EFFECTIVE AND EQUITABLE GREEN STORMWATER INFRASTRUCTURE IN THE CHESAPEAKE BAY:

Current Challenges and Next Steps

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OVERVIEW

Green stormwater infrastructure (GSI) is "the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspire stormwater and reduce flows to sewer systems or to surface waters."[1] Given the importance of GSI to meet water quality standards for urban stormwater runoff and its ancillary benefits from community "greening," our team of researchers at the University of Delaware sought to understand how municipalities and government agencies can equitably distribute and maximize the benefits of GSI for stormwater management and society, while minimizing the barriers to achieving these goals.

From September 2022 through April 2023, we convened with stormwater professionals in the Chesapeake Bay region to identify and prioritize the most pressing challenges related to effective and equitable GSI. Activities included: 1) two in-person, half-day workshops, each with approximately 20 stakeholder participants; 2) phone conversations with additional stakeholders invited to the meetings but unable to attend; 3) an online survey which received around 40 additional responses from meeting attendees and other stakeholders; and 4) a special session at the biennial Bay-wide Stormwater Partners Retreat with approximately 20 attendees to share emerging findings and gather additional feedback.

The first workshop in December 2022 included 17 stakeholder participants, of which eight were private consultants representing the engineering and design community. Other participants were from community engagement groups, government or government-affiliated organizations, and regional professional organizations. While the pre-meeting survey and initial discussions identified common GSI practices that are of most interest in the Bay (e.g., bioretention), key hindrances to GSI adoption emerged from this meeting, all of which revolved around maintenance. Through these discussions, it became clear we were missing crucial voices from the GSI maintenance space, including government entities that manage publicly-owned GSI installations, landscaping firms that contract for GSI maintenance, and community groups (e.g., HOAs) that are responsible for maintaining privately-owned GSI.

The critical barrier to effective and equitable GSI in the Chesapeake Bay Watershed is GSI maintenance.

Building upon the concerns about GSI identified during the first workshop, a second meeting in April 2023 addressed GSI maintenance and long-term performance issues. Of the 20 stakeholder participants in this second meeting, seven represented city, county, and state governments, and five represented landscaping firms. The remaining participants were from community engagement groups and the engineering and design community. To reach additional stakeholders with unique perspectives on GSI maintenance that were unable to

