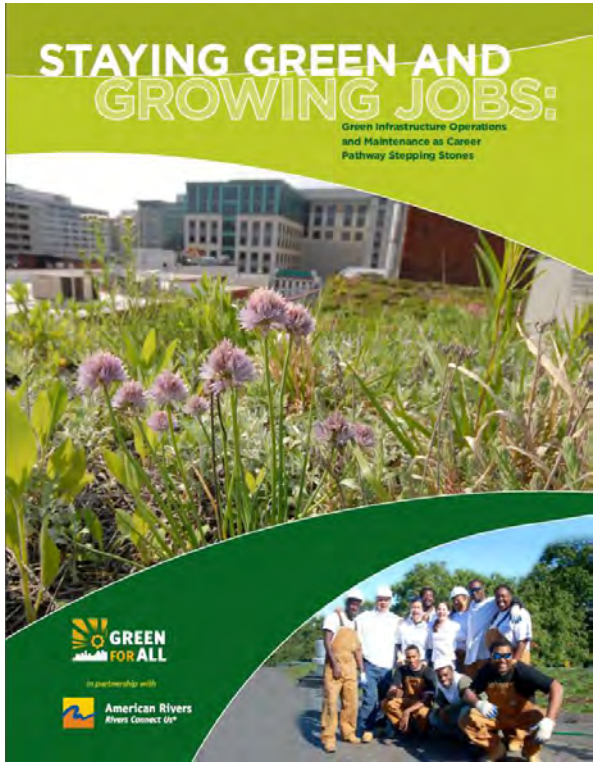
The Onondaga Earth Corps kicked-off the 2012 summer program orienting the crew to the Onondaga Lake Watershed. Our 15 person crew observed the Tully Valley mudboils and learned about the existing land surface subsidence. They learned historical information about the Onondaga Creek and Onondaga Lake as they hiked along the boardwalk on the Onondaga Nation and participated in a board game at Willow Bay.

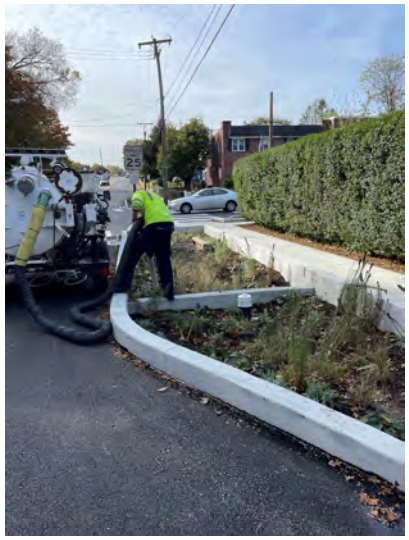
The rest of the Orientation was spent camping at Oneida Shores. The crew participated in team building activities, learned the structure of the

BJ Adigun from CH2M Hill discusses the Save the Rain program with crew members during orientation at Oneida Shores.

Linking Green Infrastructure O&M to Green Jobs

- Requires workforce with new skills
- Potential to create long term permanent jobs
- Specially trained professionals for inspections
- Opportunity to create entry level positions to disadvantaged youth (e.g. Onondaga Earth Corps)

