

MMSD
PARTNERS FOR A CLEANER ENVIRONMENT

Report

Green Infrastructure Operations and Maintenance Implementation Framework

Contract No. P-2648

Prepared by

ch2m

October 2016

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Contract No. P-2648

Prepared for

The Milwaukee Metropolitan Sewerage District

October 2016

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Executive Summary

The Milwaukee Metropolitan Sewerage District's (MMSD) 2035 Vision and Regional Green Infrastructure (GI) Plan have set an aggressive goal for GI implementation in the Milwaukee region. The MMSD 2035 Vision set the goal to use GI to capture the first half-inch of rain from impervious surfaces. This level of GI implementation will require many thousands of GI installations, all of which will need to be maintained to remain effective. In order to realize and sustain broad GI implementation across the MMSD service area, the region needs an implementable GI operation and maintenance (O&M) framework to cost-effectively protect and maintain GI benefits.

This report documents the approach and findings to answer the following question: For this significant level of GI implementation, what would be the best overall O&M framework to maintain this GI investment? This report focuses on *who* should be doing the various elements of GI maintenance and identifying what roles the MMSD, regional entities, municipalities, and private property owners should play for effective GI maintenance in the region.

To develop a recommendation for a GI O&M framework for the region, the evaluation considered the following inputs and considerations:

- Meetings with public and private stakeholders to gather their input on GI O&M needs and concerns.
- Presentations at two Technical Advisory Team (TAT) meetings to brief municipalities on the project and to solicit their input.
- Development of six GI O&M implementation framework alternatives considering variations in regional, municipal, and private property owner GI O&M responsibilities.
- Scoring and evaluation of the six GI O&M implementation framework alternatives based upon stakeholder feedback.
- Final Recommendation of a Regional Service Center that provides private and public property owners with GI O&M training and optional services offered at the regional level.

GI O&M Implementation Framework Alternatives

In all, the project considered six GI O&M implementation framework alternatives representing variations in responsibility for maintenance and training between a regional entity, municipalities, and private property owners. These six implementation framework alternatives were created in an attempt to come up with not only the most efficient, cost-effective approach, but also an acceptable strategy for maintaining GI across the region. Figure ES-1 summarizes the GI O&M responsibilities for each implementation framework.

	Framework 1			Framework 2			Framework 3		
	Regional Model			Municipal Model			Municipal & Private Model		
	Regional	Municipal	Private	Regional	Municipal	Private	Regional	Municipal	Private
Typical O&M bioretention	X				X			X	X
Typical O&M porous pavement	X				X			X	X
Specialized O&M bioretention	X				X			X	X
Specialized O&M porous pavement	X				X			X	X
Specialized O&M green roofs	X				X			X	X
Training	X				X			X	X
Inspection	X				X			X	X

	Framework 4			Framework 5			Framework 6		
	Regional Service Center			Regional Training			Regional Training & Specialized Maintenance		
	Regional	Municipal	Private	Regional	Municipal	Private	Regional	Municipal	Private
Typical O&M bioretention	X	X	X		X	X		X	X
Typical O&M porous pavement	X	X	X		X	X		X	X
Specialized O&M bioretention	X	X	X		X	X	X		
Specialized O&M porous pavement	X	X	X		X	X	X		
Specialized O&M green roofs	X	X	X		X	X	X		
Training	X			X			X		
Inspection	X	X	X		X	X	X	X	X

No responsibility
Shared responsibility
Entirely responsible

Figure ES-1. GI O&M Implementation Framework Responsibility Summary

The alternatives were scored considering the financial, implementability, and social/community impact criteria of each of the GI O&M implementation frameworks. Figure ES-2 provides a visual representation of the scores for ease of determining the highest rated frameworks. The graph breaks out the relative financial, implementation, and social/community impact scores in color-coded bands.

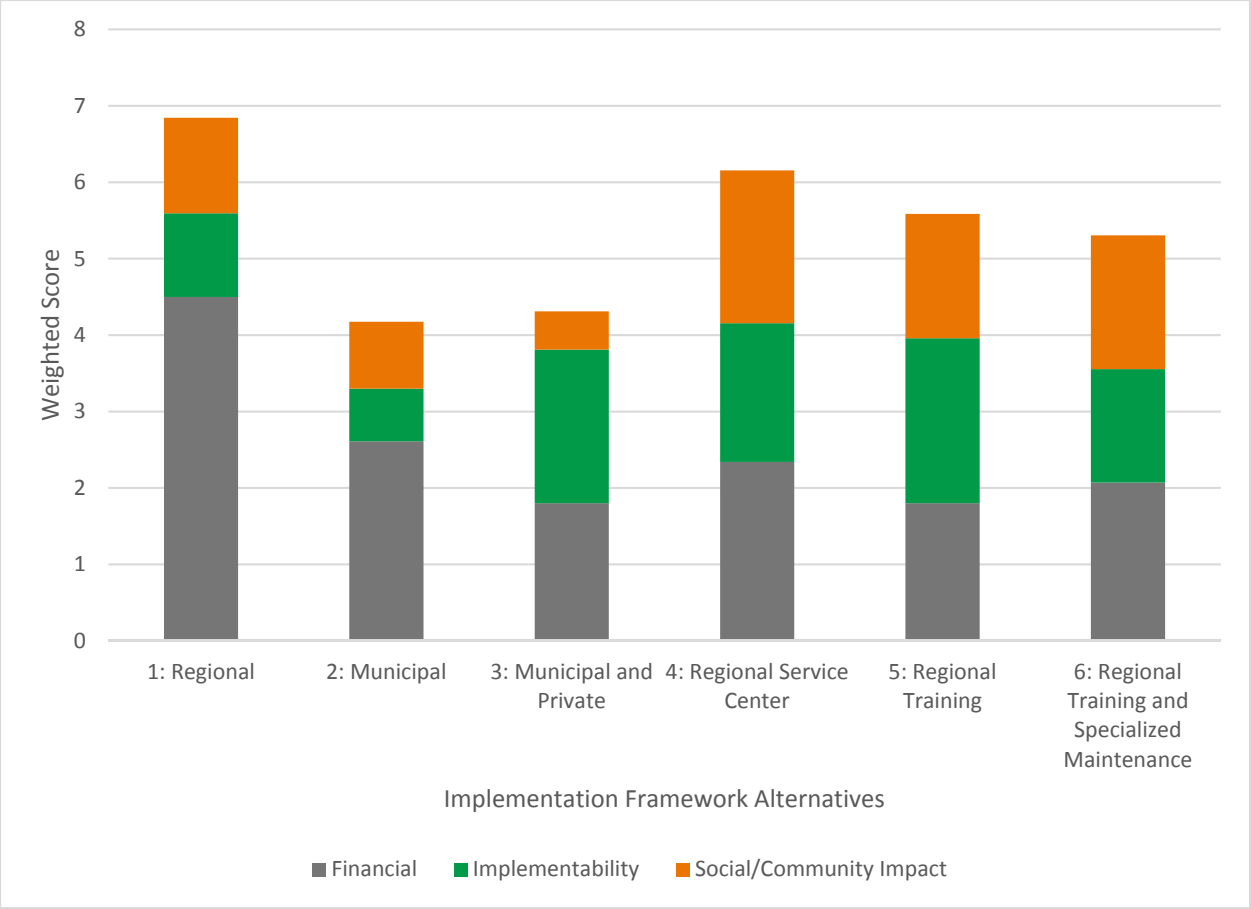

Figure ES-2. Initial GI O&M Implementation Framework Weighted Scores

As explained in the report, the Regional Model was the highest scoring implementation framework but was not recommended based on stakeholder acceptance. So the project team considered the next highest scoring alternative and its acceptability to stakeholders. Based upon this consideration, the Regional Service Center GI O&M Implementation Framework is recommended because it is the most efficient, cost-effective, and acceptable alternative to stakeholders.

Recommended Implementation Framework: Regional Service Center

Stakeholder meetings and the project survey indicated a clear preference for regional GI training and an interest in specialized maintenance support, both of which the Regional Service Center provides. Municipal stakeholders also felt strongly that municipalities should continue to be responsible for GI O&M within their municipality, which the Regional Service Center allows.

To advance GI O&M in the region, implementation of the Regional Service Center alternative includes the following recommendations that are detailed in the report:

- Provide regional training
- Actively support specialized maintenance
- Support routine maintenance assistance where requested
- Promote inspection and maintenance consistency
- Support other GI strategies where regional resources are needed

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Introduction

The Milwaukee Metropolitan Sewerage District's (MMSD) 2035 Vision and Regional Green Infrastructure (GI) Plan have set an aggressive goal for GI implementation in the Milwaukee region. The MMSD 2035 Vision set the goal to use GI to capture the first half-inch of rain from impervious surfaces. This level of GI implementation will require many thousands of GI installations, all of which will need to be maintained to remain effective. In order to realize and sustain broad GI implementation across the MMSD service area, the region needs an implementable GI operation and maintenance (O&M) framework to cost-effectively protect and maintain GI benefits.

This report documents the approach and findings to answer the following question: For this significant level of GI implementation, what would be the best overall O&M framework to maintain this GI investment? Other MMSD studies have considered *what* maintenance is needed for GI. This report focuses on *who* should be doing the various elements of GI maintenance and identifying what roles the MMSD, regional entities, municipalities, and private property owners should play for effective GI maintenance in the region.

Description of Green Infrastructure Strategies

The MMSD Regional GI Plan considered a portfolio of GI strategies to realize the MMSD 2035 Vision for using GI to capture rainfall where it falls. MMSD's 2035 Vision set the goal of capturing the first half-inch of rainfall over the impervious area in the region, an equivalent of capturing about 740 million gallons. Figure 1 shows the original portfolio of GI strategies and Figure 2 shows each strategies' relative contribution to capturing 740 million gallons for each rain event as envisioned by the Plan.

Table 1 lists the quantity of each GI strategy envisioned in the Regional GI Plan to achieve the 740-million-gallon regional goal. The GI installed to achieve the goal will be owned by municipalities and private property owners. Each strategy has varying levels of maintenance requirements. Some GI strategies require simple straightforward maintenance and equipment, such as connecting or disconnecting a rain barrel at the appropriate season. While maintenance for other GI strategies is not complicated, such as porous pavement vacuuming, they can require specialized equipment. Some GI maintenance necessitates a trained specialist, such as bioretention vegetation maintenance that requires identifying and removing undesirable plant species while nurturing desirable native plant species.

REGIONAL GREEN INFRASTRUCTURE STRATEGIES

Green infrastructure strategies capture stormwater, provide natural flood management, and bring a multitude of benefits to municipalities and residents. Each strategy shown below has already been implemented throughout the region, and much more is needed to achieve the 2035 Vision goals. The Plan focuses heavily on the strategies that would treat impervious surfaces and turf grass areas to provide economic, social, and environmental benefits to the region.

GREEN ROOFS

Business owners and public property owners with large flat roofs were mapped in the Plan and are encouraged to participate in the Regional Green Roof Initiative Program.

RAINWATER CATCHMENT

The Plan encourages residents and business owners to harvest rainwater. Doing so reduces energy costs and reduces unwanted stormwater from entering the sewer system.

POROUS PAVEMENT

The Plan recommends use of porous materials for public and private streets and parking lots.

NATIVE LANDSCAPING

The Plan encourages the public, business owners, and municipalities to replace turf grass with native landscaping to reduce runoff and save money through reduced landscape maintenance.

GREEN ALLEYS, STREETS, AND PARKING LOTS

The Plan calls for green alleys, streets, and parking lots that include several green infrastructure strategies, offering multiple economic, social, and environmental benefits.

BIORETENTION/BIOSWALES

Bioretention and bioswales can be used along transportation corridors and parking lots.

RAIN GARDENS AND SOIL AMENDMENTS

The Plan encourages residents to plant rain gardens to prevent stormwater from entering the sewer system too quickly. The Plan includes soil amendments to increase water holding capacity in lawns and improve grass growth when native landscaping is not preferred.

STORMWATER TREES

The Plan encourages municipalities to plant trees. They hold rainwater on their leaves and branches, infiltrate it into the ground, absorb it through root systems and evapotranspire it to the atmosphere.

WETLANDS

Wetlands (not quantified in this Plan) also known as bogs, marshes, and swamps allow rainwater to pool and slowly infiltrate into the ground.

GREENWAYS

Greenways (not quantified in this Plan) include riparian and non-riparian buffer zones and strips that store and drain stormwater runoff into the ground naturally.

Figure 1. Regional Green Infrastructure Plan Strategies
Source: CH2M, 2013

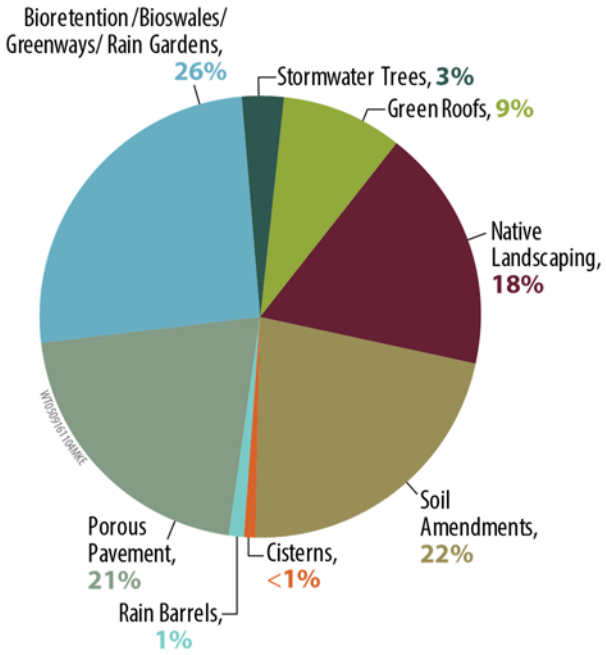

Figure 2. Storage Percentage by Green Infrastructure Strategy
Source: MMSD Regional Green Infrastructure Plan, Figure 4, CH2M, 2013

Table 1. MMSD Planning Area Green Infrastructure Quantities from the MMSD Regional Green Infrastructure Plan
Source: MMSD Regional Green Infrastructure Plan, Table 1, CH2M, 2013

Green Infrastructure Strategy	Quantity	Description
Green Roofs	1,490 acres	Equivalent to 13,000 buildings with new green roofs (assumes 5,000 SF per roof)
Bioretention/Bioswales/ Greenways/Rain Gardens	650 acres	Equivalent to 189,000 rain gardens (10 feet by 15 feet each)
Stormwater Trees	738,000	Equivalent to nine new trees per average city block
Native Landscaping	8,600 acres	Equivalent to 1,700 average city blocks with native landscaping
Porous Pavement	1,190 acres	Equivalent to 10,300 average city blocks having 25 percent porous pavement
Rain Barrels	152,000	Equivalent to 152,000 homes with one rain barrel each
Cisterns	2,020	Equivalent to 2,020 larger buildings with a cistern (minimum 6,500 SF roof)
Soil Amendments	15,200 acres	Equivalent to 2,900 average city blocks with soil amendments

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The potential complexity and cost of each GI strategy was reviewed to identify which strategies to focus on for the GI O&M implementation framework evaluation. The effort focused on the GI strategies expected to require the most maintenance and expenditure of funds, which include porous pavement, bioretention, and green roofs. While other GI strategies such as native landscaping, soil amendments, and stormwater trees were not explicitly included in the analysis comparing different O&M implementation frameworks for a variety of reasons (e.g., comprising only a small component of 740-million-gallon goal, having O&M practices that are already known and established, having relatively low or no associated maintenance), the recommendations section of this report includes general recommendations for these strategies.

Geographic information system (GIS) data from MMSD provided the ability to analyze and estimate the quantity of the bioretention, green roof, and porous pavement GI strategies based on land use characteristics consistent with those used in the Regional GI Plan. For planning purposes, municipalities were broken into three size categories (small, medium and large) to represent different sized municipalities within the region.

The quantities from the Regional GI Plan were then used to determine how much of each GI strategy would likely be located in the small, medium, and large municipalities. In the Project Approach section of this report, the municipal size breakdown and analysis of impervious area for the municipalities within the region can be found.

The area allocated for green roofs appeared to be more ambitious than current green roof implementation trends so some adjustments were made. Some judgment needed to be used in this process as green roof implementation has not been as aggressive as originally envisioned in the Regional GI Plan and some municipalities will be more likely to implement bioretention where space is available instead of green roofs since bioretention is more cost effective where open space exists. Consequently, it was assumed that small municipalities would implement 10 percent of the green roofs in the Regional GI Plan, medium municipalities would implement 20 percent, and a large municipality would be implement 30 percent, with the balance of the gallons envisioned through the Regional GI Plan made up with additional bioretention. As a result, the green roof area was reduced and replaced with an equivalent bioretention area. The analysis and results are described further in the following sections.

Background and Justification

Since the development of the MMSD Regional GI Plan, MMSD has proceeded with implementing the Plan's recommendations including those for GI O&M. GI O&M recommendations from the Regional GI Plan included developing the following:

- GI maintenance cost ranges
- Maintenance schedules and inspection checklists
- Standard maintenance expectations for strategies implemented with public funding

MMSD has begun work on all of these areas by implementing several internal initiatives and using external contractors. MMSD received an U.S. Environmental Protection Agency (EPA) technical assistance grant that was used to initiate a more in-depth discussion of GI maintenance responsibilities in Southeastern Wisconsin (EPA, 2015).

The EPA grant effort considered the GI maintenance needs of the region and obtained stakeholder input through project surveys. Survey topics included items such as training, specialized maintenance equipment, the interest in working together, and concerns around GI O&M. The project evaluated who should be responsible for GI maintenance under several scenarios, including three main models of GI O&M responsibility. The three GI maintenance framework models considered include: regional-led, municipal-led, and private property-led models. The EPA grant effort defined these models as follows (EPA, 2015):

Regional Model

Under the regional model, a regional entity—either MMSD or a new regional services entity, such as a "Green Team"—is responsible for either conducting or coordinating maintenance-related activities for some or all GI strategies. This could include small- or large-scale GI strategies in the right-of-way, on public property, or on private property. The Regional Model could be well-suited for situations in which

specialized training is needed or specialized equipment is called for, or where economies of scale can be achieved.

Local Municipal Model

Local governments are responsible for either conducting or coordinating maintenance-related activities for some or all GI strategies. This could include small- or large-scale GI strategies in the right-of-way, on public property, or on private property.

Private Property-led Model

The private property-led model applies to private property only. Under this model, property owners are responsible for conducting or coordinating maintenance-related activities for all GI strategies on their properties.

Key Prior Recommendations

Some of the key recommendations from the EPA technical assistance grant effort and how they are addressed in the GI O&M implementation framework evaluation are included in Table 2.

Table 2. Approach for addressing prior recommendations through the GI O&M implementation framework evaluation

Recommendation in EPA technical assistance grant report	How prior recommendations are addressed in the GI O&M implementation framework evaluation
1. Conducting maintenance under a strategic GI maintenance business plan will likely have to incorporate all three business models to adequately serve the existing and projected GI strategies on public and private property. There are some types of strategies (i.e., larger, more complex strategies or those that require special equipment or expertise) that might lend themselves to regional services, while others might be a better fit for the local model (e.g., small-scale strategies or those that require relatively frequent, routine maintenance).	Stakeholder input will be obtained to gauge interest in having services such as training, certification, and tracking provided through a regional GI service center. Combinations of the regional-, municipal-, and private property –led implementation framework alternatives will recognize there is no "one-size-fits-all" approach to GI O&M in the region and will allow for "ala carte" options for municipalities choosing GI O&M approaches.
2. A blanket regional approach to GI O&M is not considered feasible among participating stakeholders. According to stakeholders, GI maintenance requires a suite of approaches that address the various factors influencing GI maintenance decisions, such who owns the GI strategy, its size and complexity, and other key factors. The 28 municipalities have differing priorities, budgets, and levels of expertise. Variations in these local factors, coupled with the issues of property ownership and scale, would create challenges if a uniform approach to maintenance were adopted.	The approach to EPA technical assistance grant report recommendation 1.
3. As a result, the owner-led maintenance model will play a significant role in the overall GI maintenance plan for southeastern Wisconsin. This is likely to translate into a substantial need for private property owner education and training. Stakeholders working with private property owners emphasized the need to provide technical assistance and training that will boost confidence.	The GI O&M implementation framework approach will target private property stakeholder involvement to better gauge private property capabilities and needs. Estimates of training needs across the regional will consider private property owner training.