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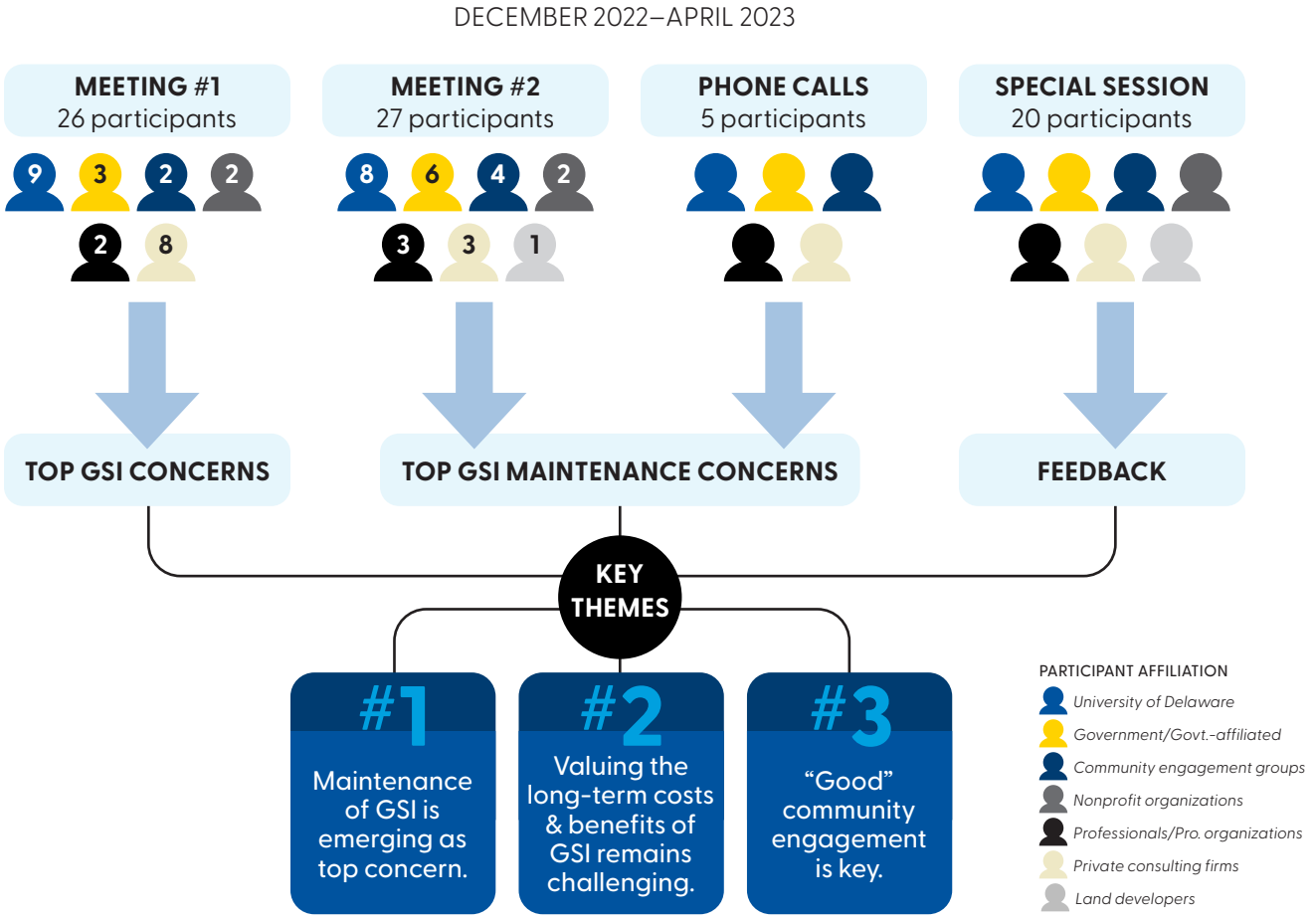
OVERVIEW CONTINUED

attend the workshop, we arranged phone call discussions. Finally, we shared initial findings from these discussions and refined our understanding of concerns in these areas at a special session at the Bay-wide Stormwater Partners Retreat, which attracts approximately 200 stormwater professionals.

From these meetings with stakeholders who represented a comprehensive knowledge base and diverse perspectives, a clear consensus emerged: the critical barrier to effective and equitable GSI in the Chesapeake Bay Watershed is GSI maintenance. This barrier encompasses many issues, including uncertainty about long-term maintenance costs, long-term benefits for stormwater management and societies, and community engagement that fosters equitable and effective GSI maintenance. One workshop participant summarized many stakeholders' thoughts: "The most challenging barriers to GSI are no longer engineering, but social barriers." While engineering (and science) can improve GSI design and stormwater management, establishing effective and equitable maintenance programs requires understanding and engaging with communities. Here, engineering may provide valuable information for community engagement, while social science offers direction for how maintenance activities are "sold" to communities for implementation.



KEY THEMES IN DISCUSSIONS

Maintenance of GSI is emerging as a top concern in the Chesapeake Bay region

When asked to identify the "top barrier" to effective and equitable GSI in the Chesapeake Bay region, participants consistently pointed to GSI maintenance[2,3,4,5]. While many aspects of GSI maintenance were cited as challenging, participants agreed that the three most pressing concerns are: 1) insufficient funding, 2) lack of stakeholder buy-in, and 3) poor plant selection and management[6].

Identifying a consistent, adequate funding source for maintenance is an ongoing struggle for both public and private owners of GSI installations. The current alarm about funding for maintenance is a shift from past concerns about funding for installation[4] , which may be an encouraging reflection of the relative abundance of financial and technical resources in the region for getting GSI installations into the ground. Where robust maintenance programs do exist, participants noted that a "lowest-bid" mentality can price out well-qualified landscapers from GSI maintenance contracts and impact overall quality of maintenance[7]. Overall, participants agreed there is a need to better understand the relationship between cost and effectiveness of different maintenance practices, in order to streamline maintenance programs while ensuring that cost-cutting measures do not come at the expense of effectiveness[6,8].