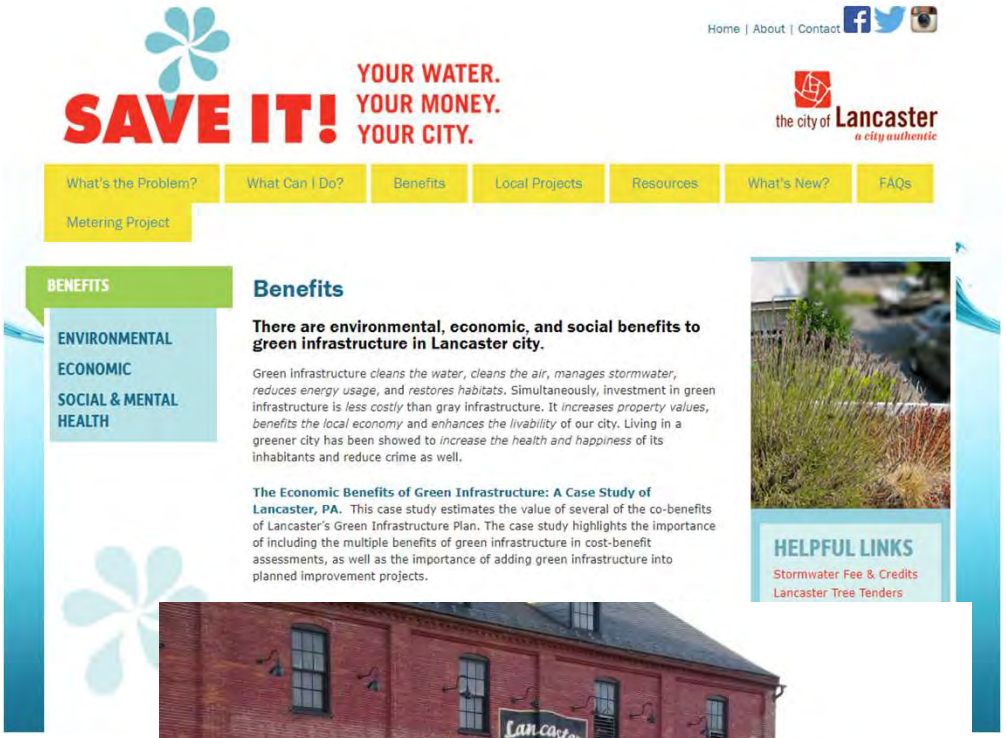




Onondaga Earth Corps

Overcoming Poor Public Awareness of BGI

- Tours and workshops
- BGI program branding
- Volunteer inspection and maintenance programs
- Private property training and self-certification policies



Poll Question #2

What are the greatest challenges or concerns you have regarding blue/green infrastructure implementation?

A. Cost

B. Maintenance

C. Public perception

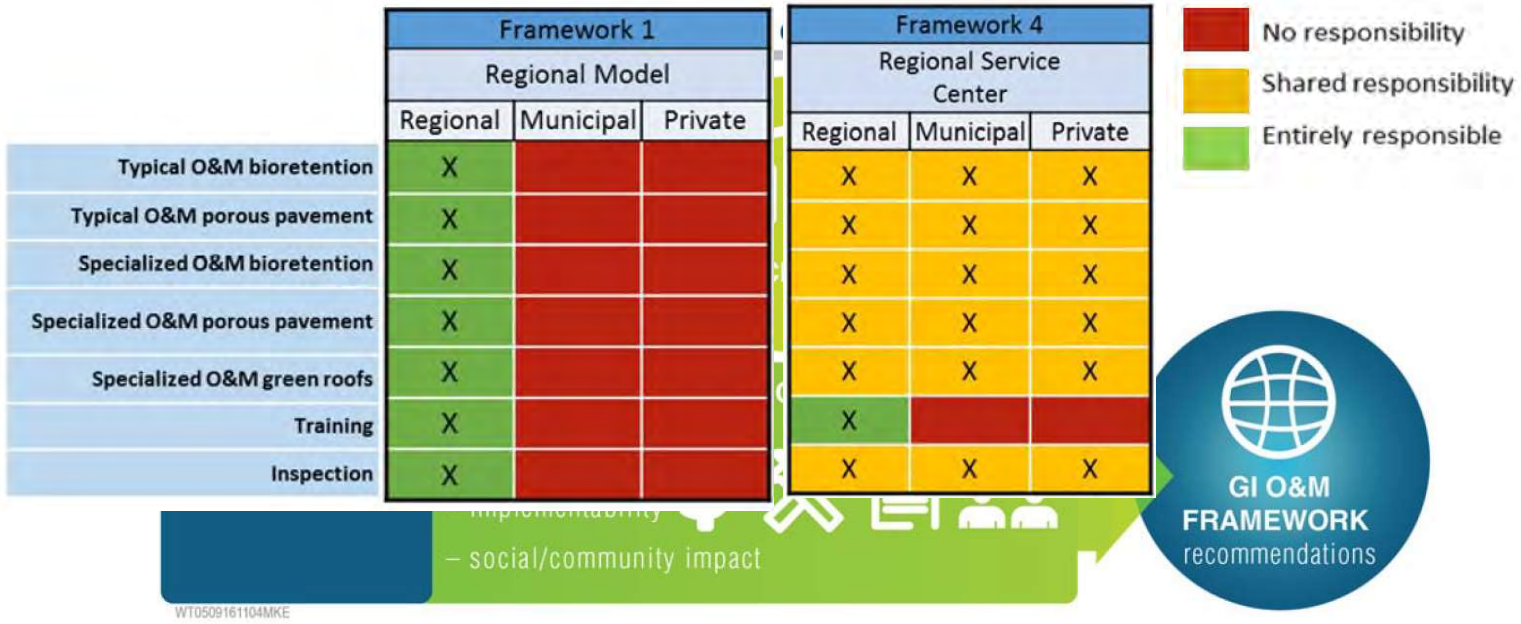
D. Lack of regulatory drivers

Effective Maintenance Starts At Planning and Policy Making

- Consider **who** will be maintaining BGI systems
- Outsource maintenance contracts or dedicated maintenance crews?
- Maintenance self-reporting for private property owners
- Standard Maintenance Procedures & Training
- Inspection & Enforcement Procedures

Milwaukee Metropolitan Sewer District: Maintenance Implementation Framework Evaluation

- What is the best O&M framework to maintain BGI based on ***who*** should be doing the maintenance
- Regional Model was highest scoring **<u>but not recommended</u>** based on stakeholder acceptance.