Table 2. Approach for addressing prior recommendations through the GI O&M implementation framework evaluation

Recommendation in EPA technical assistance grant report	How prior recommendations are addressed in the GI O&M implementation framework evaluation
4. There is a need for focused discussion on private property (commercial, industrial, and residential) maintenance issues, including incentives and disincentives. Due to the lack of private property owners participating in the process, there is a need for additional discussion on incentives to promote GI maintenance on private property and disincentives that might hinder maintenance.	See approach to EPA technical assistance grant report recommendation 3.
5. Assess the economic implications of each option to determine economies of scale. The scope of this report did not include examining the economic considerations associated with each maintenance business model. However, this information is extremely important for identifying the most cost-effective approaches to maintenance. An economic analysis could show that certain business models will generate lower overall costs for maintenance and could help prioritize the future course of action for the region to promote maintenance activities that will maximize available resources.	Financial information is extremely important for identifying efficient and cost-effective approaches to GI O&M. Evaluation criteria will be developed to quantify implementation framework efficiency. Stakeholder feedback will inform the importance of cost efficiencies compared to control over GI O&M.
6. Explore the development of a GI Service Center and identify suite of services. Survey results indicated interest in having services such as training, certification, and tracking provided through a potential GI Service Center.	Opinions of stakeholders will be requested about GI service center offerings: training, routine maintenance, specialized maintenance, and inspections.
7. Research existing GI maintenance certification standards. Certification of GI maintenance providers is a significant issue to address in all business models. MMSD should consider first researching existing GI maintenance certification standards used in the Great Lakes region or by other reputable organizations (e.g., American Society of Landscape Architects) to determine what other programs use and identify how these standards could work in southeast Wisconsin.	A summary of existing training and certifications offered for GI will be developed. This is included in Appendix A. Under a separate initiative, MMSD is also actively supporting the Water Environment Federation (WEF) and DC Water investment in developing a GI certification program.

Routine maintenance, such as removing sediment and debris from inflow points, is important to keep GI functioning effectively.

Project Approach

The MMSD 2035 Vision and Regional GI Plan have set an aggressive goal for regional GI implementation. In order to realize and sustain broad GI implementation, the region needs an implementable GI O&M implementation framework to cost-effectively maintain GI performance. Figure 3 shows the project approach to arrive at a GI O&M implementation framework recommendation.

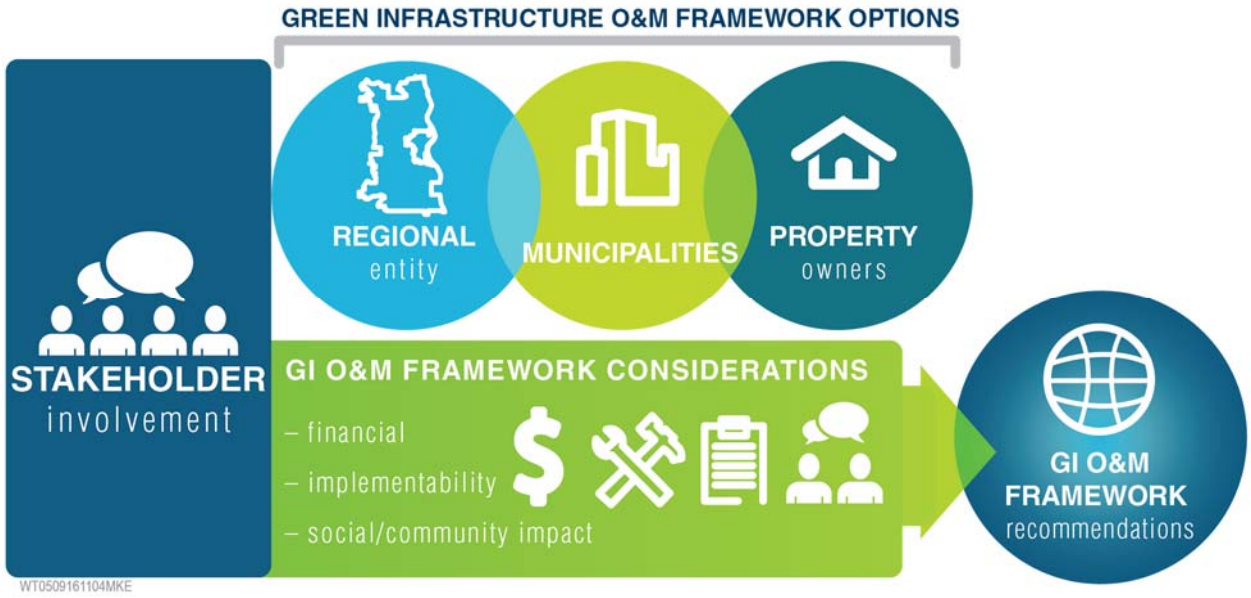

Figure 3. Project Approach

The project approach includes:

- Estimate GI by Municipality Size: The amount of GI in each municipality, both public and private, will determine the number of maintenance crews required in a municipality. Reaching a threshold of crews required to maintain GI in turn introduces efficiencies and economies of scale. Estimates of the amount of GI by municipality are made consistent with the approach used in the MMSD Regional GI Plan.
- Obtain Stakeholder Input: Stakeholder perspectives provide insight into the GI O&M capabilities they have and what they need to effectively maintain GI. Stakeholder involvement occurred through group meetings and a project survey.
- Develop Decision Criteria: Decision criteria were developed to compare GI O&M implementation framework alternatives one to another to aid in the evaluation of each implementation framework. Key criteria considered include: Financial, Implementability, and Social/Community Impact.
- Conduct Cost-Benefit Evaluation: Stakeholder feedback and decision criteria metrics influenced the cost-benefit evaluation where each alternative can be compared one to another.
- Make Recommendations: Based upon the stakeholder feedback and decision criteria evaluation findings, the project made a GI O&M recommendation for the region.

The report contains the additional details of implementing this project approach.

Municipality Green Infrastructure Projections

In order to make a framework recommendation, the amount and types of GI strategies needed to be characterized. The amount and type of GI envisioned for each municipality is important for determining how maintenance needs to occur for municipalities of different sizes, thereby informing what aspects go into each framework and who is responsible for what part of the framework. The EPA technical assistance grant determined there is no one-size-fits-all approach to GI O&M in the region. The GI O&M implementation framework project approach allows organizations to have insights into how their organization may benefit from the different O&M models.

The Regional GI Plan principles guided the GI O&M implementation framework approach. Like the Regional GI Plan, the amount of GI throughout the region needed to be determined for the GI strategies with the most significant maintenance needs for each size of municipality in the region.

Municipalities in the region were categorized as small, medium, or large based on their total amount of impervious area because that directly relates to the amount of GI that would be required to meet MMSD's 2035 Vision capture goal. As shown in Table 2, municipalities with less than 600 acres of impervious area were classified as small, those with 900 to 3,600 acres were classified as medium, and the City of Milwaukee with more than 27,000 acres was considered large. GIS analysis of the region's impervious area provided the breakpoints for municipality sizing based upon impervious area.

Using the information from the Regional GI Plan, the GI strategies most appropriate for the impervious areas for different land uses were found for each size of *average* municipality. Based on the above analysis, there are 12 small-sized municipalities, 15 medium-sized municipalities, and one large-sized municipality. These regional values were then used to determine the average amount of each GI strategy that could be expected for each size municipality. Professional judgment needed to be used in this process as green roof implementation has not been as aggressive as originally envisioned in the Regional GI Plan and some municipalities will be more likely to implement bioretention when space is available instead of green roofs because bioretention is more cost effective where open space exists. Consequently, it was assumed that small municipalities would implement 10 percent of their pro-ration of green roofs from the Regional GI Plan, medium municipalities would implement 20 percent, and a large municipality would be implement 30 percent, with the balance of the gallons envisioned through the Regional GI Plan made up with additional bioretention. Table 3 shows these adjustments.

Table 3. MMSD Planning Area Green Infrastructure Quantity Adjustments for this Project
Modified from: MMSD Regional Green Infrastructure Plan, Table 1, CH2M, 2013

Green Infrastructure Strategy	GI Plan Quantity	Quantity Adjustment	Description
Green Roofs	1480 acres	530 acres	Equivalent to 4,600 buildings with new green roofs (assumes 5,000 SF per roof)
Bioretention/Bioswales/ Greenways/Rain Gardens	440 acres	535 acres	Equivalent to 215,000 rain gardens (10 feet by 15 feet each)
Porous Pavement	1,200 acres	1,220 acres	Equivalent to 10,400 average city blocks having 25 percent porous pavement

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The area of each GI strategy was further broken down into public and private property, which is important for each framework in determining responsibility for GI O&M. This breakdown of GI strategy by municipality size and ownership can be found in Table 4. Ratios of public and private ownership and

GI implementation were made consistent with the Regional GI Plan. Table 5 presents a breakdown of the regional strategy.

Table 4. Municipal Breakdown

GIS analysis breakdown of municipality by size and impervious area

Municipality		Total Area (acre)	Total Area Percent of MMSD Service Area	Impervious Area (acres)	Impervious Area Percent in MMSD Service Area	
CALEDONIA		793	0.3%	55	6.9%	
THIENSVILLE		701	0.3%	217	31.0%	
BUTLER		509	0.2%	262	51.5%	
BAYSIDE		1,534	0.6%	329	21.4%	
RIVER HILLS		3,413	1.3%	351	10.3%	
WEST MILWAUKEE		720	0.3%	451	62.7%	
FOX POINT		1,843	0.7%	469	25.5%	SMALL
SHOREWOOD		1,021	0.4%	483	47.3%	
ELM GROVE		2,103	0.8%	551	26.2%	
ST. FRANCIS		1,643	0.6%	552	33.6%	
HALES CORNERS		2,046	0.8%	570	27.9%	
WHITEFISH BAY		1,356	0.5%	591	43.6%	
SMALL MUNICIPALITIES	**AVERAGE**	**1,473**	**0.6%**	**407**	**32.3%**	
GREENDALE		3,565	1.4%	919	25.8%	
BROWN DEER		2,813	1.1%	933	33.2%	
CUDAHY		3,053	1.2%	1,262	41.3%	
GLENDALE		3,818	1.4%	1,365	35.8%	
MUSKEGO		19,318	7.3%	1,784	9.2%	
BROOKFIELD		7,768	2.9%	1,784	23.0%	
GERMANTOWN VILLAGE		22,014	8.4%	2,158	9.8%	
GREENFIELD		7,390	2.8%	2,373	32.1%	MEDIUM
MEQUON		29,873	11.3%	2,673	8.9%	
FRANKLIN		22,199	8.4%	2,815	12.7%	
OAK CREEK		18,206	6.9%	3,107	17.1%	
MENOMONEE FALLS		12,552	4.8%	3,191	25.4%	
NEW BERLIN		15,407	5.9%	3,232	21.0%	
WAUWATOSA		8,466	3.2%	3,395	40.1%	
WEST ALLIS		7,301	2.8%	3,553	48.7%	
MEDIUM-SIZE MUNICIPALITIES	**AVERAGE**	**12,250**	**4.7%**	**2,303**	**25.6%**	
MILWAUKEE		**61,922**	**23.5%**	**27,214**	**43.9%**	**LARGE**

Table 5. GI by Municipality Size

Individual breakdown by municipal size for bioretention, porous pavement, and green roofs

Community Size	Bioretention (acres)		Bioretention (percent of region)			Porous Pavement (acres)		Porous Pavement (percent of region)			Green Roofs (acres)		Green Roofs (percent of region)		
	Public Property	Private Property	Public Property	Private Property	Total	Public Property	Private Property	Public Property	Private Property	Total	Public Property	Private Property	Public Property	Private Property	Total
1 Small Municipality	1.6	1.5	0.3%	0.3%	0.6%	4.3	2.1	0.4%	0.2%	0.6%	1.8	0.7	0.3%	0.1%	0.4%
1 Medium Municipality	9.6	8.7	1.8%	1.6%	3.4%	26.8	14.8	2.2%	1.2%	3.4%	9.2	7.8	1.7%	1.5%	3.2%
1 Large Municipality	128.4	95.8	24.0%	17.9%	41.9%	363.2	153.6	29.8%	12.6%	42.5%	101.0	141.9	19.1%	26.9%	46.0%

When considering the 12 small- and 15 medium-sized municipalities, Table 6 shows the GI by municipality size for bioretention, porous pavement, and green roofs.

Table 6. Regional GI Strategy Breakdown

Regional breakdown by municipal size for bioretention, porous pavement and green roofs

Municipality Size	Bioretention (acres)		Bioretention (percent of region)			Porous Pavement (acres)		Porous Pavement (percent of region)			Green Roofs (acres)		Green Roofs (percent of region)		
	Public Property	Private Property	Public Property	Private Property	Total	Public Property	Private Property	Public Property	Private Property	Total	Public Property	Private Property	Public Property	Private Property	Total
12 Small Municipalities	18.9	17.6	3.5%	3.3%	6.8%	51.9	24.9	4.3%	2.0%	6.3%	22.0	8.7	4.2%	1.6%	5.8%
15 Medium Municipalities	143.8	130.5	26.9%	24.4%	51.3%	401.6	221.7	33.0%	18.2%	51.2%	138.4	116.4	26.2%	22.0%	48.2%
1 Large Municipality	128.4	95.8	24.0%	17.9%	41.9%	363.2	153.6	29.8%	12.6%	42.5%	101.0	141.9	19.1%	26.9%	46.0%
Total	291.1	243.9	54.4%	45.6%	100.0%	816.7	400.2	67.1%	32.9%	100.0%	261.4	267.0	49.5%	50.5%	100.0%

Economies of Scale – Maintenance Crews

Bioretention, porous pavement, and green roof average project characteristics were found to determine the number of crews that would be required for maintenance. This information was then used to determine the number of maintenance crews required by municipality size. Examining the average amount of GI for each municipality size informs the number of maintenance crews needed for each GI strategy and where potential efficiencies could exist.

The number of maintenance crews directly relates to economy of scale and efficiency. If a municipality cannot keep a crew and/or piece of equipment busy full time, that maintenance is less efficient than a municipality that can keep a maintenance crew busy full-time. Deploying crews full-time allows greater specialization and efficiency. There are limited maintenance windows throughout the year for each GI strategy. For example, porous pavement maintenance does not happen during seasonal freezing conditions and bioretention plant maintenance must occur during the growing season. Consequently, the number of maintenance crews required must be determined within the times of the year available to complete the work.

Maintenance experience has shown efficiencies start occurring when the crews focus on completing the required maintenance activity and when a minimum number of crews is required. When staffing reaches the level that the supervisor can plan, prepare for, and direct the activities of crews, additional efficiencies are gained. Based upon experience in other cities with similar maintenance tasks, the GI O&M crew evaluation assumed economies of scale occur after achieving a minimum threshold of three crews that are conducting the same maintenance activity. This enables the crews to focus on the maintenance activity and not administration. To determine the number of maintenance crews, a 20 percent increase in efficiency when reaching a three-crew threshold was assumed. Additional economies of scale of 10 percent was assumed to occur through further regionalization of maintenance activities. Table 7 includes the efficiency factor applied to the crew needs by municipality based upon these economies of scale.

Table 7. Crew Efficiency Factors

Organization Size	Crew Efficiency Adjustment Factor (Percent Change in Efficiency)
Municipalities with fewer than three crews needed for each GI strategy	1.2 (20 percent reduced efficiency)
Municipalities with greater than three crews needed for each GI strategy	1.0 (average expected efficiency)
Regional operations	0.9 (10 percent improved efficiency)

For the purposes of estimating the number of required crews to maintain GI, the project assumed full build-out of the Regional GI Plan, and average GI strategy installation sizes for bioretention, green roof, and porous pavement GI strategies as described below.

Bioretention

Maintenance for bioretention can be divided into routine and specialized activities. Some routine maintenance may include checking and removing litter and plant debris, thinning crowded vegetation, adding new mulch if appropriate, removing and replacing dead or diseased plants, and watering when plants are getting established. More specialized maintenance includes weeding invasive species, inspecting for and correcting any erosion, and verifying soil infiltration performance and quality.

Bioretention and/or rain gardens are assumed to be the most common GI practice implemented on private properties. Table 8 documents the assumed typical project characteristics for a bioretention maintenance crew.

For this analysis, a crew was assumed to be made up of three people. For routine maintenance, it was assumed that bioretention areas would be maintained on average of four times per year, during (or shortly before or after) the growing season. This translates into crews maintaining bioretention facilities once every seven weeks on average over the 28 weeks from late April to early November. Specialized maintenance was assumed to take place once every 3 years on average and consist of replanting 30 percent of the bioretention area. Replanting is assumed to take place over a 6-week period in both the spring and fall for a total of 12 weeks per year. Therefore, 36 weeks would be available to perform non-routine maintenance on all bioretention facilities over the 3-year period.

Routine maintenance for bioretention includes trash removal.

The average bioretention size of 750 square feet (sf) was assumed to be consistent with the average size bioretention bed in the City of Milwaukee (Jaber 2016).

Table 8. Average/Typical Bioretention Project Characteristics

Bioretention (sf):	750
Average Routine Maintenance Time (person-hr):	3.7
Routine Maintenance Crew Size (number of people)	3
Amount of crew down time*	20 percent
Projects Maintained per Week (Routine)	26
Routine Maintenance per Week (acre)	0.5
Weeks available for Routine Maintenance (each round)	7
Average Non-Routine (Specialized) Maintenance Time (person-hr):	2
Specialized Maintenance Crew Size (number of people)	2
Projects Maintained per Week (Specialized)	48
Specialized Maintenance per Week (acre)	0.8
Weeks available for 1 Round of Specialized Maintenance	36

* Equipment breakdowns, sickness, vacation, etc.

Notes:

hr = hour

These average characteristics were then used to inform how many crews are required during a seasonal maintenance window for both routine and specialized maintenance. With a three person bioretention maintenance crew, this equates to 96 person-hours of maintenance a week for a full time crew with 20 percent down time. Estimates were made for both municipality size and distribution between publicly-owned and privately-owned GI. The crew needs for routine bioretention maintenance can be found in

Table 9. Table 10 presents crew needs for specialized bioretention maintenance. These values have not yet been adjusted with the crew efficiency factor.

Table 9. Projected Number of Full-Time Maintenance Crews Required for Routine Bioretention Maintenance (during the 28-week Maintenance Window)

	Number of Full Time Routine Maintenance Crews Required		
	Public Property	**Private Property**	**Total**
1 Small Municipality	0.5	0.5	1.0
1 Medium Municipality	3.0	2.8	5.8
1 Large Municipality	40.6	30.3	70.9
Entire Region	92.0	77.1	169.1

Table 10. Projected Number of Full-Time Maintenance Crews Required for Specialized Bioretention Maintenance (during Annual 12-week Maintenance Window)

	Number of Full Time Routine Maintenance Crews Required		
	Public Property	**Private Property**	**Total**
1 Small Municipality	<0.1	<0.1	0.1
1 Medium Municipality	0.3	0.3	0.6
1 Large Municipality	4.3	3.2	7.5
Entire Region	9.8	8.2	18.0

As can be seen in Table 9 and Table 10, a small municipality in the region would only be able to employ full-time one-half of a crew, which is inefficient. A typical medium-sized municipality could utilize three full-time crews, increasing the efficiency for maintenance when larger entities are responsible for maintenance implementation. Using the efficiency information from Table 7, routine bioretention maintenance for medium-sized municipalities would realize a 20 percent efficiency compared to small municipalities.

Green Roofs

A similar method was used to determine number of crews required during a specified maintenance window by municipality size for green roofs. Due to the nature of green roof maintenance, which involves working aboveground and with specialized vegetation and growth media, all maintenance for green roofs is considered specialized.

Maintenance activities for green roofs include removing dead and diseased vegetation, weeding and invasive species removal, replanting bare areas, inspecting the roof for damage, and roof/drainage repairs when necessary. The maintenance crew size for green roofs is considered to be three people. Assumed typical project characteristics are shown in Table 11.

Green roof maintenance was assumed to entail an average of three visits per year per green roof over a five-month period in the growing season. Therefore, it was assumed that crews would maintain green roofs once every seven weeks on average over the 21 weeks from approximately mid-May to mid-October. The average green roof size of 7,500 sf was assumed to be consistent with the average of green roofs MMSD has funded to date through green roof partnership programs (Sasso 2016).