A second challenge is a lack of stakeholder buy-in for maintenance, which can stem from stakeholder fatigue[9], owner turnover[9,,10,11,12], or differences in expectations about what a well-maintained GSI practice should look like[9]. Participants expressed special concern for communities or private landowners that may "inherit" responsibility for the ongoing maintenance of GSI practices that were installed by a local government or NGO, a developer, a former landowner, or prior leadership within an organization[6,7,10,11]. Not only may institutional knowledge be lost during these transfers of responsibility, but the new parties responsible for the ongoing maintenance do not always have the same time or financial resources as the original installers, particularly in low-income communities. Public perceptions and aesthetic preferences can impact both the cost and the form of maintenance. For example, some localities feel pressure to maintain overly robust (i.e., expensive) maintenance programs that err on the side of frequent maintenance in order to ensure responsiveness to community concerns about aesthetics and safety, irrespective of impact to GSI effectiveness[13].

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A third concern relates to plant selection and management. Mistakes in plant selection include incorporating plants that are not well suited for the site setting (e.g., not salt-tolerant, deer-resistant, or appropriate for soils) as well as failure to take into consideration the knowledge and expertise of the maintenance crew[9]. For example, participants noted that all-volunteer crews are often less able to maintain a complex planting scheme than professional crews trained in plant identification and GSI maintenance[4,7,8,10]. Discussions about plant management often circled back to the workforce needed for GSI maintenance[7,14]. Multiple participants pointed to the need for a job market analysis of GSI

maintenance workforce[8], as there is currently no understanding of what the market needs are with regards to the number of jobs. Without this information, some participants were inclined to see the growing need for GSI maintenance as a potentially important economic driver in the region[14], while others suggested that the number of new jobs would be minimal[12].

Valuing the long-term costs and benefits of GSI remains challenging

Another theme underlying many discussions was the need to improve how the long-term costs and benefits of GSI are valued. We found it interesting that while there was never explicit disagreement between participants, in one discussion a participant might refer to GSI as expensive while in the next, another would imply that GSI practices yield cost savings[2]. This speaks to confusion even amongst stormwater experts about what costs and benefits should be accounted for when valuing GSI practices, as well as uncertainty in how to quantify these values.

Overall, participants were united in their desire to better understand the social and economic "co-benefits" of GSI practices[3,8,15]. Many noted that the value of GSI in the region is often calculated based on nutrient removal, which shortchanges the full range of benefits that GSI practices are perceived to offer[2,3,15]. Most participants took it for granted that socioeconomic co-benefits are abundant and real, but lamented that they did not have the numbers and/or dollar values at their fingertips when working with stakeholders[4,8,15]. These participants viewed messaging around co-benefits as an important way to increase community buy-in and tailor GSI solutions to community needs. They also suggested that it was important to frame GSI practices as community assets, as opposed to single-purpose tools for stormwater management.

The current stormwater crediting system in the region is not designed to account for changes in function over time, nor are these changes well-understood or well-quantified.

While the stormwater professionals participating in these activities were generally much more comfortable articulating the stormwater management benefits of GSI practices, there was also curiosity about the degree to which these core benefits of GSI evolve over time[2,8,13,16] and/or manifest at large spatial scales[15]. Participants reported that evidence of GSI effectiveness is typically measured by visual indicators at individual installations and that quantifying water quantity impacts over time and/or collective impacts at larger scales is more challenging for most communities[13]. Participants also noted that while GSI practices can exceed expected life spans, they may look and function very differently after 20 years than they did upon installation[16]. The current stormwater crediting system in the region is not designed to account for changes in function over time, nor are these changes well-understood or well-quantified.