Standard Maintenance Procedures

- **Some overlap with existing maintenance activities**
- Vary based on primary system function, visibility, size, drainage area size, land cover/use, season, etc.
- Highly visible systems and structures require more
- Inspections required to meet regulatory requirements (e.g. MS4)
- **BGI Systems are dynamic…** ***consider adaptive management***

Blue vs. Green Infrastructure Maintenance Considerations

- Blue Infrastructure:
  - More concentrated
  - Larger drainage areas
  - Reduced frequency of inspections/cleaning; usually integrates robust pretreatment or sediment/trash forebay
- Green Infrastructure:
  - More distributed
  - Smaller drainage areas
  - Increased frequency of inspections/cleaning (depends on visibility)
- Blue/Green Infrastructure:
  - Combination of both blue and green maintenance considerations (as appropriate)
  - Lots of overlap in procedures

Source: Philadelphia Water Department

ALCOSAN O&M Guidance Manual

- Guidance for GI projects to develop a Maintenance Plan
- Routine, Non-routine, and General Maintenance Activities by GI type
- Maintenance Frequencies
- Includes Maintenance Inspection Checklists
- Manuals/guidelines protect ALCOSAN's investment in GI

Table 2-8. Routine Maintenance Task Frequencies by Service Level and GSI Type

	Maintenance Activity	Recommended Typical Frequency[1]		
		High Service Level	Moderate Service Level	Low Service Level
All GSI Technologies	GSI Inspection[3]	Monthly	Quarterly	Biannually
	Trash & Sediment Removal	Monthly	Quarterly	Biannually
	Organic Debris Removal	Quarterly	Biannually	Annually
	Sediment removal from vegetated areas and/or forebay	Monthly	Quarterly	Annually
	Collection System Cleaning	After each 1-inch storm event	Monthly	Quarterly
	Collection System Pretreatment Device Replacement	Device missing, damaged or nonfunctioning		
Vegetated GSI Systems	Weeding	Monthly	Quarterly	Biannually
	Mowing (if turf grass is present)	Weekly or biweekly during growing season	Quarterly	Annually
	Mulching	Biannually	Annually	
	Remove & Prune Plants	Biannually	Annually	
	Watering/Irrigation	Establishment/As needed		
	Cutting Back Vegetation	Annually		
	Clear overflow and drainage structures	After each 1-inch storm event	Monthly	Quarterly
	Winterization	Annually		
Infiltration Systems	Structure & System Vacuum Cleaning	Biannually		Annually
	Pipe Inspection/Pipe Jetting	Annual Inspection/Jetting as needed when 10% or more of cross section area is clogged with debris/sediment		
	Inlet Pretreatment Maintenance	Quarterly	Biannually	Annually
	Maintenance of Surface Aggregates (when present)	Quarterly	Biannually	Annually
	Bolt & Lock Care	As needed		
	Tree Care	Biannually or as needed	Annually or as needed	
	Winterization	Annually		

Inspection & Enforcement Policies & Procedures

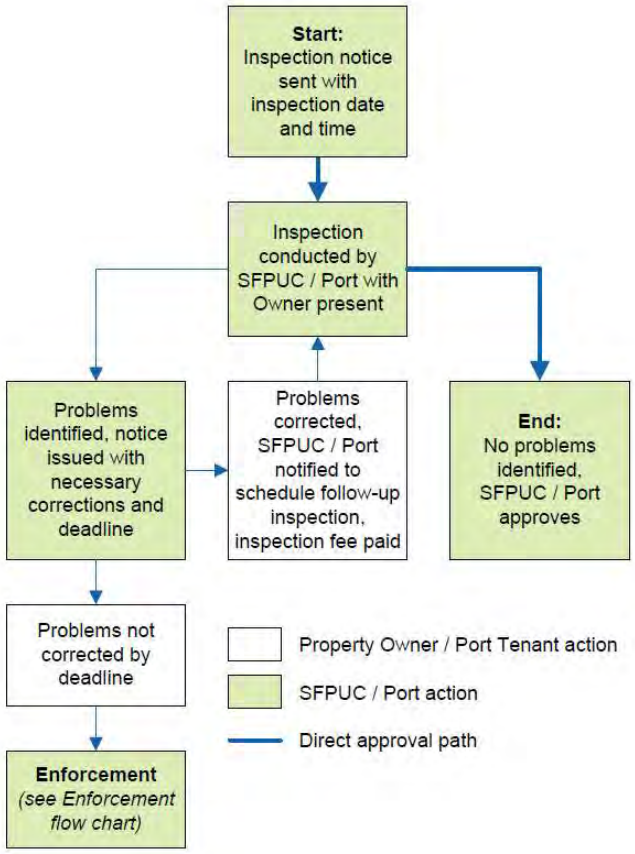
- Establish **Inspection Procedures and Schedules** for both public and private systems
- Develop or Require **Inspection Certification and Training Programs**
- Evaluate Opportunities for **Volunteer Inspection Programs**
- **Adapt Enforcement Procedures** for Green Infrastructure Practices
- **SW Fees and Credits** can provide Incentive and Reinforcement of Maintenance Requirements