Table 11. Average/Typical Green Roof Project Characteristics

Green Roof (sf):	7,500
Average Maintenance Time (person-hr):	20
Crew Size (number of people)	3
Amount of crew down time*	20 percent
Projects Maintained per Week	5
Maintenance per Week (acre)	0.8
Weeks available for Maintenance (each round)	7

*Equipment breakdowns, sickness, vacation, etc.

These characteristics were then used to determine the number of full-time crews that would be required according to each municipality size during the specified maintenance window. With a three person green roof maintenance crew, this equates to 96 person-hours of maintenance a week for a full time crew with 20 percent down time. All maintenance on green roofs is considered specialized, and Table 12 contains the number of crews projected to perform green roof maintenance by municipality size.

Table 12. Projected Number of Full-Time Maintenance Crews Required for Specialized Green Roof Maintenance (during 21-week Maintenance Window)

	Number of Full Time Routine Maintenance Crews Required		
	Public Property	**Private Property**	**Total**
1 Small Municipality	0.3	0.1	0.4
1 Medium Municipality	1.6	1.4	3.0
1 Large Municipality	17.7	24.9	42.6
Region	45.8	46.7	92.5

As with bioretention, it will be less efficient for small municipalities to maintain green roofs with only a part-time crew to maintain the public GI within their jurisdictions. The larger the responsible entity, the more efficient implementation of a GI maintenance framework possible. Using the efficiency information from Table 7, specialized green roof maintenance for medium-sized municipalities would realize a 20 percent efficiency compared to small municipalities. Green roof maintenance for a large-sized municipality would realize a 20 percent efficiency compared to small and medium municipalities.

Porous Pavement

Porous pavement maintenance consists of both routine and specialized activities, where specialized activities may require more knowledge or specialized equipment. Some routine maintenance that occurs on porous pavement includes removing leaves, grass clippings, mulch, trash and general debris, checking for standing water and sediment and maintaining surrounding vegetated areas to avoid clogging the pavement with sediment or debris. A regular street sweeper can be used for routine maintenance to keep debris and trash from accumulating. More specialized maintenance for porous pavement includes using a vacuum sweeper or pressure washer and inspecting the pavement for sunken, damaged or missing units that require replacement.

The number of crews required by municipality size was estimated for porous pavement maintenance, based on the average assumed characteristics of porous pavement projects. In this case, a crew is considered to be made up of a single person operating a sweeper. The project characteristics for the average porous pavement strategy are found in Table 13. This assumes that porous pavements would be maintained on average two times per year, once in the spring and once in the fall. Specialized maintenance is assumed to take place once every 3 years on average and consist of power washing the full porous pavement area. Power washing is assumed to take place over a 24-week period each year. Therefore, 72 weeks would be available to perform the non-routine maintenance on all porous pavement facilities over the 3-year period.

The porous pavement size of 6,000 sf was assumed based upon the average parking lot size in the region and a 4:1 loading ratio of tributary area to porous pavement area.

Some GI maintenance builds off or replaces maintenance already being performed in our region - for example inlet cleaning and parking lot cleaning.

Table 13. Average/Typical Porous Pavement Project Characteristics

Porous Pavement (sf):	6,000
Average Routine Maintenance Time (person-hr):	1.25
Amount of crew down time*	20 percent
Projects Maintained per Week (Routine)	26
Routine Maintenance per Week (acre)	3.5
Weeks available for Routine Maintenance (each round)	12
Average Specialized Maintenance Time (person-hr):	4
Projects Maintained per Week (Specialized)	8
Specialized Maintenance per Week (acre)	1.1
Weeks available for Specialized Maintenance	72**

*Equipment breakdowns, sickness, vacation, etc.
**24 weeks/year for 3-year rotation

The project characteristics informed the number of crews required by municipality size to maintain the amount of porous pavement within that size municipality (Table 14). With a one person porous pavement crew, this equates to 32 person-hours of maintenance a week for a full time crew with 20 percent down time. This is broken up into both routine and specialized maintenance, with vacuum sweeping considered specialized maintenance for porous pavement (Table 15).

Table 14. Projected Number of Full-Time Maintenance Crews Required for Routine Porous Pavement Maintenance (during the 12-week Maintenance Window)

	Number of Full Time Routine Maintenance Crews Required		
	Public Property	**Private Property**	**Total**
1 Small Municipality	0.1	0.1	0.2
1 Medium Municipality	0.6	0.4	1.0
1 Large Municipality	8.6	3.6	12.2
Region	19.3	9.5	28.8

Table 15. Projected Number of Full-Time Maintenance Crews Required for Specialized Porous Pavement Maintenance (during annual 24-week Maintenance Window)

	Number of Full Time Routine Maintenance Crews Required		
	Public Property	**Private Property**	**Total**
1 Small Municipality	<0.1	<0.1	0.1
1 Medium Municipality	0.3	0.2	0.5
1 Large Municipality	4.6	1.9	6.5
Region	10.3	5.0	15.3

Similarly, to bioretention and green roofs, maintenance programs for small municipalities are not as efficient because they cannot employ full-time crews, or only require a small portion of a full-time crew. Using the efficiency information from Table 7, routine porous pavement for large-sized municipalities would realize a 20 percent efficiency compared to small and medium municipalities.

Summary of Maintenance Crew Needs

The combined GI O&M maintenance crew needs for bioretention, porous pavement, and green roofs for both routine and specialized maintenance are summarized in Table 16. These numbers provide insight into the potential number of crews required by municipality size at full implementation of the MMSD 2035 Vision GI goal and if GI is implemented as envisioned in the MMSD Regional GI Plan. The number of crews are adjusted by the crew efficiency factors in Table 7 depending upon maintenance approach within each GI O&M implementation framework.

Table 16. Projected Total Number of Full-Time Maintenance Crews Required Bioretention, Porous Pavement, and Green Roof Maintenance (during annual Maintenance Window)

	Number of Full Time Routine Maintenance Crews Required		
	Public Property	**Private Property**	**Total**
1 Small Municipality	1.0	0.8	1.8
1 Medium Municipality	5.8	5.1	10.9
1 Large Municipality	76	64	140
Region	177	147	324

Note: number of crews for small and medium municipalities rounded to the nearest 0.1 and number of crews for a large municipality and the region rounded to the nearest 1.

For all three GI strategies, these crew numbers were then used to help inform the cost-benefit analysis, in terms of efficiency and economy of scale as well as number of people required for training and certification in GI strategy maintenance.

Decision Criteria Considerations

Decision criteria for evaluating the different GI O&M models across the region included following:

- Financial
- Implementability
- Social/community impact

Each of these criteria informed how the analysis for determining a recommended GI O&M implementation framework for the region. The Economies of Scale – Maintenance Crews section speaks directly to the financial category of importance when determining an implementation framework, as well as implementation complexity. The project sought input from stakeholders to determine how to weight each of these criteria, which in turn informed the scoring of each framework. Figure 2 depicts the decision criteria process.

Stakeholder Meetings and Survey

Stakeholder acceptance of the final recommended framework is key to implementation. If stakeholders do not approve of a given framework, implementation will be difficult. Because municipalities and private property owners in the region will all be affected by the recommended implementation framework, their input was critical for the final framework recommendation.

In order to engage stakeholders in the process of determining the recommended O&M implementation framework, the project team created a survey to gauge stakeholder capabilities in maintaining current and future GI as well as how acceptable differing GI O&M implementation framework concepts would be to them. The complete list of survey questions asked to the participating stakeholders can be found in Appendix B. The survey was administered through six stakeholder group meetings. There were four municipal group meetings and two meetings held to allow private property owners to discuss GI O&M concerns and interests and to complete the survey. Stakeholders who were invited, but could not make the scheduled meetings, were invited to complete the survey independently, but missed the opportunity to hear the perspectives of their peers at these group meetings.

All 28 municipalities in the MMSD service area, along with Milwaukee County were invited to the municipal meetings. A number of private property owners were also invited to get a diverse representation of stakeholder perspectives.

The survey contained 34 questions, aimed at determining stakeholder needs and opinions on GI O&M and the relative importance of the decision criteria. Some of the responses relevant to stakeholder acceptability are found in the following sections.

In total, 27 responses were recorded from the approximately 40 stakeholders invited to the meetings. A breakdown of the respondents can be found in Figure 4 (Survey Question 2).

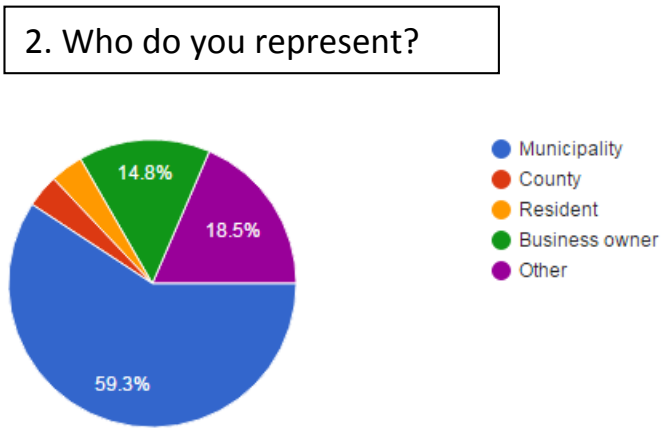

Figure 4. Stakeholder Survey Respondents
Breakdown of stakeholder survey respondents

Financial

The financial questions were aimed at determining exactly how important the cost for maintaining GI is to the various stakeholders. The questions also asked whether GI O&M implementation framework alternatives that saved money on a regional level would be viewed beneficially if that meant a tradeoff where municipalities might relinquish some control over their own maintenance in exchange for lower maintenance costs. Survey questions 3 and 4 represent a few of the financial-oriented questions (Figure 5 and Figure 6).

3. How much would you or your community have to save on GI maintenance for a regional (centralized) approach that takes care of your maintenance (for a fee) to be compelling?

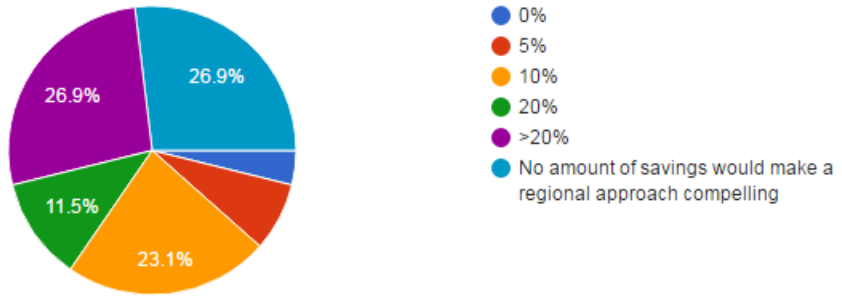

Figure 5. Survey Question 3
Gauging the importance of the financial aspect in a GI O&M implementation framework.

4. Is there a dollar amount in total cost savings that would make a regional (centralized) approach to take care of your GI maintenance (for a fee) more compelling to you or your community?

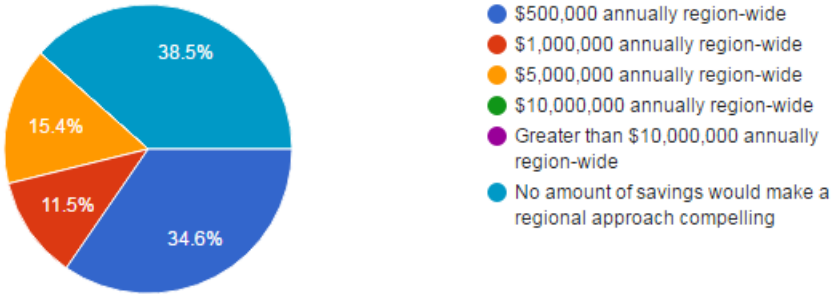

Figure 6. Survey Question 4
Gauging the importance of the financial aspect in a GI O&M implementation framework.

From the responses to these financial questions, it is clear that many stakeholders (approximately 40 to 60 percent) feel strongly that either no financial benefit to the region or a greater than 20 percent cost savings would be required for having less GI maintenance control within their own jurisdictions. This is very informative for eventual framework scoring, as the financial component may not be as important to stakeholders as initially thought, while stakeholder acceptability may need to carry more weight.

Implementability

The intent of these questions is to determine how important the complexity of implementing a GI O&M framework is to stakeholders. The implementability criteria is intended to obtain stakeholder input on training needs, ability to complete maintenance, and willingness to outsource maintenance to a professional or regional organization. Survey questions 12, 13, 18, and 20 represent a few of the implementability-oriented questions (Figure 7, Figure 8, Figure 9, and Figure 10).

12. If you do NOT have the skills/capabilities to maintain existing GI within your authority, would any of the following be considered helpful for obtaining the necessary skills? Please select your top 3:

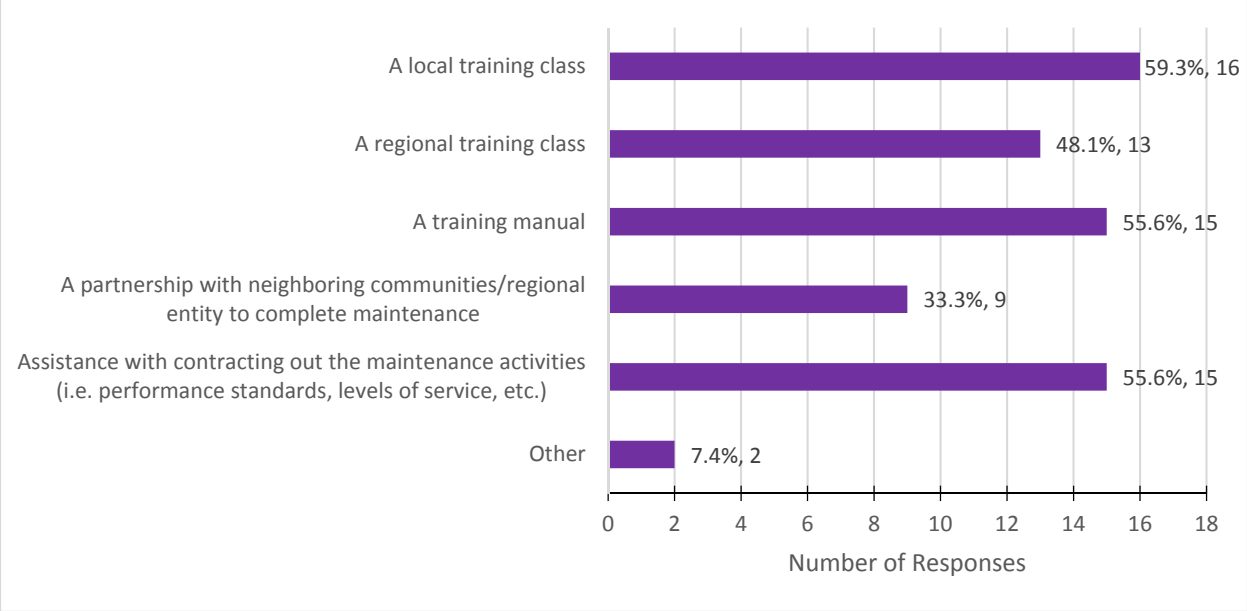

Figure 7. Survey Question 12

Percent of stakeholders interested in GI maintenance training.

13. Is there a GI strategy you would prefer to outsource for maintenance? Check all that apply:

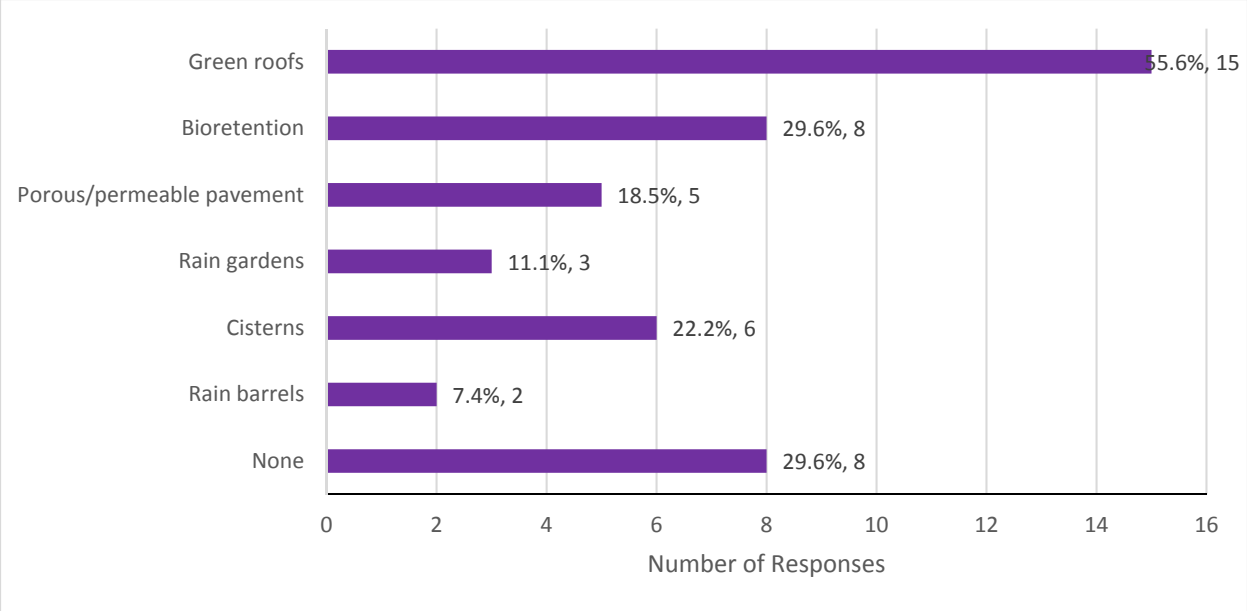

Figure 8. Survey Question 13

Percent of stakeholders interested in outsourcing maintenance by GI strategy.

18. Under what circumstances would you be willing to let another entity maintain the GI you are responsible for?

If the cost of the maintenance was free.
Memorandums of Understanding (MOU)
When specialized knowledge or equipment is required
Would depend on cost, responsiveness, and maintaining a level of local control over level of service and timely response
If something was highly specialized and required lots of maintenance/service
Grant funding, shared responsibility
Better service at a lower cost
If it becomes too large for us and we needed to outsource the maintenance. If the partners were well trained, prompt and insured we would look into it.
If additional GI is used in the Village that would require specialized maintenance, i.e. cisterns or permeable pavement.
Meaningful cost savings and specialized equipment.
If it was out of my control, i.e., funds, staff, risks
Specialized maintenance like green roofs and cisterns or if a partnership could be made like with the Audubon Society or UEC to bring opportunities to students

Figure 9. Survey Question 18

Willingness to outsource to another entity.

20. Is the level of service you expect (and are willing to pay for) consistent across all strategies or is it variable depending upon the location?

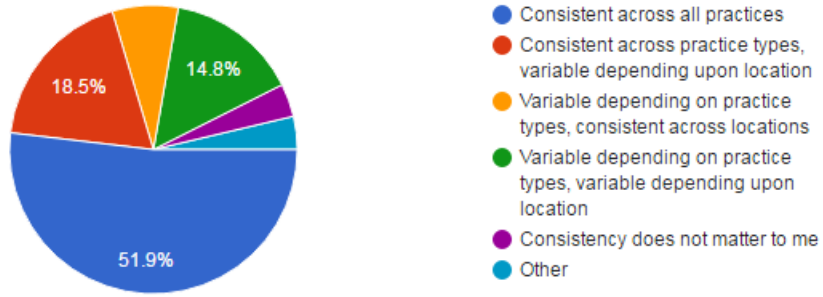

Figure 10. Survey Question 20
Stakeholder expectations for level of service.

The implementability questions are informative for what aspects of the GI O&M implementation framework issues are preferred or undesired by stakeholders. It is clear from the above questions that stakeholders are very interested in training, and also many would like to outsource maintenance for green roofs. It also seems many are interested in a regional entity preforming specialized maintenance, and that they would like a consistent level of service for all GI strategies no matter what organization provides maintenance or where GI strategies are located. These are all important factors in determining which frameworks will be most accepted by stakeholders.