In terms of costs, the major concerns again revolved around maintenance. It is self-evident to most participants that there is a relationship between the cost of maintenance and all benefits of GSI practices; without proper maintenance by well-trained individuals, the benefits of GSI may not persist and there is a risk that the installation becomes more of a burden than a boon for a community[17]. However, it remains unclear how to quantify this relationship and value investments in maintenance. Participants emphasized that the cost of a planned maintenance program

should be incorporated into initial project budgets[2,7] and that more information about the cost vs. benefit of various maintenance practices would help minimize this expense and perhaps increase stakeholder buy-in[8,9] .

"Good" community engagement is key

The importance of community engagement was another theme that was present throughout our meetings. Many of the lessons learned that participants shared from their time working on GSI projects touched on the importance of early communication with community leaders or tapping into existing resident interests[2]. Similarly, many maintenance "wins" involved working closely with community advocates and coordinating GSI design to address existing community needs, while maintenance "mistakes" involved not understanding the existing community use of spaces or limits on community resources for maintaining practices[7]. Ultimately, participants voted "community engagement" as one of the top three barriers to effective and equitable GSI[3], and "stakeholder buy-in" as one of the top three challenges related to GSI maintenance[58].

One aspect of good community engagement that participants were especially interested in is improving their marketing of GSI to individual communities. Many suggested that a lack of public awareness, understanding, or knowledge of GSI was a key challenge to community engagement[3,9], and these participants saw improved outreach as a solution[8, 15].

It is the "co-benefits" of GSI practices beyond stormwater management that are most important to communities.

In general, participants agreed that it is the "co-benefits" of GSI practices beyond stormwater management that are most important to communities[4,15]. These stakeholders wanted more access to information about how to quantify these co-benefits as well as guidance on which co-benefits are most important to individual communities in order to better tailor their messaging[8,15].

Another aspect of good community engagement that many participants mentioned is listening to the community's values and needs early and frequently throughout the life of a GSI project. Some noted that one of the challenges of building these community relationships is that it is not a hard deliverable, so it can be difficult to find funding for or articulate why professionals ostensibly responsible for designing and installing a project may need to attend community meetings for a year before a project design starts and stay in the community for a few years after the project is installed[14]. Despite this, there was wide recognition that projects that have prioritized this level of community engagement are the most successful and least prone to costly mistakes[2,7].

1 *Water Infrastructure Improvement Act, 2019*
2 *Meeting #1: Lessons Learned (Introductions)*
3 *Meeting #1: GSI Barriers Fishbone Exercise*
4 *Special Session: Reaction to Meetings*
5 *Phone Call 1: Community Outreach*
6 *Meeting #2: Maintenance Challenges*
7 *Meeting #2: Maintenance Mistakes & Wins*
8 *Special Session: Research Needs*
9 *Meeting #2: Maintenance Challenges Fishbone Exercise*
10 *Phone Call 1: Community Outreach*
11 *Phone Call 3: Homeowner's Association*
12 *Phone Call 4: Engineering Firm*
13 *Special Session: Effectiveness of GSI*
14 *Special Session: Equity and GSI Maintenance*
15 *Meeting #1: GSI Benefits Open Discussion*
16 *Meeting #2: Maintenance Mistakes and Wins Open Discussion*
17 *Survey open ended response*

NEXT STEPS

When asked to identify information gaps, participants identified three primary areas of need:

1st **Communication strategies to effectively engage with communities and foster stakeholder buy-in.** Participantsexpressedthe need for support in their communication with communities with the aim of increasing support for GSI. Specifically, they requested additional information about the social and economic co-benefits of GSI in order to tailor outreach about co-benefits to community needs and interests. Relatedly, some requested additional information on how to engage with environmental justice communities.

2nd **Guidance on maintenance funding programs and best practices, including details on what types of interventions are most cost-effective.** Participants highlighted the need for information on both the funding and technical aspects of maintenance. In particular, they expressed a gap in information on long term function of GSI and requested guidance on best long-term maintenance practices. Some highlighted that this is particularly important due to uncertainty about GSI performance under future climate scenarios. Participants also described the need for additional opportunities for and guidance on allocating O&M into project budgets.