SITE CONDITIONS-RE: Building Cistern
Satisfactory (S) - In compliance
Marginal (M) - In compliance, needs maintenance
Unsatisfactory (U) - Needs immediate attention or repair to achieve compliance
Not Applicable (N/A) - Not present or can't be observed

SITE CONDITION	STATUS	POSSIBLE MAINTENANCE SOLUTION(S)
Unpleasant Odors	Satisfactory - No unpleasant odors originate from any part of the system	
Lids, Access Hatches, Ladders, etc. Damaged / Inoperative / Inaccessible / Missing	Satisfactory - Access equipment in working order	
Catchment Surface Condition	Marginal - Small amount of dirt/sediment present. Surface materials have slight wear.	Clear any debris and sediment accumulation on catchment surface
Conveyance System Condition	Marginal - Minor debris/algae present in gutters or around downspouts. Materials have slight wear but not affecting system functionality	Remove accumulated debris and clogs.
Pretreatment Device / First Flush Diverter Clear of Debris	Satisfactory - Moderate amount of debris present (less than 30% of capacity) in sediment catchment or on filter surface	
Pretreatment Device / First Flush Diverter Clear of Debris		

San Francisco Public Utility Commission: Parcel Based GI Maintenance Tracking

- Require Annual Maintenance **Self-Certification Checklist Submission –** Private & Public Properties
- **Triennial Maintenance Inspections** to verify compliance
- Follow-up and **Enforcement** (if required)
- Based on **Maintenance Agreement** at time of permit



Training in Green Infrastructure O&M

- Provide practical training on maintenance standards and guidelines
- Established maintenance training programs
  - National Green Infrastructure Certification Program
  - Chesapeake Bay Landscape Professional (CBLP) Certification Program
  - Chesapeake Bay Stormwater Training Partnership Program
  - Montgomery County, MD – Contractor Training
  - Other state and university training programs
    - NC State
    - Washington State University
    - Denver, CO

Poll Question #3

What are the greatest challenges or concerns you have regarding maintaining blue/green infrastructure implementation?

A. *Cost*
B. *Lack of resources (equipment, staff, etc.)*
C. *Already have too much to maintain!*
D. *Training*

Effective Maintenance Begins with Design

How can design yield blue/green infrastructure projects that are readily accessible and maintainable?

Design Impacts Maintenance (and Vice Versa)

- **Design for minimal maintenance** where limited resources are available or when located on private property
  - BGI types that require greater or specialized maintenance might be better suited for sites with rigorous ongoing maintenance (e.g. schools, commercial areas, plazas/parks)
- **Design pre-treatment** that ensures long-term functionality
- **Design for ease of inspection and maintenance**, provide access
- Accurately understand **proposed soil and hydrologic conditions**
  - Drought tolerant (sandy soils)
  - Salt tolerant (roadways)

Employ Strategies to Avoid “Bare Areas”

- Erosion control fabric/energy dissipators
  - Biodegradable erosion control fabric on slopes during plant establishment
  - Place “tougher plants” near water entry points to act as vegetative energy dissipators (in addition to structural energy dissipators)
- Plant densely (employ denser spacing) to eliminate opportunities for weeds to establish
- Consider a layered “plant community” approach
  - “Green mulch” approach using diminutive filler groundcover species
  - Improves system resilience to varying conditions (light, water, etc.)

Realistically Assess Maintenance Capabilities and Community Preferences

- Keep plant palettes “simple” in terms of anticipated landscape maintenance tasks (grasses/perennials require similar types of maintenance vs. shrubs)
- Maintenance staff may have concerns about being able to distinguish weeds vs. desired plants
  - Provide images in any maintenance manuals
- Consider community preferences: more “naturalistic” palettes may look weedy to some communities vs “garden-like” palettes

VS.