Social/Community Impact

23. Would you be willing to share resources with neighboring communities/agencies/entities to maintain GI strategies?

Several questions in the survey were aimed at gauging stakeholder importance for social and community impact. Some of the questions in the complexity section touched on partnerships, outsourcing and willingness to partner. Survey questions 23, 24, and 30 represent a few of the Social/Community impact-oriented questions (Figure 11, Figure 12, and Figure 13).

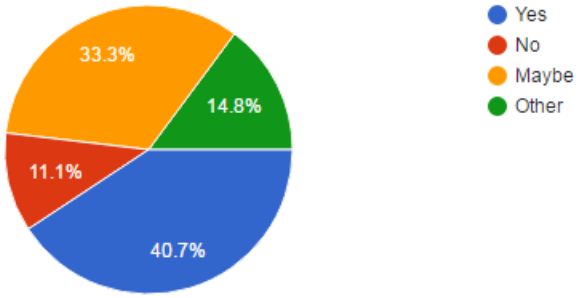

Figure 11. Survey Question 23
Stakeholder willingness to form partnerships with neighboring municipalities or organizations.

24. Are you interested in partnering with any of the following agencies/entities to better maintain the GI in your area? Check all that apply:

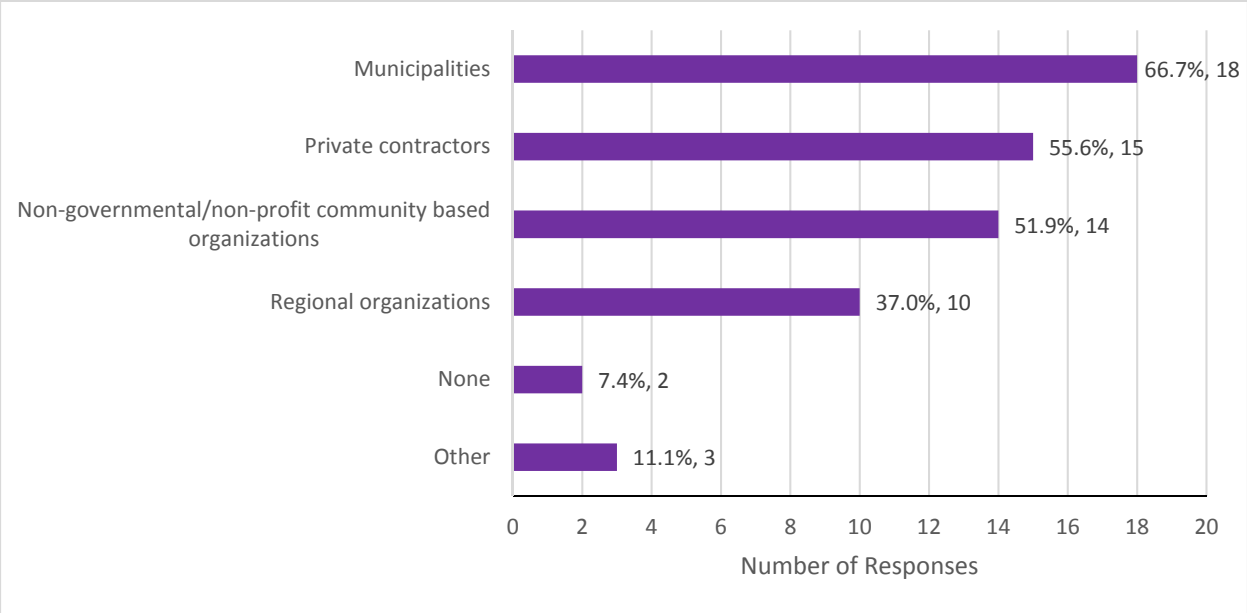

Figure 12. Survey Question 24

Percent of stakeholders willing to form partnerships with neighboring municipalities or organizations.

30. If there were a regional GI service center to support some aspects of GI O&M, what services would you like provided? Check all that apply:

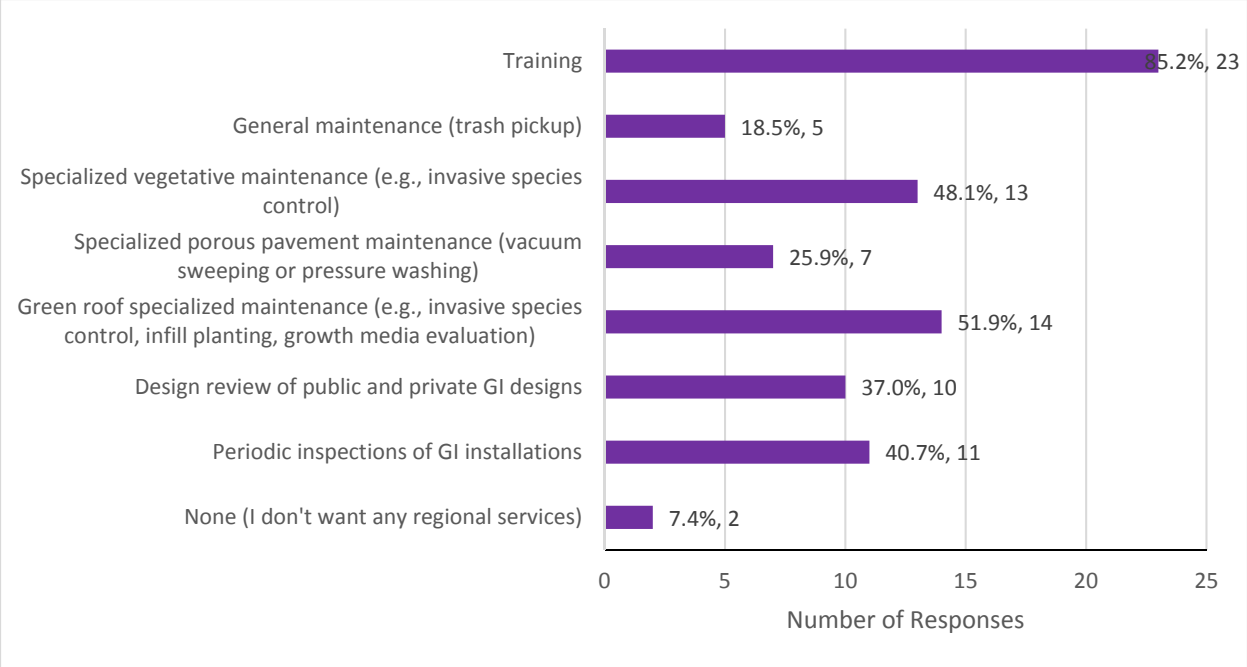

Figure 13. Survey Question 30

Percent of stakeholders willing to use services from a regional GI service center.

These questions show how stakeholders feel about creating partnerships in order to complete GI maintenance. It is clear many are willing to partner, even if only with each other, to ensure maintenance is completed. It is also clear that many stakeholders are very interested in training and certification for GI O&M, and would welcome a regional entity leading a training program.

From all of the questions, a general picture of stakeholder willingness and acceptability of various aspects within the different GI O&M implementation framework alternatives can be drawn. Several key takeaways include:

- The financial savings to the region are less important to stakeholders than having the ability to choose when and with whom partnerships are formed.
- Consistency across the region for O&M of all GI strategies is important.
- Being properly trained to maintain the various GI strategies is important and stakeholders support regional training.
- Majority of stakeholders would like to partner or outsource specialized to either private contractors, a regional entity, or a neighboring municipality.

All of these factors were considered when determining the weighting for scoring the criteria for each of the GI O&M implementation framework alternatives.

Weighting the Three Criteria

In order to help determine the weighting of the three categories, a question in the survey was dedicated to asking each respondent to rank the three categories in terms of the most to least important, with a rating of five meaning most important and one meaning least important. Each category was described as follows:

- Financial – The overall cost efficiency and reliability of funding based upon the O&M model framework. Cost efficiency is represented by the relative costs of maintaining GI across the region. Funding reliability reflects how consistency of funding may be impacted by the different O&M model frameworks.
- Implementability (Complexity) – Reflects the difficulty of framework implementation from an administrative and stakeholder acceptability viewpoint and whether the entities responsible for maintenance within each framework can do so consistently, capably, and with a clear definition of who is responsible.
- Social/Community Impact – Considers the social and community building aspects of the various frameworks, and how they encourage collaboration to solve the region's stormwater challenges by building partnerships, improving aesthetics, and encouraging development of a resilient workforce across the region.

The responses to question 32 (category ranking question above) are seen in Figure 14. The results show the stakeholders felt the financial criteria of the framework is the most important, with implementability and social/community impact criteria having slightly less importance. Implementability and social/community have similar importance. The resulting relative importance is included in Table 23 and summarized here:

- Financial (45 percent)
- Implementability (30 percent)
- Social/Community (25 percent)

32. Please rate the following three O&M criteria categories for relative importance:

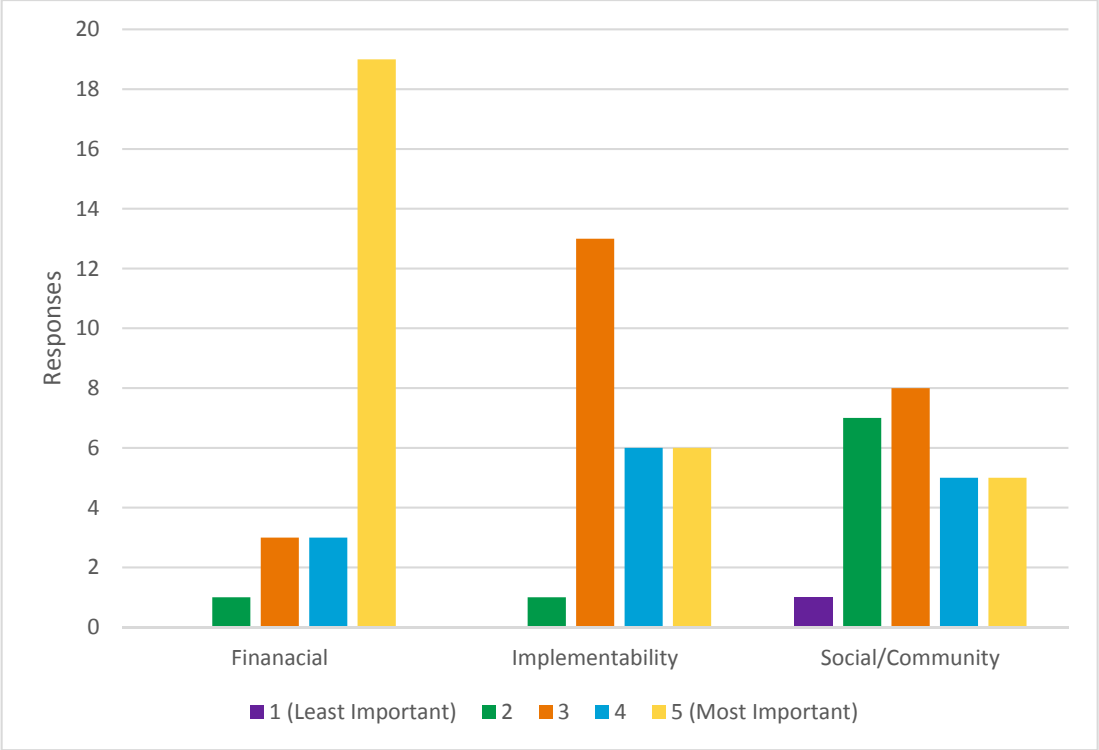

Figure 14. Survey Question 32
Stakeholder criteria ranking.

Overall, the survey was very informative on what stakeholders would accept in a framework, the level of support for various framework alternatives, and what would not be supported. The survey helped inform how to weight the three criteria, gave an important look into what stakeholders are currently doing to maintain their GI strategies, and what they are capable of doing. With the survey results in mind, the different GI O&M implementation framework alternatives were developed. Appendix B contains the complete survey questions and results.

Framework Implementation Alternatives

Implementation of GI O&M across the MMSD service area considered:

- Routine Maintenance
- Specialized Maintenance
- Training
- Inspections

Responsibility for these key O&M issues varied by GI O&M implementation framework. In all, the project considered six GI O&M implementation framework alternatives representing variations in responsibility between a regional entity, municipalities, and private property owners. These six implementation framework alternatives were created in an attempt to come up with not only the most

efficient, cost-effective approach, but also an acceptable strategy for maintaining GI across the region. Each of the six frameworks are described below in detail.

Implementation Framework 1 – Regional

In Implementation Framework 1, a single regional entity is responsible for all GI O&M throughout the region. Inspections, training, and routine and specialized maintenance will all be undertaken by this one entity. This model assumes the administrative task of creating memorandums of understanding and other documentation can be undertaken in order to create the necessary agreements to have a single entity maintaining GI throughout the region. Table 17 illustrates the responsibilities assigned to the various entities.

Table 17. Implementation Framework 1 – Regional

	Regional Entity	Municipalities	Private Property Owners
Routine O&M for all Strategies	Responsible for all strategies	No responsibilities	No responsibilities
Specialized O&M for all Strategies	Responsible for all strategies	No responsibilities	No responsibilities
Training	Responsible for all training	No responsibilities	No responsibilities
Inspections	Responsible for all inspections	No responsibilities	No responsibilities

Implementation Framework 2 – Municipal

In this GI O&M implementation framework, the individual municipalities in the region are in charge of all GI O&M within their jurisdiction, including private property GI. Each municipality is also responsible for the training necessary to properly maintain the GI within their jurisdictions. This implementation framework assumes each municipality has the authority to inspect and maintain GI on private property, or can create the necessary administrative agreements to do so. Table 18 presents an assignment of responsibilities for this implementation framework.

Table 18. Framework 2 – Municipal

	Regional Entity	Municipalities	Private Property Owners
Routine O&M for All Strategies	No responsibilities	Responsible for all strategies within their jurisdictions	No responsibilities
Specialized O&M for All Strategies	No responsibilities	Responsible for all strategies within their jurisdictions	No responsibilities
Training	No responsibilities	Responsible for training anyone needing training to maintain strategies within their jurisdictions	No responsibilities
Inspections	No responsibilities	Responsible for all strategies within their jurisdictions	No responsibilities

Implementation Framework 3 – Municipal and Private

This GI O&M implementation framework assumes that municipalities and private property owners would each be responsible for GI O&M strategies within their jurisdiction for both routine and specialized maintenance. It assumes the municipalities would provide the necessary training to properly maintain the various GI strategies as well as inspections of public GI strategies for aesthetics and functionality. Municipalities would have to decide for themselves whether they would inspect GI strategies on private property or rely on property owners to submit documentation stating maintenance is being undertaken by the owner or a contractor. Table 19 provides a description of responsibilities. This implementation framework assumes half of all private property owners in the region would outsource their GI O&M to private contractors with the remaining conducting do-it-yourself (DIY) maintenance.

Table 19. Framework 3 – Municipal and Private

	Regional Entity	Municipalities	Private Property Owners
Routine O&M for All Strategies	None unless owned by the regional entity	Responsible for all strategies on public property	Responsible for strategies on their own property
Specialized O&M for All Strategies	None unless owned by the regional entity	Responsible for all strategies on public property	Responsible for strategies on their own property
Training	Only for staff who maintain GI owned by the regional entity	Must provide for private property, required for staff (or contractor) performing maintenance, must be re-certified every 2 years	Required for owner (or contractor) performing maintenance, must be re-certified every 2 years
Inspections	None unless owned by the regional entity or on strategies entity has a financial interest in	Inspect or require inspection report from private property owners once per year	Prepare and submit inspection report for municipalities as required

Implementation Framework 4 – Regional Service Center

This GI O&M implementation framework assumes a regional GI service center would be set up by a regional entity to offer training for anyone requiring and or performing GI O&M services. The GI service center would also offer routine and specialized maintenance for the various GI strategies for a fee. The method for financing the GI service center and fee structure are beyond the scope of this project. Municipalities and private property owners alike could choose which services they would like to pay the regional entity to complete and which services they would like to complete themselves, given those performing the maintenance are certified to do so. Table 20 describes the responsibilities for each organization.

This implementation framework assumes approximately 50 percent of private property owners in the region will outsource to the regional service center, 25 percent would outsource to private contractors, and 25 percent would take care of their own maintenance. It assumes the regional GI service center would provide training to the entire region, and that 75 percent of small-sized municipalities would outsource their GI O&M to the regional GI service center, 25 percent of medium-sized municipalities would outsource to the regional GI service center, and no outsourcing to a large-sized municipality.

Table 20. Framework 4 – Regional Service Center

	Regional Entity	Municipalities	Private Property Owners
Routine O&M for All Strategies	Offered as an option through the service center	Responsible for all strategies on public property, can do in-house or through service center	Responsible for strategies on their own property, can DIY, contract, or use service center
Specialized O&M for All Strategies	Offered as an option through the service center	Responsible for all strategies on public property, can do in-house or through service center	Responsible for strategies on their own property, can DIY, contract, or use service center
Training	Training offered for entire region for a fee through the service center	Must have trained certified workers performing maintenance, use service center for training	Must have trained certified workers performing maintenance, use service center for training
Inspections	Inspections offered through service center	Strategies must be inspected, use service center or complete in-house	Prepare and submit inspection form once per year if not maintained by the service center

Implementation Framework 5 – Regional Training

This GI O&M implementation framework assumes that all municipalities and private property owners would be responsible for GI O&M within their jurisdictions for both routine and specialized maintenance. A regional entity would provide all training for the region. Municipalities decide for themselves whether they inspect GI strategies on private property or rely on property owners to submit documentation stating maintenance is being undertaken by the owner or a contractor, as long as the one completing the maintenance is certified. Training would be held by the regional entity and be required once every two years to maintain a GI O&M certification. Table 21 provides a summary of these responsibilities. This framework assumes approximately 50 percent of private property owners would outsource their GI O&M to private contractors and 50 percent would maintain their own GI.

Table 21. Framework 5 – Regional Training

	Regional Entity	Municipalities	Private Property Owners
Routine O&M for All Strategies	Only on strategies entity has a financial interest in	Responsible for all strategies on public property	Responsible for strategies on their own property
Specialized O&M for All Strategies	Only on strategies entity has a financial interest in	Responsible for all strategies on public property	Responsible for strategies on their own property
Training	Offer for certification in GI O&M maintenance for a fee	Required for staff (or contractor) performing maintenance	Required for owner (or contractor) performing maintenance
Inspections	Only on strategies entity has a financial interest in	Inspect or require inspection report from private property owners	Fill out inspection report for municipalities as required

Implementation Framework 6 – Regional Training and Specialized Maintenance

This GI O&M implementation framework assumes municipalities and private property owners would be responsible for GI O&M within their jurisdictions for routine maintenance. A regional entity would provide all specialized maintenance and the necessary training to properly maintain the various GI strategies as well as inspections where municipalities deem it necessary, for a fee. Inspections would be performed by those responsible for GI O&M to determine when specialized maintenance is necessary, and by the regional entity whenever specialized maintenance is performed. The method for financing the regionally provided GI O&M and fee structure are beyond the scope of this project. Table 22 provides an assignment of responsibilities for this framework. This model assumes 50 percent of private property owners would outsource their routine GI maintenance to private contractors, and 50 percent would maintain their own GI. All specialized maintenance is undertaken by the regional entity.

Table 22. Framework 6 – Regional Training and Specialized Maintenance

	Regional Entity	Municipalities	Private Property Owners
Routine O&M for All Strategies	Only on strategies entity has a financial interest in	Responsible for all strategies on public property	Responsible for strategies on their own property
Specialized O&M for All Strategies	Responsible for all strategies throughout the region	Request specialized maintenance based on inspections	Request specialized maintenance based on inspections
Training	Offer for certification in GI O&M maintenance for a fee	Required for staff (or contractor) performing maintenance	Required for owner (or contractor) performing maintenance
Inspections	Once per year on all strategies throughout the region, offered on those strategies the municipalities deems necessary	Inspect all strategies while routinely maintaining them; coordinates for specialized maintenance	Inspect all strategies while routinely maintaining them, coordinates for specialized maintenance

Figure 15 summarizes the GI O&M responsibilities for each implementation framework.