3rd **Analysis of the GSI job market to better understand the level of need for workforce development.** There were repeated requests for additional information about the potential for GSI workforce development. As mentioned above, there were differing perspectives on this potential, but many agreed that there was limited information available about the types and number of GSI jobs that could be created in the region. In response, many participants requested an analysis of workforce needs that could be used to inform the creation of and investment in training programs.

Looking forward, the need for effective and equitable GSI will continue to grow in the Chesapeake Bay as current stormwater infrastructure ages and precipitation events intensify. These discussions illustrated that the GSI field has made significant technical advancements to support this implementation. Moving forward, additional insights into the long-term performance of GSI practices and role of maintenance in protecting long-term benefits will be needed. There is a consensus that these engineering insights need to be more tightly coupled to improved community outreach and engagement to better tailor solutions for the individual needs and resources of different communities. In light of this, these discussions point to the need for GSI projects to prioritize both social and environmental factors throughout the planning, design, installation, post-installation stages.

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APPENDIX: ACTIVITY SUMMARY

Meeting #1: Barriers and Opportunities for Effective & Equitable GSI

Date: December 19, 2022
Location: University of Delaware, Newark, DE
UD Participants: Carolyn Voter, Paul Imhoff, Rebecca Nixon, Yao Hu, Rachel Zobel, Abbie Pierson, Amy Slocum, Cherie Conrad, Helen Stimson
Stakeholder Participants: 17 stormwater professionals from the Chesapeake Bay region affiliated with private consulting firms (8), nonprofit organizations (2), community engagement groups (2), government (or government-affiliated) organizations (3), and regional professional organizations (2).
Agenda:

9:30–9:45 am: Coffee, check-in

9:45–10:45 am: Welcome & Introduction, Carolyn Voter (UD)

- *Who we are.* UD team members share: 1) name, 2) role/title, 3) expertise or interest that is relevant to the day's meeting.
- *Project background.* NSF project goals and objectives for the day's meeting.
- *Who you are:* Stakeholder participants share: 1) who you are, 2) lesson learned from your GSI experiences, 3) one thing you hope to get out of the day
- *Open discussion.* Insights, challenges, additions

10:45–11:45 am: GSI Benefits

- *Definition of GSI.* Abbie Pierson (undergraduate student, UD)
- *Benefits of GSI.* Rachel Zobel (graduate student, UD)
- *Open discussion* about the benefits of GSI. Insights, challenges, additions.
- *Break-out discussions.* Randomly divide participants into 3 groups: 1) Urban Street Trees, 2) Bioretention Facilities, 3) Biochar. On flip charts, brainstorm:
  – Where is this practice already installed in the Chesapeake Bay area?
  – Where do you think this practice should be installed more?
  – Why should this particular GSI practice be installed more widely? What are the benefits?
  – Are there any concerns about installing this practice more widely?
  – Group debrief. One person per group reports out (3 min), open discussion (5 min)

11:45 am–12:30 pm: Lunch

12:30– 1:30 pm: GSI Barriers

- *Fishbone exercise.* What key challenges or barriers exist that impede the implementation of effective and equitable GSI in the Chesapeake Bay region? (Helen Stimson, Facilitator)
  – Participants silently write one idea per sticky note, place on back wall
  – Participants silently arrange sticky notes into columns representing unique topics
  – Facilitator walks through each column, group helps name the column
  – Participants vote (using sticky dots) on top concerns

1:30pm-2:00pm: Wrap up

- *Revisit goals, next steps.* Carolyn Voter (UD)
- *Written, anonymous feedback.* Participants answer: 1) who should we invite next? 2) best ways to distribute deliverables?, 3) anything else you'd like to share with us?