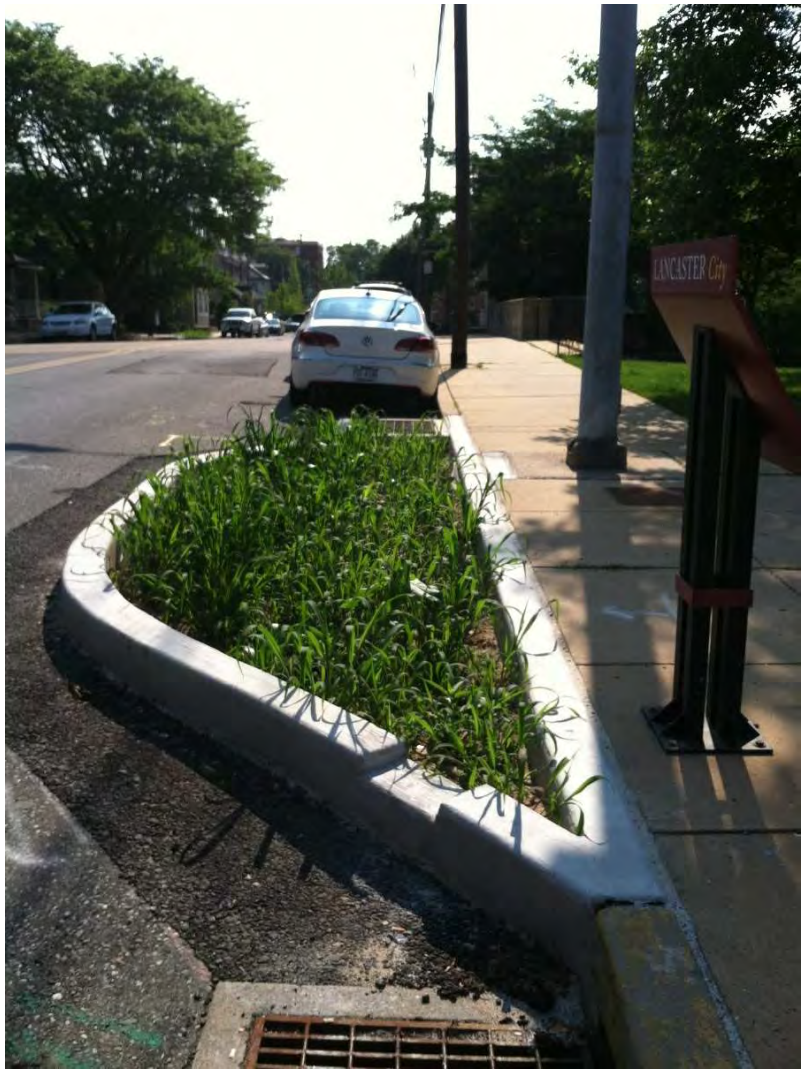
Activity

Know Your Weeds!

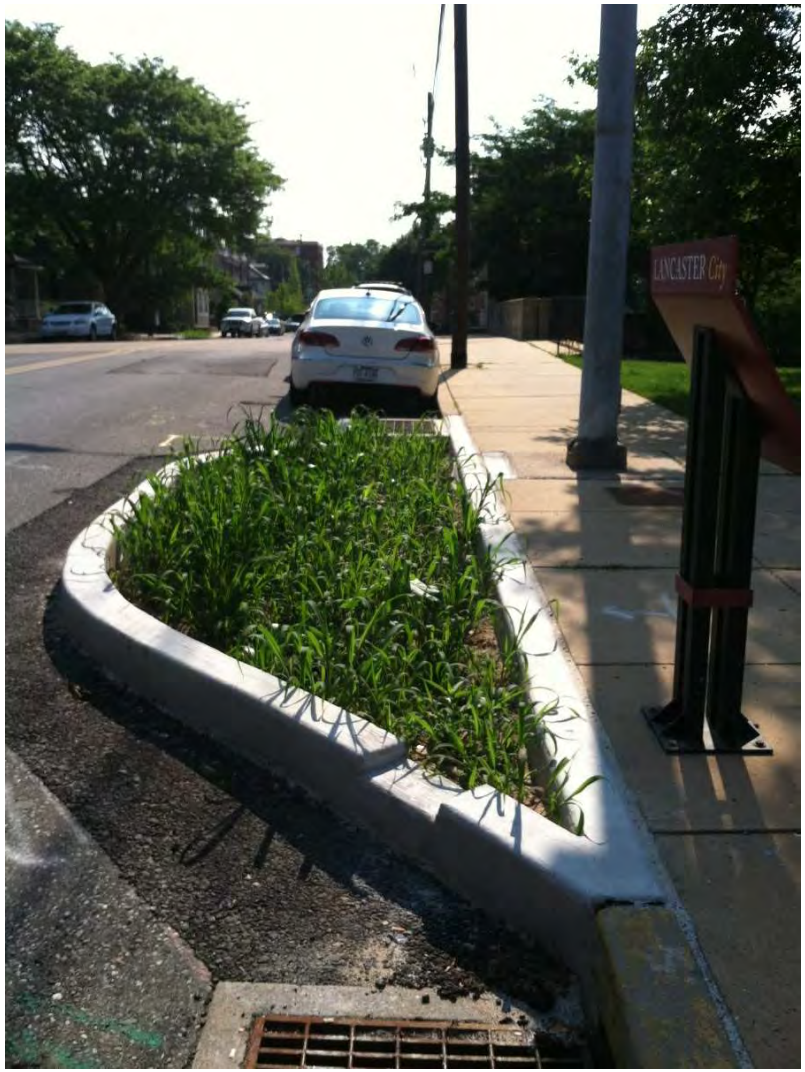
Weed
or
BGI Planting?

BGI Planting!

Bushy Bluestem /
Andropogon glomeratus



Weed
or
BGI Planting?



Weeds!

Weed
or
BGI Planting?

BGI Planting!

Juncus / *Juncus tenuis*

Weed
or
BGI Planting?

Weed!

Alligator Weed /
Alternanthera philoxeroides

Weed
or
BGI Planting?

BGI Planting!

Goldsturm /
Redbeckia fulgida

Case Study: City of Lancaster, PA

How has one of the leading BGI communities successfully maintained its BGI assets?