	Framework 1			Framework 2			Framework 3		
	Regional Model			Municipal Model			Municipal & Private Model		
	Regional	Municipal	Private	Regional	Municipal	Private	Regional	Municipal	Private
Typical O&M bioretention	X				X			X	X
Typical O&M porous pavement	X				X			X	X
Specialized O&M bioretention	X				X			X	X
Specialized O&M porous pavement	X				X			X	X
Specialized O&M green roofs	X				X			X	X
Training	X				X			X	X
Inspection	X				X			X	X

	Framework 4			Framework 5			Framework 6		
	Regional Service Center			Regional Training			Regional Training & Specialized Maintenance		
	Regional	Municipal	Private	Regional	Municipal	Private	Regional	Municipal	Private
Typical O&M bioretention	X	X	X		X	X		X	X
Typical O&M porous pavement	X	X	X		X	X		X	X
Specialized O&M bioretention	X	X	X		X	X	X		
Specialized O&M porous pavement	X	X	X		X	X	X		
Specialized O&M green roofs	X	X	X		X	X	X		
Training	X			X			X		
Inspection	X	X	X		X	X	X	X	X

No responsibility
Shared responsibility
Entirely responsible

Figure 15. GI O&M Implementation Framework Responsibility Summary.

Decision Matrix (Cost-Benefit Analysis)

To determine which GI O&M implementation framework is the most cost-effective, the implementation framework alternatives were scored using a formal and rigorous evaluation process. The criteria were developed and weighted based on stakeholder and MMSD staff input.

Criteria

The criteria includes:

- **Financial:** The overall cost efficiency and reliability of funding based upon the GI O&M implementation framework. Cost efficiency is represented by the relative costs of maintaining GI across the region. Funding reliability reflects how the consistency of funding may be impacted by the different GI O&M implementation frameworks.
- **Implementability:** Reflects the difficulty of framework implementation from an administrative and stakeholder acceptability viewpoint and whether the entities responsible for maintenance within each framework can do so consistently, capably, and with a clear definition of who is responsible.
- **Social/Community Impact:** Considers the social and community building aspects of the various frameworks, and how they encourage collaboration to solve the region's stormwater challenges by building partnerships, improving aesthetics, and encouraging development of a resilient workforce across the region.

The values assigned to the three criteria based on input from stakeholders are shown in the Table 23. The Final Rating was used for scoring each of the GI O&M implementation framework.

Maintenance needs can change as GI matures– the maintenance requirements for this bioretention area in 2015 are considerably less than shortly after planting in 2007.

Table 23. Stakeholder Input on Relative Importance of Decision Criteria

Stakeholder Group Feedback	Financial	Complexity	Social/Community Impact
Overall Average:	43	30	27
Municipal Average:	47	31	22
County Average:	50	30	20
Private (w/out Universities) Average:	37	24	39
Universities Average:	26	36	38
Private (w/Universities) Average:	33	28	39
Final Rating:	**45%**	**30%**	**25%**

Criteria and Scoring

Given the three fundamental criteria for the MMSD GI O&M implementation framework, sub-criteria that define the basis for evaluation of the alternatives were developed. Sub-criteria for evaluation of the MMSD GI O&M implementation framework alternatives are as follows:

1. Financial

a. **Efficiency:** The implementation of GI O&M across the region is done in an efficient and cost-effective manner. Higher efficiency would generally be achieved through economies of scale. Efficiency is measured in the number of GI O&M crews required.

Score	Description of Performance
0	Regional O&M crew projections at full 2035 Vision implementation are least efficient.
5	Regional O&M crew projections at full 2035 Vision implementation are moderately efficient.
10	Regional O&M crew projections at full 2035 Vision implementation are most efficient.

b. **Funding Reliability:** The GI O&M implementation framework includes a funding mechanism consistent with the model that will likely maintain a consistent GI O&M level of service throughout the region.

Score	Description of Performance
0	The framework likely relies upon the largest number of mechanisms to fund GI O&M within the region.
5	The framework likely relies upon a moderate number of mechanisms to fund GI O&M within the region.
10	The framework likely relies upon a minimal number of mechanisms to fund GI O&M within the region.

2. Implementability

a. **Administrative Needs:** The degree to which new regulations, agreements, or administrative processes are needed to realize the GI O&M implementation framework. The more the necessary administrative structures are already in place, the easier the framework will be to implement.

Score	Description of Performance
0	The framework's administrative structure would have a significant amount of change required with no other examples to draw from in public infrastructure maintenance.
5	The framework's administrative structure would be a modest amount of change required, but examples of other entities implementing a similar type of structure are available.
10	The framework's administrative structure follows existing models already in place in the region.

b. **Training Needs:** The relative size and complexity of the GI maintenance training program(s) needed to realize the GI O&M implementation framework. Training/certification requirements will be a part of any GI O&M implementation framework.

Score	Description of Performance
0	The framework necessitates a large number of entities undergoing training in GI O&M. Framework involves greatest number of organizations training annually.
5	The framework necessitates training multiple organizations in GI O&M. Framework involves a moderate number of organizations training annually.
10	The framework necessitates training a few organizations in GI O&M. Framework involves a low number of organizations training annually.

c. **Stakeholder Acceptability:** The level of anticipated acceptability to stakeholders, especially as it relates to working with other entities to have maintenance performed on GI the stakeholder owns or has jurisdiction over. Considers the level of control, accountability, and regulatory requirements for GI O&M.

Score	Description of Performance
0	The framework is likely to be supported by the least number of stakeholders (less than 50 percent).
5	The framework is likely to have a moderate amount of support from stakeholders (50 to 75 percent).
10	The framework is supported by the vast majority of stakeholders (greater than 75 percent).

d. **Consistent with Capabilities:** The degree to which the entity carrying out the GI O&M after implementing the framework has the capabilities to accomplish the required GI O&M, including consideration of the entity's likelihood to have staff and equipment capable to complete the required GI O&M.

Score	Description of Performance
0	The entity responsible for O&M within the framework has little current capacity to complete maintenance. The entity generally does not have interest, staff, or equipment needed to complete the maintenance.
5	The entity responsible for O&M within the framework has the capacity to complete some, but not all, of the maintenance. The entity generally does have interest in doing maintenance and has some of the staff and equipment needed to complete the maintenance.
10	The entity responsible for O&M within the framework has the capacity to complete all maintenance. The entity has interest in doing maintenance and has the staff and equipment needed to complete the maintenance, or is willing to obtain them.

e. Consistent GI Maintenance: GI O&M conducted within the framework promotes consistent GI O&M across the region. Each type of GI practice is maintained similarly and at a level of service appropriate for the location and GI strategy.

Score	Description of Performance
0	The framework would likely lead to inconsistent O&M due to the large number of entities responsible for O&M across the region.
5	The framework would generally be expected to have consistent GI O&M, but would likely have some inconsistent O&M due to a moderate number of entities responsible for O&M across the region.
10	The framework would generally be expected to have the most consistent GI O&M due to the lower number of entities responsible for O&M across the region.

3. Social/Community Impact

a. Encourages Partnerships: The framework encourages collaboration at the private, municipal, and regional scale to achieve the 2035 Vision GI goals with meaningful and valued roles for the region's broader non-governmental organization (NGO), workforce development, and academia collaborators.

Score	Description of Performance
0	The framework has few regional partnerships. GI O&M consists of mostly uncoordinated efforts with little contribution from broader NGO, workforce development, and academia stakeholders.
5	The framework has some regional partnerships with partial collaboration at different scales and with broader partners.
10	The framework has significant regional partnering to address the region's GI and water quality goals. There are shared resources at private, municipal, and regional levels with contributions from the broader NGO, workforce development, and academia stakeholders.

b. Includes Workforce Development: The framework encourages the development of a steady and competent workforce for the maintenance of GI. It encourages organizations to become trained and begin training others for the development of a GI O&M workforce for the region.

Score	Description of Performance
0	The framework does little to encourage development of a steady workforce. Individuals are trained in GI O&M on an as-needed basis, with no system put in place to continue training and develop a workforce.
5	The framework encourages development of a steady workforce for individual entity needs. Groups lead training in GI O&M with the intent of developing a system to continue training future groups in GI O&M. Training is not consistent across the region.
10	The framework strongly encourages development of a steady workforce for the region's needs. Workforce development training for proper GI maintenance is coordinated and consistent across the region.

Performance Measures and Scales

Evaluation of the GI O&M implementation framework alternatives was accomplished by scoring the anticipated performance of the alternatives in terms of the criteria previously listed and their anticipated contributions to the GI O&M implementation framework objectives. Table 24 provides the principal performance measures for each criteria.

Table 24. Principal Performance Measures for Each Criteria

No.	Criteria	Performance Measure
1. Financial		
a.	Efficiency	Relative GI O&M efficiency for the region using economies of scale and efficiency with fewer GI O&M crews scoring higher.
b.	Funding Reliability	Stability/reliability of funding for GI O&M, frameworks requiring more separate funding sources are considered to be less reliable overall and as a result score lower.
2. Implementability		
a.	Administrative Needs	Implementation of new administrative structures would score lower than having existing processes in place.
b.	Training Needs	Number of people and level of training required to complete GI O&M with fewer numbers requiring training scoring higher.
c.	Stakeholder Acceptability	Anticipated level of acceptability/comfort of entities responsible for GI O&M who would accept the framework with greater acceptability and similarity to status quo scoring higher.
d.	Consistent with Capabilities	Considers the likelihood that responsible entities have staff and equipment capable of completing required GI O&M. Lower capabilities scores lower.
e.	Consistent GI Maintenance	The relative number of entities responsible for O&M across the region with a higher score provided for fewer entities.
3. Social/Community Impact		
a.	Encourages Partnerships	Number of partnership opportunities for GI O&M across the region with more opportunities scoring higher.
b.	Includes Workforce Development	Workforce development is coordinated and consistent across the region with more consistency through fewer organizations scoring higher.

Evaluation Process

The objectives and criteria were employed in an evaluation process designed so the selected GI O&M implementation framework yields the highest net benefits, defined in terms of contributions to the stated objectives. The process is briefly summarized as follows:

1. Scoring alternatives using a decision matrix and criteria weights based on stakeholder input:
    a. Financial (45 percent)
    b. Implementability (30 percent)
    c. Social/Community (25 percent)
2. Test the robustness of top-ranked alternatives by varying the criteria weights.
3. Scoring and ranking to support recommendation of the selected alternative.

Cost Benefit Evaluation

The project team evaluated the decision matrix criteria for each GI O&M implementation framework in order to compare each implementation framework consistently. The evaluation involves a three-step process of scoring the implementation framework alternatives, testing their robustness, and choosing the highest scoring implementation framework that becomes the recommendation for the region. The scoring results create a rank of each implementation framework.

Weighting and Scoring

Sub-criteria Weighting

The sub-criteria weighting factors in Table 25 were determined considering input from stakeholders and the project team judgment.

Table 25. Sub-criteria Weights

Criteria	Sub-Criteria	Sub-Criteria Weighting Factor
Financial (45%)	Efficiency	60%
	Funding Reliability	40%
Complexity (30%)	Administrative Needs	10%
	Training Needs	10%
	Stakeholder Acceptability	50%
	Consistent with Capabilities	15%
	Consistently Maintains GI	15%
Social/Community Impact (25%)	Encourages Partnerships	50%
	Includes Workforce Development	50%

The sub-criteria weights were used with the scoring for each criteria and criteria weighting factors for each GI O&M implementation framework. Adding the resulting weighted scores together produced the overall score for each GI O&M implementation framework. This multi-step weighting system allowed each implementation framework to be considered independently and compares each implementation framework consistently one to another in order to minimize bias when making a recommendation.

Cost Efficiency Score

GI O&M cost information in the Milwaukee area was found to vary in consistency through information gained from several Milwaukee area GI O&M evaluations and contracts.

The Milwaukee County (County) Stormwater Facility O&M project was a pilot project for 1 year from 2014 to 2015 to evaluate maintaining various best managements practices (BMPs), including the following GI strategies: porous pavement, biofiltration, infiltration and bioretention cells, and rain gardens (Milwaukee County, 2016). The project evaluated porous pavement that had been installed in 2012, a bioretention basin installed in 2008, and infiltration cells and rain gardens installed in 2007. Since their installation, these GI strategies had been minimally maintained. The maintenance needed for these systems was more intense than if they were maintained on a regular basis, making the costs associated with the maintenance less typical.

In a separate effort, in 2014 the City of Milwaukee (City) requested bids to perform maintenance at 56 of its bioretention strategies, totaling 42,000 sf. These bioretention facilities were installed between 2009 and 2012. Prior to that, minimal maintenance had been performed on these strategies. The City received two bids at $562,850 and $103,595 (Milwaukee, 2014). The difference between the two bids was $459,255, with the lowest bid being $53,595 more expensive than the engineering estimate of $50,000. The variance between the two bids and the engineering estimate suggest uncertainties in the actual costs to perform GI O&M in the Milwaukee area. These examples of cost uncertainty under the current conditions in the Milwaukee region could be for several reasons, including GI O&M procedures that are not consistent across the region, maintenance frequency varying considerably, and that there are few experienced contractors. These factors all contribute to uncertainty in GI O&M costs. As GI implementation increases, these factors should become more consistent over time.

Typical GI O&M costs also do not consider credits or offsets for maintenance activities that are already occurring. For example, there would have likely been lawn maintenance on the same land where bioretention is installed, or other landscape maintenance expenses and porous pavement would already have had pavement maintenance and sweeping costs. To estimate actual incremental additional maintenance GI O&M costs, each of these maintenance costs should be considered a credit or offset to come up with a baseline condition of net maintenance costs.

Cost efficiencies and economies of scale are expected for larger municipalities with specialized O&M crews. As a result, the cost efficiency criteria focused upon estimating the number of maintenance crews needed. This approach allowed for economies of scale to be considered with more efficiency for municipalities with multiple crews or where private property outsource maintenance to contractors who realize economies of scale by maintaining multiple properties. This approach allowed for a comparison of relative efficiencies across the region, without assigning a specific dollar amount to maintenance activities given the variations in costs observed in the region.

The cost efficiency score took into account the number of GI O&M crews for both routine and specialized maintenance. For this analysis, the need for fewer than 3 crews was assumed to be less efficient. The GI O&M implementation framework with the lowest number of maintenance crews (best overall regional efficiency) was given a score of 10, while GI O&M implementation framework alternatives requiring more maintenance crews (lower regional efficiency) received lower scores. Consequently, the highest scoring implementation framework has the lowest number of crews. Table 26 shows the final cost score numbers and Table 24 includes the scores for the other criteria.

Table 26. Cost Efficiency Scores

Number of Maintenance Crews by Maintenance Type and GI O&M Implementation Framework.

No.	Description	Bioretention - Routine	Porous Pavement - Routine	Bioretention - Specialized	Porous Pavement - Specialized	Green Roofs - Specialized	Overall Crew Totals	Cost Score
1	Regional	151	26	16	14	83	290	**10**
2	Municipal	193	33	21	18	107	372	**5**
3	Municipal and Private	186	32	20	17	103	357	**6**
4	Regional Service Center	173	27	18	15	88	322	**8**
5	Regional Training	186	31	20	17	103	356	**6**
6	Regional Training and Specialized Maintenance	186	31	16	14	83	330	**7**

All the sub-criteria were evaluated and scored in a similar fashion. A discussion of each criteria can be found in Appendix C. Table 27 includes a summary criteria of the values and scores.

Implementation Framework Weighted Scores

Using the scores for the GI O&M implementation framework alternatives and multiplying them by the average weights determined from stakeholders, the GI O&M implementation framework alternatives were scored and weighted to compare to each other. Table 27 provides the scoring results.

Table 27. Sub-Criteria Scores (Except Cost)
GI O&M Implementation Framework scores.

Framework No.	Description	Funding Reliability		Administrative Needs		Training Needs		Stakeholder Acceptability		Consistent with Capabilities		Consistently Maintains GI		Encourages Partnerships		Includes Workforce Development	
		Number of Entities Funding O&M	Score	Number of Entities Affected	Score	Number of Organizations Training	Score	Questions. 3, 4, 30, and 31 from Survey	Score	Question 11 from survey	Score	Number of Entities Maintaining Strategies	Score	Number of Entities and Number of Issues	Score	Number of Training Organizers	Score
1	Regional	1	10	29	1	1	10	Least Acceptable	0	Most Capable	7	1	10	1	2	1	8
2	Municipal	28	7	28	2	28	1	Somewhat Acceptable	1	Least Capable	3	28	7	56	5	28	2
3	Municipal and Private	4962	1	0	10	28	1	Most Acceptable	10	Least Capable	3	5,000	1	No Partnerships	2	28	2
4	Regional Service Center	4962	1	15	6	1	10	Acceptable	5	Most Capable	8	1,269	5	1734	8	1	8
5	Regional Training	4962	1	1	8	1	10	More Acceptable	9	Capable	5	5,000	1	129	5	1	8
6	Regional Training and Specialized Maintenance	4962	1	15	4	1	10	Acceptable	5	Capable	5	4,232	2	129	6	1	8

Note:
No. = number(s)

Table 28. Initial Weighted Scoring
GI O&M implementation framework initial weighted score.

Criteria	Sub-Criteria	Sub Criteria Weight:	Unweighted Scores by GI O&M Implementation Framework Number						Criteria Weighted Score by GI O&M Implementation Framework					
			No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	1	2	3	4	5	6
Financial (45%)	**Efficiency**	**60%**	10	5	6	8	6	7	4.50	2.61	1.80	2.34	1.80	2.07
	Funding Reliability	**40%**	10	7	1	1	1	1						
Implementation (30%)	**Administrative Needs**	**10%**	1	2	10	6	8	4	1.10	0.69	2.01	1.82	2.16	1.49
	Training Needs	**10%**	10	1	1	10	10	10						
	Stakeholder Acceptability	**50%**	0	1	10	5	9	5						
	Consistent with Capabilities	**15%**	7	3	3	8	5	5						
	Consistently Maintains GI	**15%**	10	7	1	5	1	2						
Social/Community Impact (25%)	**Encourages Partnerships**	**50%**	2	5	2	8	5	6	1.25	0.88	0.50	2.00	1.63	1.75
	Includes Workforce Development	**50%**	8	2	2	8	8	8						
	SCORE TOTALS:								**6.85**	**4.18**	**4.31**	**6.16**	**5.59**	**5.31**

Overall Score

Table 28 shows the overall score determined by the decision matrix. Figure 16 provides a visual representation of the score for ease of determining the highest rated frameworks. The graph breaks out the relative financial, implementation, and social/community impact scores in color-coded bands.

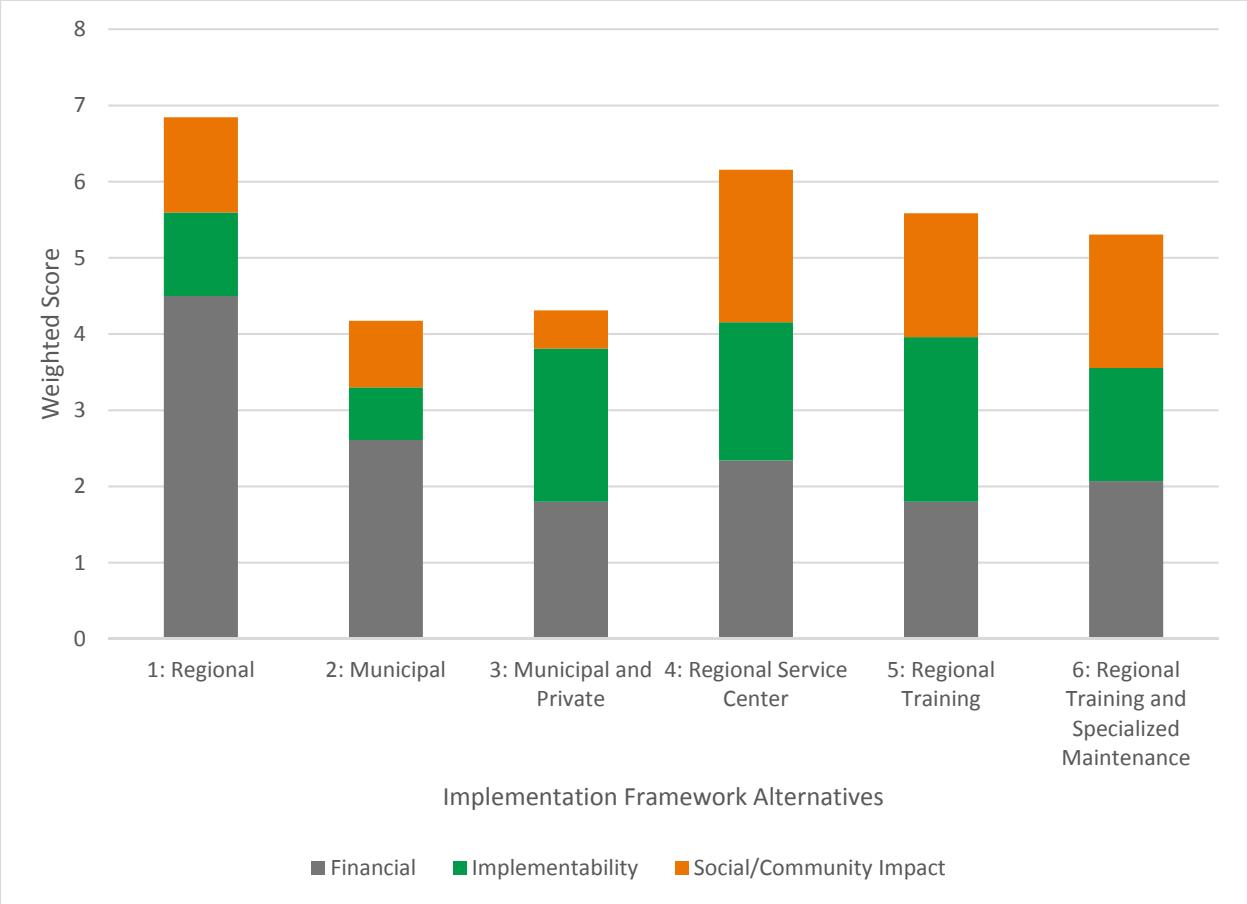

Figure 16. Initial GI O&M Implementation Framework Weighted Scores

The Regional Implementation Framework garners the overall highest score, a significant portion of which is made of the financial criteria score. However, after looking at stakeholder survey responses, the Regional Implementation Framework would not appear to be acceptable to most stakeholders. As a result, the Regional Implementation Framework is not recommended.