Meeting #2: The Role of Maintenance in Effective & Equitable GSI

Date: April 6, 2023
Location: University of Delaware, Newark, DE
UD Participants: Carolyn Voter, Paul Imhoff, Rebecca Nixon, Yao Hu, Rachel Zobel, Abbie Pierson, Amy Slocum, Cherie Conrad
Stakeholder Participants: 19 stormwater professionals from the Chesapeake Bay region affiliated with government organizations (6), community engagement groups (4), landscaping professionals (3), private consulting firms (3), nonprofit organizations (2), and land developers (1).
Agenda:

12:00–12:30 pm: Welcome & Introductions

- *Who we are.* UD team members share: 1) name, 2) role/title, 3) expertise or interest that is relevant to the day's meeting.
- *Project background.* NSF project goals and objectives for the day's meeting.
- *Who you are:* Stakeholder participants share: 1) who you are, 2) GSI maintenance experience that sticks with you, 3) one thing you hope to get out of the day

12:30–1:15 pm: Lunch

1:15–2:30 pm: Maintenance Mistakes and Wins

- *Break-out discussions.* Randomly divide participants into 4 groups. At each of 4 different stations (8 min each), brainstorm examples of "mistakes" and "wins" you have seen, heard of, or can imagine related to GSI maintenance at each stage of a project:
  – **Planning:** site selection, community engagement, etc. ahead of design
  – **Design:** engineering design of the installation for the identified site
  – **Installation:** construction of the installation
  – **Post-Installation:** ongoing monitoring/maintenance after installed
- *Group debrief.* One person per station reports out (3 min), open discussion (20 min)

2:30–2:45 pm: Break

2:45–3:45 pm: Maintenance Challengess

- *Fishbone Exercise.* What are the challenges & barriers of maintaining GSI? Think broadly! Might be social, economic, environmental, hydrologic, etc.
  – Participants silently write one idea per sticky note, place on back wall
  – Participants silently arrange sticky notes into columns representing unique topics
  – Facilitator walks through each column, group helps name the column
  – Participants vote (using sticky dots) on top concerns

3:45–4:00 pm: Wrap up

- *Written, anonymous feedback.* Participants answer: 1) do you have suggestions on good ways to distribute deliverables?, 2) do you know of any locations with long-term records of GSI installation performance?, 3) what else are you left thinking?

Special Session: Bay-wide Stormwater Partners Retreat

Date: April 14, 2023
Location: Bay-wide Stormwater Partners Retreat, Shepherdstown, WV
UD Participants: Carolyn Voter, Rebecca Nixon
Stakeholder Participants: 120 stormwater professionals in attendance at the retreat, including three who participated in Meeting #1 and one who participated in both Meeting #1 and Meeting #2.
Agenda:

5 min: Introduction

3 min: Get to Know Your Neighbors

- *Turn to your neighbor(s):* 1) introduce yourself, 2) what about the keywords "effective" and/or "equitable" made you interested in attending this session?

5 min: Sharing out: Survey Findings, Becca Nixon (UD)

7 min: Sharing out: Meetings, Carolyn Voter (UD)

35 min: Open Discussion

- *Reaction to Meetings:* Insights and challenges to the survey and meeting findings
- *Equity and GSI Maintenance:* Based on your experiences, in what ways do you see maintenance of GSI relate to environmental justice?
- *Effectiveness of GSI:* What information do you or others use to decide if an existing GSI practice is effective?

10 min: Wrap Up

- *Research Needs.* Written, anonymous feedback on: What new information, understanding, or knowledge would you need to begin addressing the concerns we discussed today or your own personal GSI headaches?

Phone Calls: Individual Stakeholders not at Meetings

All phone calls lasted about 1 hour and focused on the stakeholder's experience with maintaining stormwater infrastructure.

Phone Call 1: Community Outreach

Date: March 23, 2023
UD participant: Carolyn Voter
Stakeholder participant: Director of outreach for non-profit focused on clean water and environmental justice in the Chesapeake Bay watershed

Phone Call 2: Public Utility

Date: March 23, 2023
UD participant: Carolyn Voter
Stakeholder participant: Stormwater asset manager at a public utility

Phone Call 3: Homeowner's Association

Date: March 31, 2023
UD participant: Carolyn Voter
Stakeholder participant: Resident and former president of a homeowners association in the Chesapeake Bay watershed

Phone Call 4: Engineering Firm

Date: April 20, 2023
UD participant: Carolyn Voter
Stakeholder participant: Founder of a water resources engineering firm focused on stormwater maintenance

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