City of Lancaster GI Program : Measuring Success through O&M

- Full-time staff to support implementation (design & construction), monitoring & maintenance
- Trained existing parks staff to serve as dedicated bioretention maintenance crew
- Program staff, inspector, and field staff are all CBLP certified
- Field inspection & performance testing informs future design & construction
  - During construction and post-construction

City of Lancaster GI Program : Measuring Success through O&M

Performance Metrics

1. Gallons of stormwater captured annually
2. Gallons of combined sewer overflow reduced
3. SW permits & credits
4. Number of projects completed
5. Pounds of TN, TP, TSS diverted
6. Public outreach events & interactions

Inspection & Performance

1. BMP's are installed and maintained properly
2. BMP's function as intended
3. Functionality maintained over time
4. Reducing maintenance & observation

City of Lancaster: Measuring Success

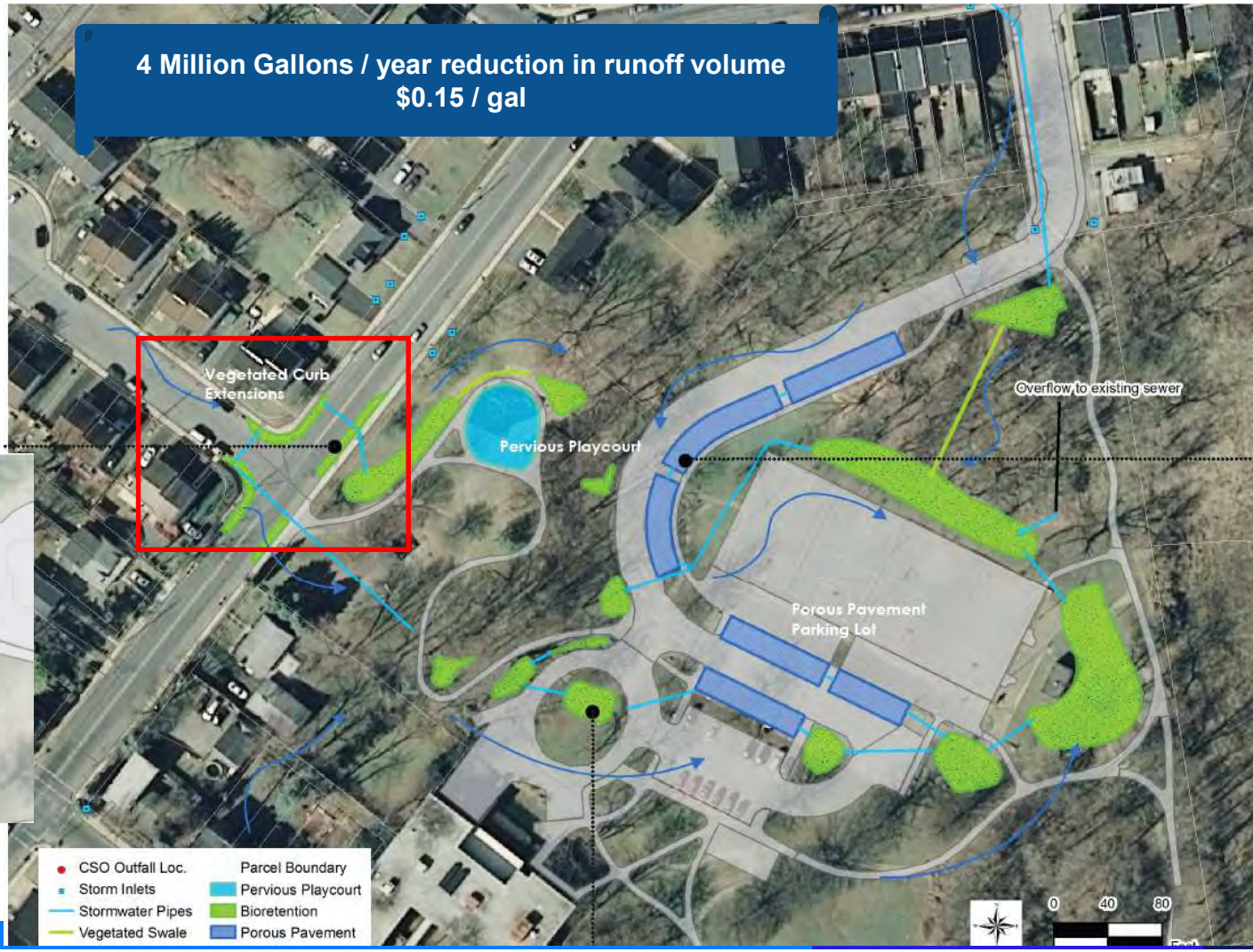
- GI Maintenance Plan:
  - Maintenance activities & schedules
  - Field performance testing & documentation
  - CMMS updates to track, document, and adapt maintenance activities