The next three highest scoring implementation framework alternatives are hybrids of the first three. They all have regional training included and varying amounts of regional maintenance responsibility, all at a lesser degree than the pure Regional Implementation Framework.

Because the highest scoring implementation framework would not be accepted, the project team considered other criteria scores would be representative of stakeholder feedback or not. To aid this evaluation, the weighted scores were looked at in a few different ways to help determine which GI O&M implementation framework would not only be the most efficient and cost-effective, but also acceptable to stakeholders.

Implementability Scores Only

The first variation of the weighted scoring results looked at only the implementability criteria (i.e., the criteria weight for implementability was increased to 100% and the others were zeroed out). This criteria contains the sub-criteria of Stakeholder Acceptability, and the framework must be accepted by stakeholders. Figure 17 shows the results for all six frameworks only considering implementability.

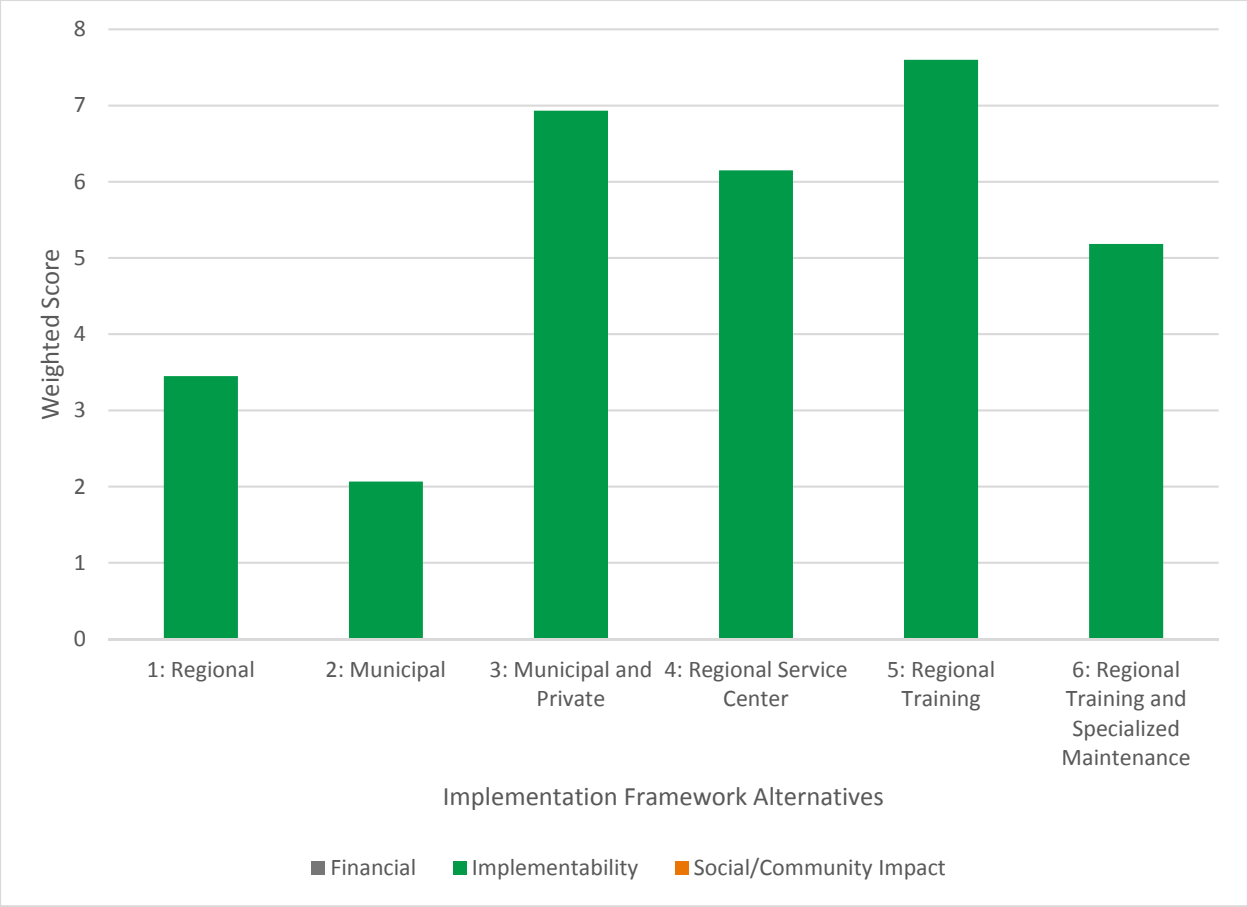

Figure 17. Only Implementability Criteria Scores
Only considering the Implementability criteria, removing Financial and Social/Community criteria.

Based on only the implementability criteria, Implementation Framework 5, the Regional Training Implementation Framework, comes out as the most accepted implementation framework. This is not surprising, considering that more than 80 percent of stakeholders who responded to the survey commented they would like to see training offered by a Regional Service Center (see question 30 in the *Stakeholder Meetings and Survey* section of this report). Implementation Framework 3, the Municipal and Private Implementation Framework, scored the second highest, which is not surprising considering this implementation framework most closely represents the status quo and stakeholders expressed interest in keeping control of their own maintenance. The Municipal Implementation Framework scored the least where all GI O&M is led by municipalities, including on private property.

Financial Scores Only

Another variation on the scoring looked at scores of the implementation framework alternatives based on only the Financial criteria. Prior to the stakeholder survey, the financial category was believed to be the most important aspect to stakeholders. (Figure 15). Stakeholders also responded that the Financial criteria was the most important of the three main criteria. However, stakeholder survey results (Figures 5 and 6) indicated 40 to 60 percent of stakeholders feel strongly that either no financial benefit to the

region or a greater than 20 percent cost savings would be required for having less GI maintenance control within their own jurisdictions. Because stakeholders view the financial considerations differently depending upon the implementation framework, the financial criteria results were independent of the other criteria. Figure 18 shows the results of looking only at the Financial criteria scores. Based upon the Financial criteria scoring, a higher number is better.

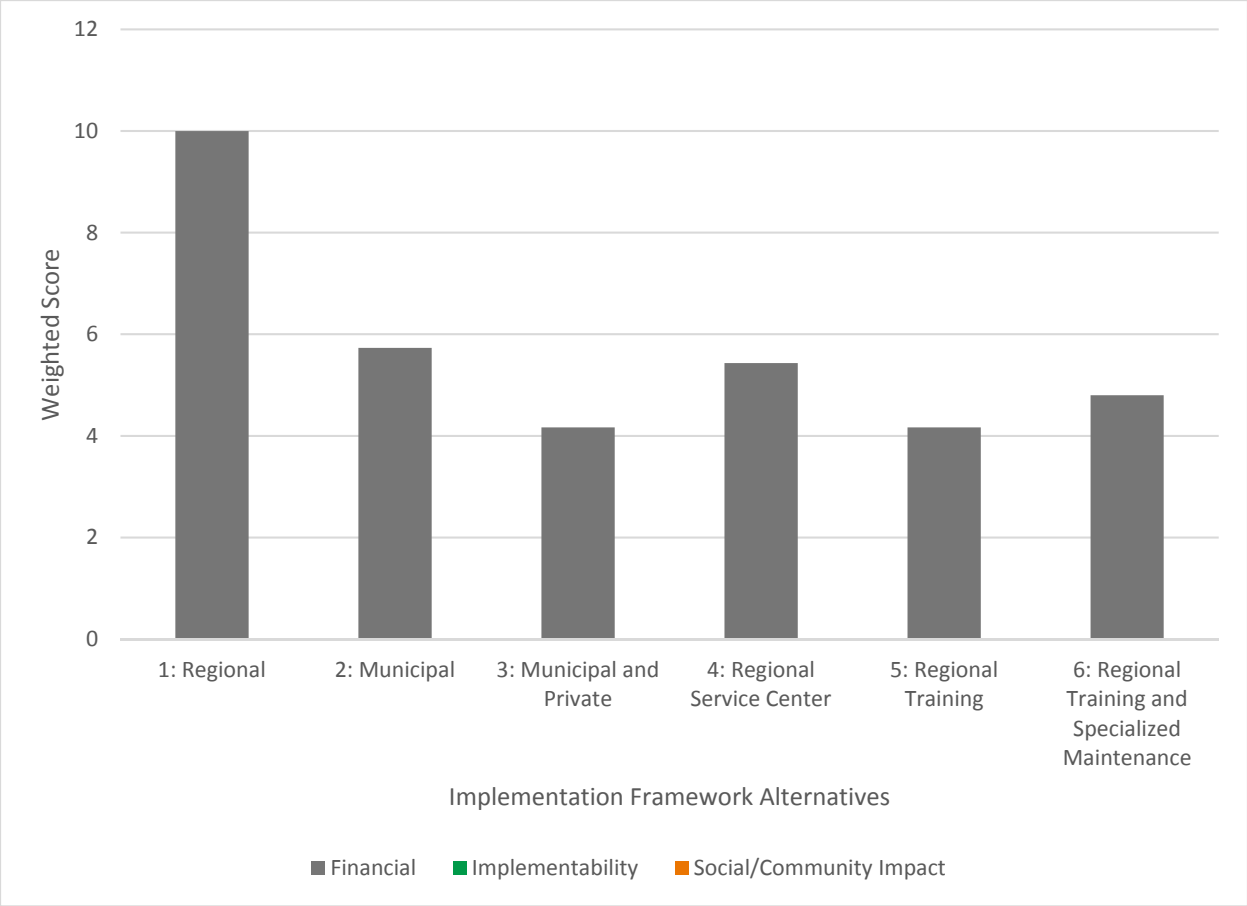

Figure 18. Financial Criteria Only Scores

Considering only the Financial criteria and removing Implementability and Social/Community Impact criteria

The results of this scoring show that Framework 1, the Regional Implementation Framework, scores the highest. This implementation framework offers the most efficiencies for training, inspections, routine maintenance, and specialized maintenance. Framework 2, – the Municipal Implementation Framework, scored the next highest. This implementation framework offers some efficiencies by having municipalities conduct more maintenance of private property GI, which doesn't experience economies of scale unless outsourced. Implementation Frameworks 1 and 2, even though they scored well on the Financial criteria, are the least acceptable to stakeholders. Noting that 40 to 60 percent of stakeholders indicated financial benefits are not as important as maintaining control over GI O&M. These findings are somewhat contradictory in that the Financial criteria were stressed to be the most important while there was little support for regional control even if it provides cost savings.

The Municipal and Private Implementation Framework and the Regional Training Implementation Framework had the lowest financial criteria scores, which reflects the status quo and the status quo with regional training respectively because fewer economies of scale occur with these two implementation framework alternatives than with those that include some regionalization of maintenance activities.

Financial Scores Not Considered

While stakeholders did deem financial the most important category, 40 to 60 percent of survey respondents noted no amount of savings would make a regional approach to GI O&M acceptable to them. The framework implemented must be undertaken in an acceptable way to stakeholders. The scoring was looked at making all financial aspects even among the various implementation framework alternatives to see what effect looking at only Implementability and Social/Community Impact criteria would have. Figure 19 shows these results.

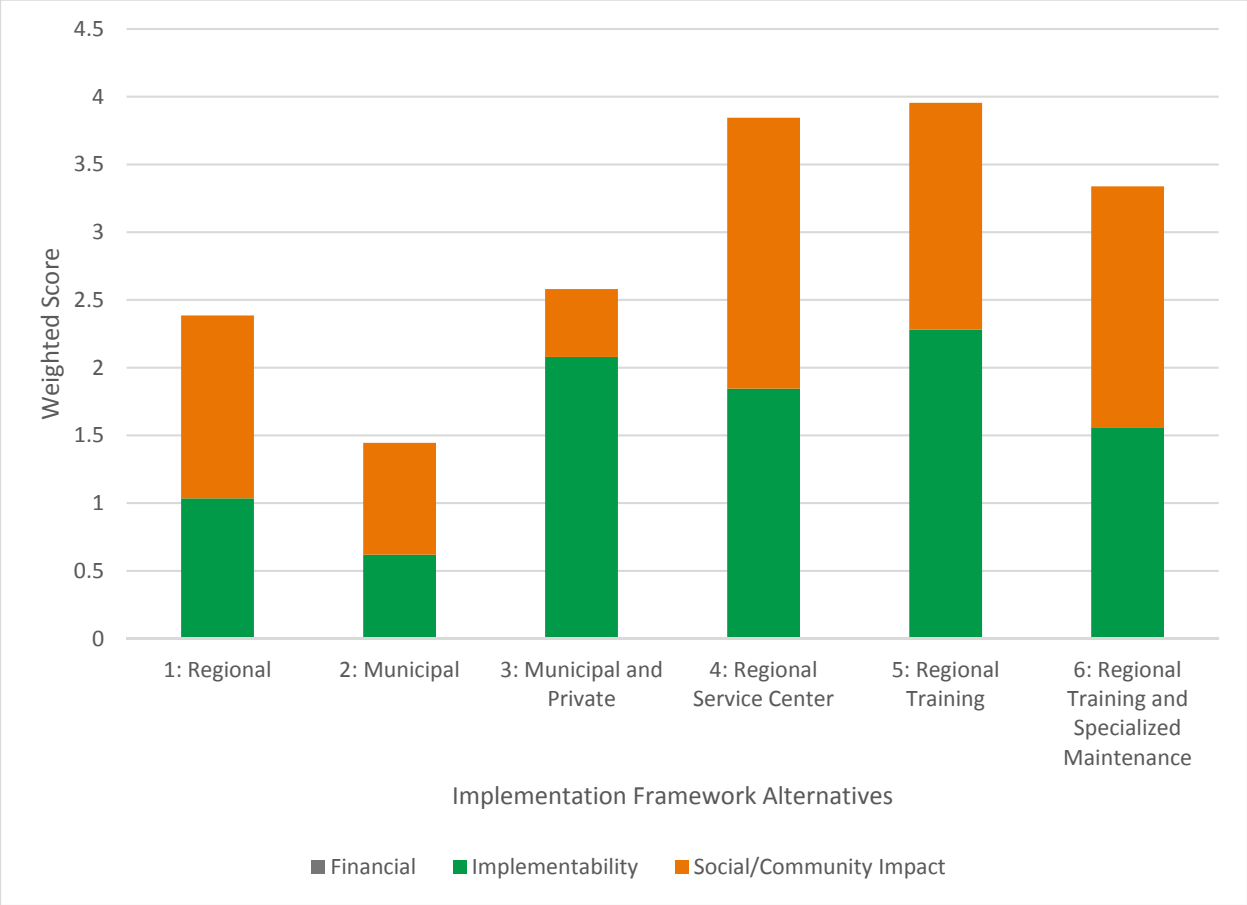

Figure 19. Financial Criteria Not Included Scores

Considering Implementability and Social/Community Impact criteria and ignoring the Financial criteria

Looking at these scores, when the Financial criteria is removed from the results, Framework 5 – Regional Training Implementation Framework scores the highest. Framework 4 – Regional Service Center scores the next highest, with Framework 3 – Municipal and Private Implementation Framework and Framework 6 – Regional Training and Specialized Maintenance Implementation Framework being virtually tied for third. Acceptability of a regional entity providing GI O&M training for the region is emphasized in these scores as is the lack of acceptability of a regional entity performing the maintenance.

Recommended Implementation Framework: Regional Service Center

Based upon the feedback from stakeholders and cost efficiency considerations, the Regional Service Center Implementation Framework is recommended. Based upon stakeholder meetings and the project survey, stakeholders indicated clear preference for regional GI training and an interest in specialized maintenance support, both of which the Regional Service Center has. Municipal stakeholders also felt

strongly that municipalities should continue to be responsible for GI O&M within their municipality, which the Regional Service Center allows.

As identified in the EPA technical assistance grant findings (EPA 2015), there is no "one-size-fits-all" solution for GI O&M in the region. The Regional Service Center addresses this previous finding by providing options for municipalities and private property owners that benefits them, whether taking advantage of GI training or choosing to obtain assistance on specialized GI maintenance. For example, while many stakeholders indicated interest in specialized maintenance support, but just 20 percent of stakeholders indicated interest in routine maintenance support. Given the diversity of municipal sizes and capabilities in the region and their individual preferences, it is clear there will be variation in what municipalities view as a benefit to them for GI O&M. A Regional Service Center provides the opportunity to select services that offer the most value to the stakeholder.

Although the Regional Implementation Framework offered the most financial benefits through crew efficiencies, it is not considered acceptable to stakeholders so it was not recommended. The Regional Service Center has the potential to provide some of the efficiencies of the Regional Implementation Framework, if a high adoption from municipalities and private property owners occurs.

The additional economy of scale efficiency benefits that occur for the Regional Service Center Implementation Framework and the Regional Training and Specialized Maintenance Implementation Framework end up scoring higher than the Regional Training Implementation Framework, which only has regional training and no other GI O&M support. As a result, there are no maintenance economies of scale realized. The implementation framework that offers the most flexibility to offer training, routine maintenance, and specialized maintenance is the Regional Service Center Implementation Framework. Therefore, the Regional Service Center Implementation Framework is recommended. Additional specific recommendations follow.

Partial Implementation Considerations

The analysis documented in this report assumes full implementation of the MMSD 2035 Vision to capture 740 million gallon of runoff during every storm. Through 2015, 21 million gallons of GI has been installed and documented by MMSD. Because it will take some time to achieve the 740 million gallon goal, it is beneficial to review interim needs and the GI implementation framework alternatives in light of realizing partial implementation on the way to full implementation. Partial implementation can inform nearer-term GI O&M crew and training needs for starting up the Regional Service Center recommendation.

Signage and other displays such as pavement markings can help ensure proper O&M takes place

Partial implementation also considered if any GI O&M implementation frameworks would be more advantageous when implementation is still in the beginning stages. A partial implementation stage of 20 percent of full implementation was assumed at as a reasonable nearer-term condition. Reviewing the criteria, it was concluded that partial implementation increases the efficiency of the implementation framework alternatives with regional services. Municipalities will need fewer crews for partial implementation and generally be less efficient. With fewer crews, there will generally be less expertise within municipalities for specialized GI O&M, which would also favor implementation framework alternatives containing specialized regional maintenance offerings. As a result, the Regional Service Center recommendation is favorable in both a partial and full implementation of the 2035 Vision.

See Table 29 below for overall crew needs for partial (20 percent) implementation.