Estimated Maintenance Frequencies and Cost

GI Technology	Infiltration Trench	Bioretention	Porous Pavement	Average
Average Construction Cost ($/SF)	$34.45	$52.86	$19.01	$35.44
Routine Maintenance Cost ($/SF/yr)	$0.34	$1.21	$0.42	$0.66
Routine Maintenance Frequency (#/yr)	2	4	6	---
Non-Routine Maintenance Cost ($/SF)	$0.37	$1.71	$0.22	$0.77
Non-Routine Maintenance Interval (yr)	2	3	3	---
Total Annual O&M Cost ($/SF/yr)	$0.53	$1.78	$0.49	$0.93
Total Annual O&M Cost (% of construction)	**1.5%**	**3.4%**	**2.6%**	**2.5%**

Brandon Park

- Installed in 2012
- Multiple GI systems manage onsite and offsite runoff



Bioretention Performance Issues at Brandon Park

- Bioretention Grading & Erosion:
  - Soil erosion due to runoff from adjacent impervious areas that drain directly into system - especially on slopes
  - Washout around energy dissipators
- Vegetation:
  - Planting density too low
  - Bare areas observed due to incorrect species selection/urban conditions

Green Streets: Design and Maintenance Challenges

- Existing mature street trees
- Utilities and other infrastructure
- Street slope, limited space, subgrade conditions
- Public perception / education
- Contractor education / oversight
- Trash, sediment, debris, snow… maintenance!
- Costs (construction + maintenance)
- And the list goes on…

Mulberry Street & Charlotte Street: 1-way to 2-way Conversion

- Integrates GI at pedestrian crossings and on-street parking zones
- Improves vehicular traffic, bike and pedestrian safety, green stormwater management
- Significant cost savings by integrating green with traffic project funded with State Smart Growth funding
- Enhanced City Bike Plan
- Community Outreach

Collaboration and Adaptive Design is Key to Success

- Collaboration:
  - City Planning – Enhanced Bike Plan, Tree Planting/Protection, Community Engagement
  - PennDOT – Schedule impacts, additional reviews, and standard specifications
  - Integrated Design – Traffic, Signals, and GI
  - Utilities – Relocation and Protection
  - City Public Works and Engineering – Maintenance & utility offsets
- Adaptive Design:
  - Simplified grading – Level surfaces
  - Surface Pretreatment and Energy Dissipators – Easy to maintain
  - Early tree assessment – Protect & replace
  - City Engineering – Larger utility offsets
  - Public Works coordination – Reduce disturbance in ROW

Simplified Grading

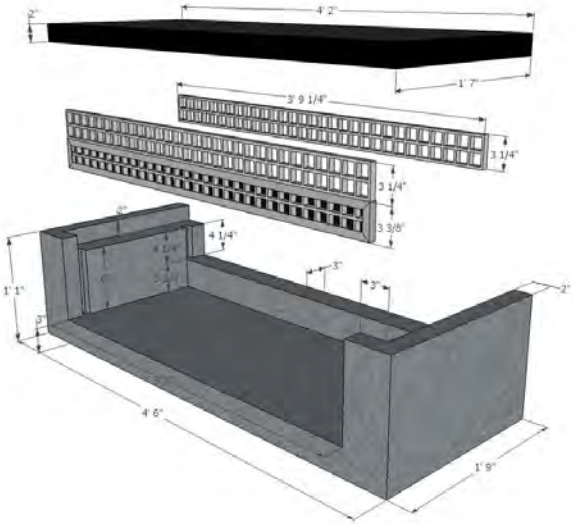
Surface GI Pretreatment Lessons Learned

- Cobble gets filled with sediment & is hard to maintain
- Lack of adequate pretreatment structure can cause surface soils to get clogged with sediment & debris

Stepped Sediment Forebay / Energy Dissipator

Plum and Walnut Street: Retrofitted Forebay / Energy Dissipator

Integrated Inlet and Pretreatment Structures (Rain Guardian Turret and Bunker)



Permeable Pavement Lessons Learned

- Permeable Asphalt & Flexible pavements
  - Play Surfaces (basketball, playgrounds)
  - Pathways & Sidewalks (flexible pavement where large trees)
  - Parking Lots

Permeable Pavement Lessons Learned

- Private & Public Alleys are a challenge
  - Unpaved driveways can clog pavement
  - Tree canopy and more difficult to maintain (hard to access; owners don't maintain)
  - Homeowner agreements can be difficult to obtain (for private alleys)
  - Current strategy: lower maintenance infiltration trenches with pretreatment and standard pavements in alleys