Table 29. Maintenance Crew Needs by Green Infrastructure Strategy and Municipality Size at Partial (20 percent) Implementation

Municipality Size	Bioretention		Green Roof		Porous Pavement		Total		
	Public Property	Private Property	Public Property	Private Property	Public Property	Private Property	Public Property	Private Property	Public and Private Property Total
Small Municipality	0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.2	0.4
Medium Municipality	0.7	0.6	0.3	0.3	0.2	0.1	1.2	1.0	2.2
Large Municipality	9.0	6.4	3.5	5.0	2.6	1.1	15.2	12.5	27.7
TOTALS	**20.4**	**16.8**	**9.1**	**9.4**	**5.9**	**2.9**	**35.4**	**29.0**	**64.4**

As shown in Table 29, for all required GI maintenance in a small municipality, less than one full-time crew is projected, and for a medium size municipality only one to two crews are projected for maintenance of all GI strategies at a 20 percent partial implementation. For this low level of staffing requirement, municipalities may choose to conduct the GI maintenance on their own, or with the inefficiencies of only part time staff municipalities could find value in allowing a regional service center to provide specialized GI O&M training or maintenance services. As a result, the recommendation of the Regional Service Center framework remains whether at partial of full implementation of the MMSD 2035 Vision.

Recommendations for Implementing the Regional Service Center Implementation Framework

The overall recommended alternative for implementing GI O&M across the region is Framework 4, Regional Service Center. The following sections describe how this will affect all stakeholders in the region and attempt to show how this framework can be implemented to achieve appropriate maintenance across the region for GI strategies.

Municipal and Private Property Owner Recommendations

Training

Municipalities are recommended to take advantage of the regional training that would become available. This would allow municipal staff to not only be trained, but also avoid having to evaluate different training options or develop materials on their own.

Private property owners are also recommended to take advantage of the regional training that would become available. This would allow property owners to understand the GI O&M requirements for the GI

they own and help routine maintenance be better understood so that costly specialized maintenance or repairs would become less common.

As GI O&M training and certification programs are developed in the MMSD service area, a certification requirement to perform GI O&M at certain facilities could be considered.

Maintenance

Municipalities should also consider what GI routine maintenance and specialized maintenance activities they can best perform and which activities they would consider outsourcing. Options for outsourcing could be private contractors or a regional service center-supplied maintenance crew. Additional discussions of what resources would be beneficial and what MOUs would need to be in place to take advantage of economies of scale available through regionalization should take place.

Private property owners should also consider what GI maintenance they would like to perform and what they would prefer to outsource. Options for outsourcing could be private contractors or a regional service center-supplied maintenance crew.

Inspections and Tracking

In response to the project survey, a number of municipalities noted various stormwater maintenance tracking tools they use. These resources varied from simple spreadsheets to more elaborate databases connected to maintenance scheduling software. Municipalities should consider what inspection and maintenance tracking needs they have. Standardizing not only inspection procedures, but also documentation would provide consistency for the region. Standardization would create economies of scale if implemented across the region. Municipal participation in a committee on inspection and maintenance tools would be beneficial.

Private property owners should expect that a recurring inspection requirement will likely occur in the future if it does not already exist for GI on their properties. Private property owner input will be valuable to create inspection and tracking tools that function well for private property owners who would likely not have the regular exposure to GI maintenance that municipal staff have.

Milwaukee Metropolitan Sewerage District Recommendations

To advance GI O&M in the region, the project team makes the following recommendations.

1. Provide Regional Training

There is strong support from both municipal and private property stakeholders for regional training. MMSD should develop training and certification programs that include the following:

- Routine maintenance: offer training so workers can obtain knowledge and certification to conduct routine GI maintenance. Routine maintenance training should cover bioretention vegetation maintenance, trash removal, and other routine maintenance needs for both bioretention and porous pavement. Completing the training should result in a certification that would need to be renewed on a multi-year basis. Routine maintenance training would be most applicable to municipal staff, private contractors, and some private property owners. Routine maintenance for other GI strategies is described in recommendation 5.
- Specialized maintenance: Offer training for workers to obtain knowledge and certification to conduct specialized maintenance. Separate classes and certifications could be required for vegetative maintenance for bioretention and green roofs compared to porous pavement specialized

maintenance, which would require specialized equipment training. Completing the training should result in a certification that would need to be renewed on a multi-year basis. Specialized maintenance training would be most applicable to municipal maintenance staff and private contractors.

- GI property owner training: geared toward raising awareness of the O&M required for GI on their property. If GI property owners are conducting their own maintenance, this training should be required, especially where regional funding is used for installation.

2. Actively Support Specialized Maintenance

Survey responses indicated a strong interested in specialized maintenance support from a regional service center. For multiple GI strategies, 50 percent of survey respondents indicated they would benefit from specialized maintenance support. There are several options that could be used to provide this support and it is recommended that the next steps to determining specialized maintenance support continue to develop one or more of these options. The following options could be explored as GI implementation increases in the region:

- Develop staff who have the training and specialized equipment to provide specialized maintenance. Effort would be needed to determine what these staff would do outside of the maintenance season and what the fee would be for such services.
- Obtain a contract to provide specialized maintenance services from outside contractors certified in specialized maintenance. Legal/contracting input from municipalities and private property owners is needed to determine how to develop a contract that could be accessed by these entities and meet their procurement requirements. Coordination with other MMSD maintenance contracts could be beneficial, such as watercourse maintenance and future maintenance activities that will be required for MMSD owned infrastructure in the 30th Street Corridor area. If these contracts were required to have GI O&M certification requirements and could be accessed by others. The contracts could start creating economies of scale value for other parties interested in outsourcing maintenance.
- Develop standard scope of work and request for bid templates that municipalities and private property owners could use to solicit specialized maintenance. GI O&M discussion needs with stakeholders should consider current, near-term, and long-term O&M needs as implementation ramps up across the region.

It is recommended MMSD convene municipal and private property stakeholders to further discuss their needs and options available to actively support specialized maintenance needs.

Vegetative specialized maintenance certification should be considered for all GI strategies with vegetation (bioretention, green roofs, native landscaping, etc.). The Regional GI Plan envisioned native landscaping as providing 18 percent of the regional volume goal. Native landscaping has the potential to result in long-term maintenance savings due to reduced lawn mowing requirements after successful establishment.

3. Support Routine Maintenance Assistance Where Requested

Survey responses indicated some interest in routine GI maintenance support from a regional service center. About 20 percent of survey respondents indicated they would benefit from such support. There is expected to be less interest in this offering, but this service could be provided as a benefit to the region, especially if economies of scale can be realized.

There would be similar next steps as those listed for specialized maintenance. Requiring GI certification in MMSD watercourse maintenance contracts could be particularly useful to have the contract capacity available that could then be accessed by others who would find this service beneficial.

It is recommended MMSD convene municipal and private property stakeholders to further discuss their needs and options available to actively support routine maintenance.

4. Promote Inspection and Maintenance Consistency

MMSD and the region can obtain multiple benefits through standardizing GI inspection and maintenance tracking tools. MMSD and others would benefit from having access to information – collected in a more consistent manner – useful in tracking GI implementation status in the region. Regional organizations could benefit from having a standardized set of tools that could be tied to the GI O&M training certifications which could also be helpful for other purposes, such as Wisconsin Department of Natural Resources (WDNR) stormwater reporting requirements. Next steps could include the following:

- Developing an electronic-based tool that could be used remotely to complete and record inspections.
- Consider how inspection information could tie into other MMSD asset management goals.
- Determine if other tools, such as identifying GI installations at construction completion, could be coordinated with an inspection tool. Having online access to design drawings, specifications, and other relevant information could aid future maintenance needs.
- Coordinate tool development with other stormwater reporting requirements municipalities and private property owners have.

5. Support Other GI Strategies Where Regional Resources are Needed

While the primary analysis to come up with a GI O&M implementation framework focused upon bioretention, porous pavement, and green roofs, other GI strategies such as residential rain gardens, native landscaping, soil amendments, and stormwater trees are an important component of the Regional GI Plan.

Table 30 includes general recommendations for these strategies.

Maintenance of single-family home rain gardens is generally similar to maintenance of other landscape areas

Table 30. Additional Green Infrastructure Strategies
General GI O&M implementation framework recommendations

GI Strategy	Regional GI Plan Target Land Use	Overview	GI O&M Implementation Framework Recommendations
Rain Gardens	Residential	Approximately 5 percent of the 740 MG regional goal with the private residential land owner assumed to be responsible for maintenance, which would be similar to that required for other residential landscaping. Rain gardens on non-residential land uses are included as part of the bioretention GI strategy.	Provide resources needed to support rain gardens (tracking, periodic inspections for certain funding agreements, O&M fact sheets, workshops, etc.). Additional inspection tracking may be needed in the future if rain gardens are used as a TMDL implementation strategy.
Rain Barrels	Residential	1 percent of the 740 MG regional goal, maintenance relatively minimal and easy to perform, private residential land owner responsible for maintenance.	Provide information and reminders on O&M, especially winterizing and reconnecting rain barrels, vector control, and using the stored water. Ask people if they would pay for a rain barrel installation and winterization. This could be offered through a service center.
Soil Amendments	Residential	? No additional maintenance anticipated once installed. A small decrease in landscape maintenance costs was envisioned in the GI Plan due to improved plant health and reduced fertilizer and irrigation needs.	Some regional support for the soil amendment GI strategy would be beneficial (technical advice, fact sheets, material sources, etc.).
Stormwater Trees	Public street right-of-way	3 percent of the 740 MG regional goal. Tree maintenance (e.g., pruning) is fairly well established and historically municipally-led for public trees, while private trees responsibility of private property owner.	Resources would be beneficial to reinforce a regional/municipal emphasis on tree planting, track implementation, and encourage collaboration.
Native Landscaping	Large turf grass areas	. A significant decrease in landscape maintenance costs was envisioned in the GI Plan after vegetative establishment compared to frequent turf grass mowing. After establishment, maintenance typically consists of mowing meadow areas once or twice per year.	Specialized maintenance, such as invasive species control, could benefit from additional resources (e.g., training) at a multi-municipal or regional level.
Cisterns	Non-residential buildings	Less than 1 percent of the 740 MG regional goal. Individual cisterns will likely have different O&M requirements.	Regional tracking and information sharing for larger cisterns should occur.

Additional recommendations for other GI strategies include:

- Rain gardens: MMSD has implemented many gain garden programs, including targeting implementation in specific municipalities and neighborhoods. It is recommended that MMSD gather information on how many of the constructed rain gardens are still functioning since they were implemented. This will inform what maintenance educational efforts are needed for residential homeowners as well as why rain gardens have been removed in order to target improvements to the installation and maintenance program in the future.

- Rain barrels: Rain barrels are a small percentage of the overall MMSD GI vision. However, they actively involve residents in managing water where it falls and can lead homeowners to adopt or support other GI strategies. Rain barrels require routine maintenance for winterization and re-connection in the spring. MMSD should consider how guidance on these simple, but critical, maintenance activities could be more broadly broadcast to customers. The service center should consider offering a service to install rain barrels in the spring and winterize them in the fall.
- Electronic communication in the form of a text message, app, email, or other notification could remind rain barrel owners of the following:
  - Winterizing needs
  - Rain barrel should be drained down to capture an approaching storm
  - Time for reconnection in the spring
  - Steps to help with vector control
  - Other GI-related communications such as annual rain garden plant sale, invasive species information sharing, or other relevant GI communications
- Stormwater trees: The Regional GI Plan identified the many benefits of trees to the region. Educational information on tree pruning, mulching, proper leaf disposal, and pest alerts all would be useful information to be disseminated at a regional level.
- Native landscaping: The training programs should consider certifications for native landscape maintenance in addition to the vegetative maintenance certification offered for bioretention and green roofs.
- Cisterns: Cisterns are expected to be a small percentage of GI in the region. Nonetheless, gathering information on how they are functioning, what works well for maintaining them, and providing examples of successful installations in the region would be helpful for others considering new installations and understanding their maintenance requirements and the experiences others have had.

Summary

A future Regional Service Center provides the regional training opportunity highly supported by stakeholders and offers the potential for additional financial efficiencies through offering specialized and routine GI maintenance support to municipalities and private property owners. The Regional Service Center GI O&M Implementation Framework, together with the report recommendations, provides municipalities, private property GI owners, and MMSD the path forward to provide the GI maintenance needed to realize the MMSD 2035 Vision of 740 million gallons of GI capacity.

The high level of GI installation called for in the MMSD 2035 Vision will require many thousands of GI installations, all of which will need to be maintained to remain effective. The Regional Service Center implementation framework when implemented and supported by municipalities and private property owners is capable of realizing and sustaining broad GI implementation across the MMSD service area to cost-effectively protect and maintain GI benefits.

References

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City of Milwaukee. 2014. DPW Schedule of Bids Received: Notice NO. 132-1-2014

Jaber, Nader. 2016. Environmental engineer, City of Milwaukee. Personnel phone communication. March 28.

Milwaukee County. Stormwater Facility Maintenance Annual Report. 2016.

Sasso, Lisa. 2016. Project Manager, MMSD. Personnel email communication. March 3.

U.S. Environmental Protection Agency (EPA). 2015. Elements of a Green infrastructure Maintenance Plan, A Stakeholder-Driven Process to Determine the Preferred Approach to Green Infrastructure Maintenance in Southeast Wisconsin. April.

Appendix A
Summary of Training and Certification Programs

STORMWATER SOLUTIONS ENGINEERING LLC

MEMORANDUM

TO: Lisa Sasso / Milwaukee Metropolitan Sewerage District
Project Manager

Mark Mittag, P.E. / CH2M
Water Resources Project Manager

FROM: Alyssa B. Schmitt / Stormwater Solutions Engineering, LLC
Project Engineer

CC: Carrie Bristoll-Groll, PE, CFM / Stormwater Solutions Engineering, LLC
Principal Civil Engineer

DATE: April 22, 2016

SUBJECT: MMSD GI O&M – Training and Certifications Standards Review

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Stormwater Solutions Engineering, LLC (SSE) was contracted by the Milwaukee Metropolitan Sewerage District (MMSD) as a sub-consultant to CH2M for the 'Green Infrastructure Operation and Maintenance Implementation Framework'. A portion of the scope was Task B4: Review Training and Certification Standards. SSE was contracted to review certification standards and their applicability towards the MMSD region. Up to six standards will be reviewed, including the pending WEF standards development effort. After a meeting with Mark (CH2M), the scope was narrowed to focus on reviewing two to four standards. Standards review will be developed into a technical memorandum and will be included as an appendix to the Framework Report. This memo serves as a draft technical memorandum.

Attachment 1 is a table that summarizes 10 certified training programs in stormwater. These programs are intensive and are geared towards erosion control and some stormwater managers.

The following three programs implemented by North Carolina State University Extension, the University of Minnesota Extension, and Colorado State University Extension focus on stormwater best management practice (BMP) maintenance certifications. Compared to the programs listed in Table 1, these programs focus specifically on stormwater BMP maintenance, with the inclusion of green infrastructure.

North Carolina State University hosts a Stormwater (BMP) Inspection and Maintenance Workshop. The goal of the certification is to understand stormwater, how it affects water quality and regulations associated with it; understand stormwater management devices used in North Carolina and how they function; understand inspection and maintenance requirements of each stormwater practice. This workshop is geared towards commercial landscapers, property managers, owners, homeowner associations, professionals with licensures, regulators, municipal and county landscape, and personnel. The two day workshop provides certification in stormwater BMP

inspection and maintenance. The certification is awarded by the NC State University Cooperative Extension house in Biological and Agricultural Engineering. Attendees must attend both days of the workshop and receive a score of at least 80% of the examination. The attendees have two hours to complete exam that is 50 questions comprised of multiple choice, true and false, and short answer. The certification lasts up to three years, the remaining portion of the year in which the exam is taken, plus the two following years. Recertification lasts an additional three years, and no re-examination is associated with the 5 hour update course. Communities in North Carolina may either require or recommend this certification of people who conduct maintenance on and/or inspect stormwater management practices. The state of North Carolina's NC DENR endorses, but does not require this certification. This certification is not intended to be a replacement for professional licenses and is only supplement to them. Table 1 outlines the fees for registration.

Table 1
Registration Fees

Early Bird Registration (applies if registering two weeks in advance)	
Professional Rate	$215
Government/Non-Profit Rate	$160
Regular Registration	
Professional Rate	$265
Government/Non-Profit Rate	$210
Recertification Fee	$75

The typical agenda consists of an introduction to stormwater, watersheds, stormwater regulations, BMP functions, elements of BMP maintenance, retention pond maintenance, wetland maintenance, bioretention maintenance, licensing and certification, field tour of local BMPs. The second day goes over level spreader maintenance, green BMPs (swales, green roofs, cisterns, infiltration trenches) maintenance, parking lot BMPs (permeable pavement, sand filters and proprietary systems), final BMP question and answer, and finally, the examination.

The University of Minnesota Extension hosts a Stormwater Practices Inspection and Maintenance Certification. This course is designed for those who inspect, maintain or direct maintenance on stormwater control measures and practices, such as ponds and infiltration systems. The goals of this class are that participants will be able to define, classify and explain the fundamental forms and functions of stormwater practices and their related maintenance needs; participants will be able to identify, apply and analyze stormwater practices using visual inspection forms to define and implement a preliminary Stormwater Practices Maintenance Program; participants will enhance their knowledge of the importance of stormwater practice maintenance communication with stakeholders and citizens and resources for effective outreach; become a certified stormwater practices maintenance professional. Attendees will learn the fundamentals of BMP processes, mechanics, operations and maintenance needs, and how to create and execute a maintenance work plan. They suggested attendees such be parks and public works staff, consultants such as engineers and designers, private contractors, stormwater managers, private land owners (big and small properties), property managers and homeowners associations, BMP and project designers, and anyone with stormwater BMP responsibilities. Attendees, who complete

the course and pass the voluntary exam, will be certified in Stormwater Management Practice Maintenance by the University of Minnesota Erosion and Stormwater Management Certification Program. The registration cost is $250 per person.

The agenda consists of the fundaments of stormwater practices maintenance, vegetated and biological stormwater practices maintenance, surface and in-ground stormwater practices maintenance, underground and volume reduction stormwater practices maintenance, rules and regulations, stormwater practices maintenance programs and cases studies, and communications and putting it all together.

The Colorado State University Extension hosts training for Permanent Stormwater BMP Inspection and Maintenance. This is a 2-day training workshop teaches participants how to recognize BMP maintenance needs and how to perform maintenance correctly. The workshop includes 8 hours of presentations and discussions in a classroom setting, 4-hour field trip and a 2-hour written exam (optional). The participants that successfully pass the written exam receive certification from the Colorado State University Extension. The suggested attendees are government (city/county/school) maintenance personnel, permanent BMP inspectors, MS4 managers/coordinators, landscape contractors, property managers, homeowner's association managers, etc. The registration cost is $250 per person.

There are other documents available that support that idea and benefits of having a green infrastructure certification program. 'Seeing Green: Green Infrastructure Maintenance Training and Workforce Development Opportunities in Northeast Ohio' is a report that explores the potential that exists in the Cleveland market for the creation of training and how a workforce development program can be created in Greater Cleveland, using green infrastructure maintenance as an entry point to an articulated career pathway.

The DC Water and the Water Environmental Federation (WEF) National Green Infrastructure Certification Program will be one of few programs that's primary focus is green infrastructure, and that is recognized on a national level. Most of the certification programs currently in place do not have a direct focus on green infrastructure, but as stormwater BMP maintenance as a whole. They are also focused towards people that have knowledge of stormwater BMPs are looking to expand upon their certifications.