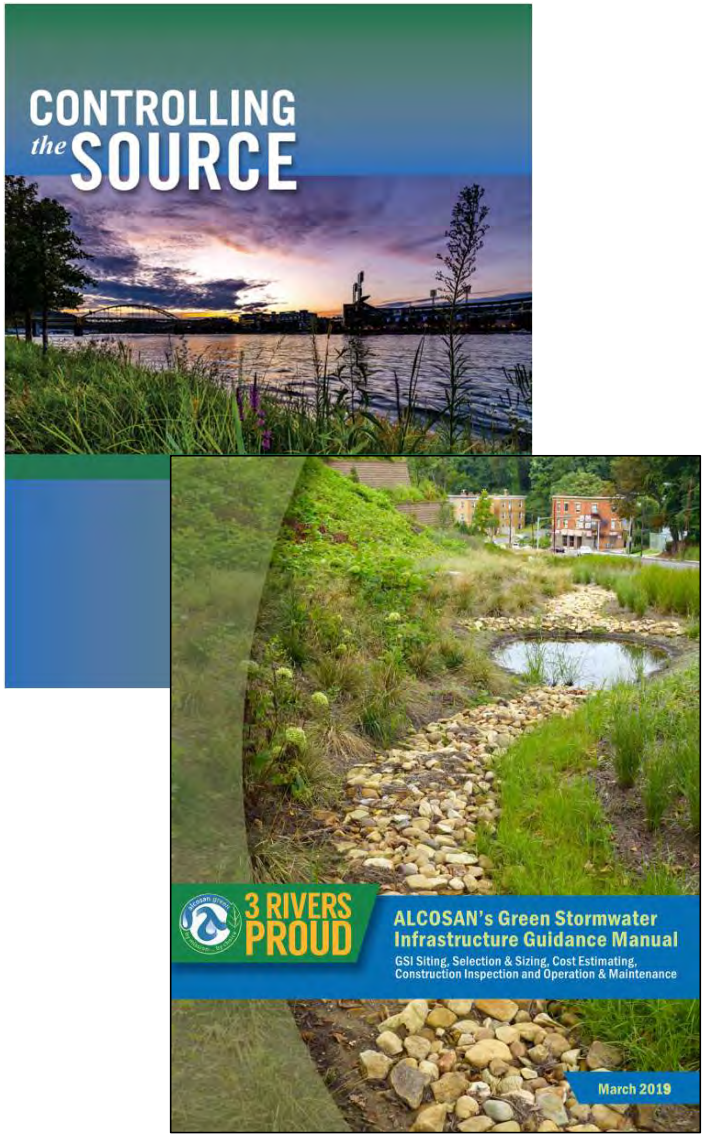
Permeable Pavement

- Permeable Pavers
  - Used on public streets with posted street sweeping
  - No gravel between pavers reduces clogging potential on green streets (PaveDrain)
  - Vacuum sweep to maintain/restore porosity

Resources

BGI Maintenance Guidance Resources

Reference Name	Publishing Agency	Date Published/ Updated	Link
ALCOSAN's Green Stormwater Infrastructure Guidance Manual	ALCOSAN	2019	https://www.alcosan.org/docs/default-source/grow/alcosan_guidancedocs_march2019.pdf?sfvrsn=7c5d69ae_4
Addressing Green Infrastructure Design Challenges in the Pittsburgh Region Fact Sheet Series	EPA, EnvironmentalProtection Agency	January 2014	Addressing Green Infrastructure Design Challenges in the PittsburghRegion
Resource Guide for Planning, Designing and Implementing Green Infrastructure in Parks	National Recreation and Park Association	2017	Resource Guide for Planning, Designing and Implementing GreenInfrastructure in Parks
Green Solutions Fact Sheets	3 Rivers Wet Weather	2016	Green Solutions Bioswales Disconnected Downspout Green Roof Planter Box Permeable Pavement Rain Barrel Rain Garden Vegetated Filter Strip Vegetated Swale
Procedures Manual for Developers Chapter 9: Green Stormwater Infrastructure	Pittsburgh Water and Sewer Authority	January 2018	Procedures Manual for Developers
Pennsylvania Stormwater BMP Manual	Pennsylvania Department of Environmental Protection, Bureau ofWatershed Management	December 2006	Pennsylvania Stormwater BMPManual
Green Stormwater Infrastructure Planning & Design Manual	Philadelphia Water	April 2018	Green Stormwater Infrastructure Planning & Design Manual
Green Streets Design Manual	Philadelphia Water, Philadelphia Streets	2014	City of Philadelphia Green Streets Design Manual
Best Management Practice (BMP) Toolkit	Westmoreland Conservation District.	2015 - 2016	Westmoreland Conservation DistrictBMP Toolkit



BGI Maintenance Guidance Resources

- Controlling the Source, ALCOSAN, 2020
  https://www.alcosan.org/our-plan/plan-documents/controlling-the-source
- Staying Green: Strategies to Improve Operations and Maintenance of Green Infrastructure in the Chesapeake Bay Watershed, American Rivers (2013):
  http://americanrivers.org/wp-content/uploads/2016/05/staying-green-strategies-improve-operations-and-maintenance.pdf
- National Green Infrastructure Certification Program (NGICP):
  http://ngicp.org/

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Thank You! Questions?

Kate Austin

AustinK@cityoflancasterpa.com

Susan Beck, PE

Susan.Beck@Jacobs.com

Daniel Wible, PE

Daniel.Wible@Jacobs.com

Water Resource Center

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