STORMWATER SOLUTIONS ENGINEERING LLC

Reference List:

http://www.bae.ncsu.edu/topic/bmp-im/certification.html
https://www.erosion.umn.edu/certification-courses/bmp-maintenance
http://stormwatercenter.colostate.edu/training/
Seeing Green: Green Infrastructure Maintenance Training and Workforce Development Opportunities in Northeast Ohio

247 Freshwater Way, Suite 410
Milwaukee, WI 53204

Office (414) 810-1245
www.stormwater-solutions-engineering.com

SUMMARY OF CERTIFIED TRAINING PROGRAMS IN STORMWATER[1]

ORG NAME	CERTIFICATION TITLE	COURSE DURATION	ELIGIBILITY REQUIR.	HOW OFFERED	COURSE FEE	EXAM FEE	EXAM	CERTIF / PERIOD	LETTERS	C.E.U.s / PDH
APWA – Am. Public Works Assoc.	CSM – Certified Stormwater Manager	5 days	Yes	1. APWA Meet. 2. Assess. Ctrs.	$195 – member $245 – nonmember	$550	Yes	5 years	CSM	Yes
EnviroCert International, Inc.	CPSWQ – Certif. Prof. in Storm Water Quality	1 day	Yes	1.Exam Guides 2.Optional Review Course	$200 – appl. Fee May have exam fee Review Course extra	Locally decided	Yes	1 year	CPSWQ	Unk.
EnviroCert International, Inc.	CESSWI – Certif. Erosion Sediment & Storm Water Inspector	1 day	Yes	1.Exam Guides 2.Optional Review Course	$200 – appl. Fee May have exam fee Review Course extra	Locally decided	Yes	1 year	CESSWI	Unk.
EnviroCert International, Inc.	CMS4S – Certif. Municipal Storm Sewer System Specialist	1 day	Yes	1.Exam Guides 2.Optional Review Course	$200 – appl. Fee May have exam fee Review Course extra	Locally decided	Yes	1 year	CMS4S	Unk.
EnviroCert International, Inc.	CPESC – Certif. Prof. in Erosion & Sediment Control	1 day	Yes	1.Exam Guides 2.Optional Review Course	$200 – appl. Fee May have exam fee Review Course extra	Locally decided	Yes	1 year	CPESC	Unk.
North Central Texas Council of Governments	Storm Water Pollution Prevention During Construction	1 day	No	Seminar	$140	N/A	No	N/A	N/A	Unk.
NPDES Training Institute, Inc.	CMS4CEI – Certified MS4 Compliance & Enforcement Inspector	1 day	Pass exam	Seminar	$225	Included	Yes	1 year?	CMS4CEI	Unk.
National Stormwater Center	CSI-Municipal – Certif. Stormwater Inspector-Municipal	2 day class 4 day online	Pass exam (other?)	1.Classroom 2.Online	$824	Included	Yes	5 years	CSI	Yes
National Stormwater Center	CSI-Construction – Certif. Stormwater Inspector-Construction	2 day class 4 day online	Pass exam (other?)	1.Classroom 2.Online	$824	Included	Yes	5 years	CSI	Yes
CISEC, Inc.	CISEC – Certified Inspector of Sediment & Erosion Control	2 day class Own pace online	Yes	1.Classroom 2.Online	$300 online & class + $35 for manual	$150	Yes	Annual renewal; 3 year re-register	CISEC	Unk.

American Public Works Association http://www.apwa.net/credentialing/certification/certified-stormwater-manager-(csm)
EnviroCert International, Inc. http://www.cpesc.org/ affiliated with IECA, the International Erosion Control Association.
NCTCOG Class: http://nctcog.org/envir/SEEclean/stormwater/program-areas/construction/index.asp
NPDES Training Institute, Inc. http://www.npdestraining.com/
National Stormwater Center, part of the Conservation Preservation Environmental, a 501(c)(3) https://www.npdes.com/training/certifications
CISEC, Inc. http://www.cisecinc.org/ affiliated with IECA, the International Erosion Control Association.

Green Country Stormwater Alliance
Give Clean Water a Helping Hand

[1] *Prepared by INCOG, April 2014 (with one add by CH2M HILL, October 2014). This list of courses is not comprehensive. It represents courses most often offered at EPA MS4 conferences and in the south central US.*

Appendix B
Survey Questions and Results

QUESTIONS RESPONSES 26

Regional Green Infrastructure Operations and Maintenance Survey

Form description

1. Name/Organization:

Short answer text

2. Who do you represent?

Select one that best represents your situation

- Municipality
- County
- Resident
- Business owner
- Other...

3. How much would you or your community have to save on GI maintenance for a regional (centralized) approach that takes care of your maintenance (for a fee) to be compelling?

- 0%
- 5%
- 10%
- 20%
- >20%
- No amount of savings would make a regional approach compelling

4. Is there a dollar amount in total cost savings that would make a regional (centralized) approach to take care of your GI maintenance (for a fee) more compelling to you or your community?

- $500,000 annually region-wide
- $1,000,000 annually region-wide
- $5,000,000 annually region-wide
- $10,000,000 annually region-wide
- Greater than $10,000,000 annually region-wide
- No amount of savings would make a regional approach compelling

5. If you are currently maintaining the GI (or stormwater best management practices) you are responsible for, how reliable is the source of funding you are using for operations and maintenance

- Very reliable - it will always be available for GI O&M
- Somewhat reliable - it is currently available for GI O&M but may not be in the future
- Somewhat unreliable - the funding source will end soon and I'll have to find another
- Very unreliable - I have trouble finding funding for GI O&M every year
- I don't maintain my GI
- I don't have any GI to maintain

6. How is O&M occurring for the GI (or stormwater best management practices) that you are responsible for maintaining?

- We maintain the current practices in house
- It is outsourced to a private contractor
- We do general maintenance (i.e., picking up trash, keeping the practice clean), but outsource spe
- We maintain some practices and outsource maintenance for other types of practices
- We maintain our practices but not to the level that is required
- My practices are not currently maintained

7. How difficult is it for you to procure additional funding for GI

- Very simple

- ○ Somewhat simple
- ○ Neither simple nor difficult
- ○ Somewhat difficult
- ○ Very difficult
- ○ Not Applicable

8. What GI strategies do you have the O&M equipment to maintain? Check all that apply:

- ☐ Green roofs
- ☐ Bio-retention
- ☐ Porous/permeable pavement
- ☐ Rain gardens
- ☐ Cisterns
- ☐ Rain barrels

9. As more GI is implemented, does your community have the capability for maintaining additional practices?

- ○ Yes, funding and equipment are available for increased maintenance needs
- ○ Somewhat, the funding is available but we lack the necessary equipment
- ○ Somewhat, the community already owns or shares the equipment but additional funding may be
- ○ No, neither funding nor equipment is available for additional maintenance needs

- ○ Not Applicable
- ○ Other...

10. Does someone besides you/your community maintain the GI practices you are responsible for maintaining (e.g., a neighborhood group, a non-profit, a business improvement district)?

- ○ Yes (please state who on 'describe' line below)
- ○ No
- ○ Unsure

Describe:

Short answer text

11. What types of GI do you have the skills and capabilities to maintain? Check all that apply:

- ☐ Green roofs
- ☐ Bio-retention
- ☐ Porous/permeable pavement
- ☐ Rain gardens
- ☐ Cisterns
- ☐ Rain barrels

12. If you do NOT have the skills/capabilities to maintain existing GI within your authority, would any of the following be considered helpful for obtaining the necessary skills? Please select your top 3:

- [ ] A local training class
- [ ] A regional training class
- [ ] A training manual for all practices
- [ ] A partnership with neighboring communities/regional entity to complete maintenance
- [ ] Assistance with contracting out the maintenance activities (i.e. performance standards, levels c
- [ ] Other...

13. Is there a GI practice you would prefer to outsource for maintenance? Check all that apply:

- [ ] Green roofs
- [ ] Bio-retention
- [ ] Porous/permeable pavement
- [ ] Rain gardens
- [ ] Cisterns
- [ ] Rain barrels
- [ ] None

14. For vegetated GI practices (rain gardens, bio-retention, etc.) you are responsible for maintaining, what level of service do you expect and would be willing to pay for?

- ○ Excellent - vegetation is healthy, no bare spots, no erosion, no significant sediment or debris
- ○ Good - vegetation is healthy, minimal bare spots, some eriosion, sediment or debris accumulatio
- ○ Fair - vegetation is fairly healthy, a few bare spots, noticeable erosion, visible sediment and debri
- ○ Low - vegetation is lacking, many bare spots, erosion and channelization present, sediment and
- ○ Not Applicable

15. For GI practices you are responsible for maintaining, what level of service do you expect and would be willing to pay for, for porous pavement infrastructure practices?

- ○ Good - clean twice per year, infiltration rate of 20+ in/hr, 100% trash removal
- ○ Moderate - clean once per year, infiltration rate of 10 in/hr, 75% trash removal
- ○ Low - clean less than once per year, infiltration rate of 1-3 in/hr, 20% trash removal
- ○ Not Applicable

16. If someone would maintain the GI you are responsible for, what would your top concerns be? Please check up to 5.

- ☐ Promptness of service
- ☐ Reliability of service
- ☐ Accountability for maintenance (who to call if a practice looks like it requires more maintenance

- [ ] Level of service (how well a practice is maintained compared to others in the region)
- [ ] Continuity of service (how consistently the practices are maintained throughout the region)
- [ ] Private property being maintained by a municipality
- [ ] Municipal interest in doing private property maintenance
- [ ] Municipal property being maintained by a regional entity
- [ ] Cost escalation and/or change orders
- [ ] Other...

17. Would you be interested in any of the following for maintaining the GI you are responsible for? Check all that apply:

- [ ] Outsourcing all maintenance to a private contractor
- [ ] Outsourcing only specialized maintenance to a private contractor (trash pickup, keeping practic
- [ ] Outsourcing all maintenance to a regional entity
- [ ] Outsourcing specialized maintenance to a regional entity
- [ ] Forming partnerships with neighboring communities to perform REGULAR maintenance with sh
- [ ] Forming partnerships with neighboring communities to perform SPECIALIZED maintenance wit
- [ ] Other...

18. Under what circumstances would you be willing to let another entity maintain the GI you are responsible for? Fill in below:

Short answer text

19. If you/your community maintains the GI you are responsible for, are there standards and/or regulations that govern that

- Yes
- No
- Unsure
- Other...

20. Is the level of service you expect (and are willing to pay for) consistent across all practices or is it variable depending upon

- Consistent across all practices
- Consistent across practice types, variable depending upon location
- Variable depending on practice types, consistent across locations
- Variable depending on practice types, variable depending upon location
- Consistency does not matter to me
- Other...

21. If you represent a municipality or county do you expect to have increased GI operations and maintenance in the future?

- Yes
- No

- Unsure
- Not applicable
- Other...

22. If you are currently maintaining your GI, are you partnering with other agencies/neighboring communities to complete the

- Yes
- No
- Other...

23. Would you be willing to share resources with neighboring communities/agencies/entities to maintain GI practices?

- Yes
- No
- Maybe
- Other...

24. Are you interested in partnering with any of the following agencies/entities to better maintain the GI in your area? Check all

- [ ] Municipalities
- [ ] Private contractors

- [ ] Non-governmental/non-profit community based organizations
- [ ] Regional organizations
- [ ] None
- [ ] Other...

25. How important to you is collaboration between the various levels of local and regional entities for GI maintenance?

- ( ) Very important
- ( ) Somewhat important
- ( ) Neither important nor unimportant
- ( ) Somewhat unimportant
- ( ) Not important at all
- ( ) Not Applicable

26. Which sources of information do you most often use for information about GI O&M? Check all that apply:

- [ ] Wisconsin Department of Natural Resources (WDNR)
- [ ] Milwaukee Metropolitan Sewage District (MMSD)
- [ ] U.S. Environmental Protection Agency (U.S. EPA)
- [ ] Municipalities
- [ ] Contractors

- [ ] Other...

27.a What role do you think the WDNR should play in GI maintenance in your area?

Short answer text

27.b What role do you think the MMSD should play in GI maintenance in your area?

Short answer text

27.c What role do you think the U.S. EPA should play in GI maintenance in your area?

Short answer text

27.d What role do you think municipalities should play in GI maintenance in your area?

Short answer text

27.e What role do you think contractors should play in GI maintenance in your area?

Short answer text

28. How do you decide when to maintain your GI practice(s)? Please fill in below:

- ○ We maintain our practices at regular intervals (e.g., once per year, spring and fall, etc.).
- ○ We maintain our practices when we observe they need it.

- ○ We maintain our practices when we receive a complaint.
- ○ Not applicable.
- ○ Other...

29. Is your community part of a watershed based stormwater permit (expands beyond the boundaries of your municipality)?

- ○ Currently in one
- ○ Not in one, but would like to be
- ○ Not in one, don't think I will be
- ○ Unsure
- ○ Not Applicable

30. If there were a regional GI service center to support some aspects of GI O&M, what services would you like provided? Check all

- ☐ Training
- ☐ General maintenance (trash pick-up)
- ☐ Specialized vegetative maintenance (e.g., invasive species control)
- ☐ Specialized porous pavement maintenance (vacuum sweeping or pressure washing)
- ☐ Green roof specialized maintenance (e.g., invasive species control, infill planting, growth media
- ☐ Design review of public and private GI designs

- [ ] Periodic inspections of GI installations
- [ ] None (I don't want any regional services)

31. If you were to provide services to private property owners in your community to support aspects of GI O&M, what services would you like to provide? Check all that apply:

- [ ] Training
- [ ] General maintenance (trash pick-up)
- [ ] Specialized vegetative maintenance (invasive species control)
- [ ] Specialized porous pavement maintenance (vacuum sweeping or pressure washing)
- [ ] Green roof specialized maintenance (invasive species control, infill planting, growth media evalu
- [ ] Design review of public and private GI designs
- [ ] Periodic inspections of GI installations
- [ ] None (I don't want to provide any services)

32. Please rate the following three O&M criteria categories for relative importance:

Row 1.	Financial: The overall cost-efficiency and reliability of funding based upon the O&M model
Row 2.	Complexity: Reflects the difficulty of framework implementation from an administrative ar
Row 3.	Social/Community Impact: Considers the social and community building aspects of the va

Column 1. 1 (Least Important)

Column 2. 2

Column 3. 3

Column 4. 4

Column 5. 5 (Most Important)

33. If your community is maintaining green infrastructure (GI), about how much do they spend per year on maintenance?

- ○ Less than $1000
- ○ $1,000 - $25,000
- ○ $25,000 - $100,0000
- ○ Unsure
- ○ Not Applicable; no current expenditures on GI maintenance
- ○ Other...

34. Please describe what existing O&M tracking tools you use for stormwater or GI maintenance that you think would be useful tools

Short answer text

Regional Green Infrastructure Operations and Maintenance

QUESTIONS | RESPONSES 26

26 responses

SUMMARY | INDIVIDUAL

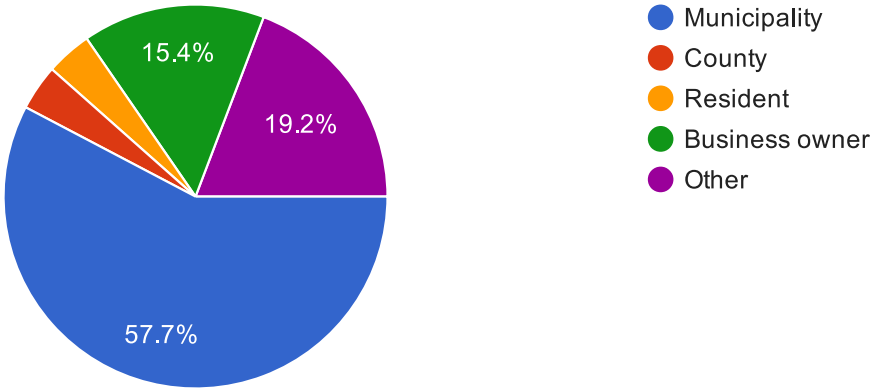
Accepting responses

1. Name/Organization: (26 responses)

Ben High
Ben High
Ben High
Steve Keith/Milwaukee County
Jeff Nettesheim/ Village of Menomonee Falls
Sue Winnen/City of Oak Creek
glen morrow- city of franklin, wi
city of West Allis

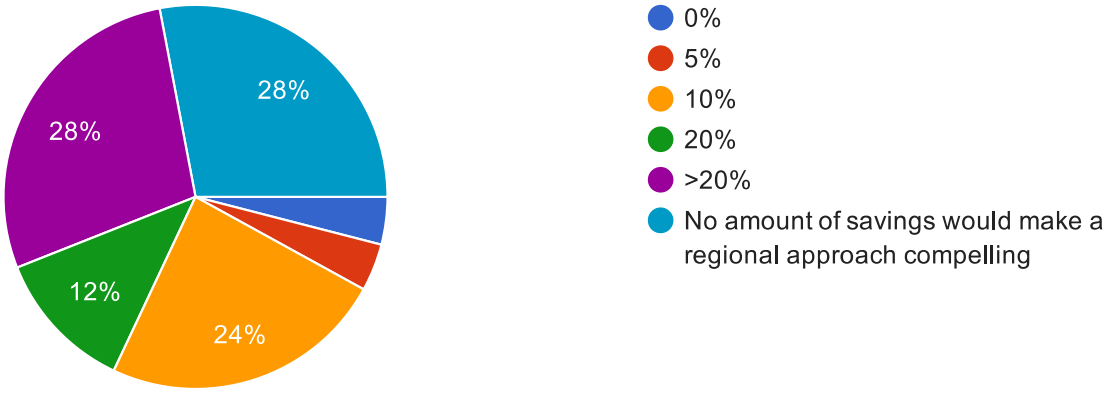
Urban Ecology Center
Andy Wiegman
Luke Gunia/Aquatics Unlimited
Erick Thompson/ Wangard Partners
James Wasley, Professor, UWM
Village of Whitefish Bay
City of Brookfield
City of Milwaukee
Jim Lindhorst City of St Francis
Kristen Lundeen/City of Mequon
Sue Vliet
Theresa Enk / Alverno College
Kate Nelson
Fix Development
Bayside
Shorewood
City of greenfield
City of Cudahy

2. Who do you represent? (26 responses)



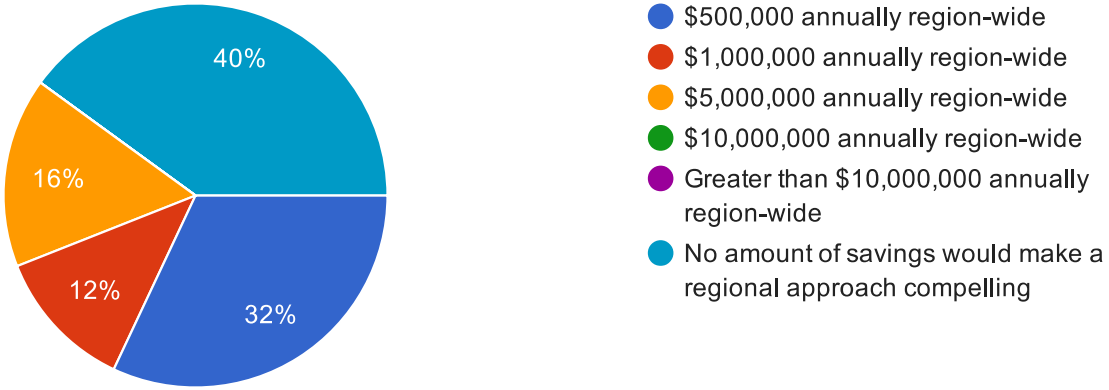
3. How much would you or your community have to save on GI maintenance for a regional (centralized) approach that takes care of your maintenance (for a fee) to be compelling?

(25 responses)



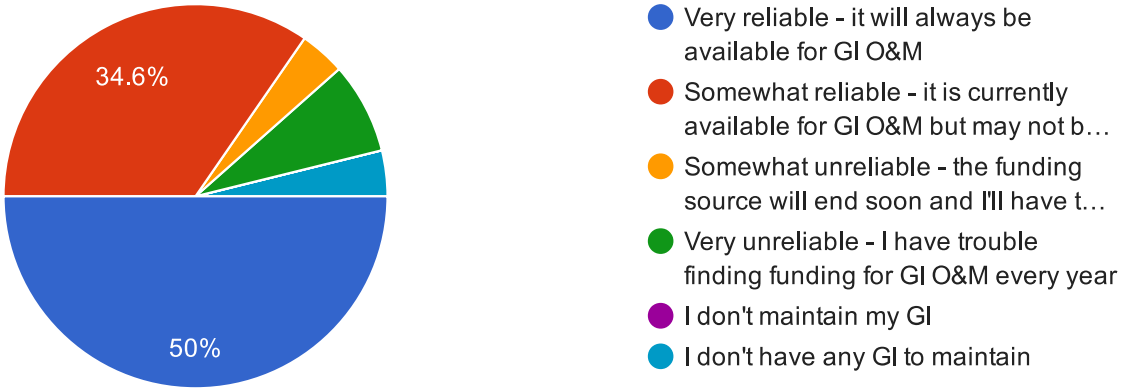
4. Is there a dollar amount in total cost savings that would make a regional (centralized) approach to take care of your GI maintenance (for a fee) more compelling to you or your community?

(25 responses)



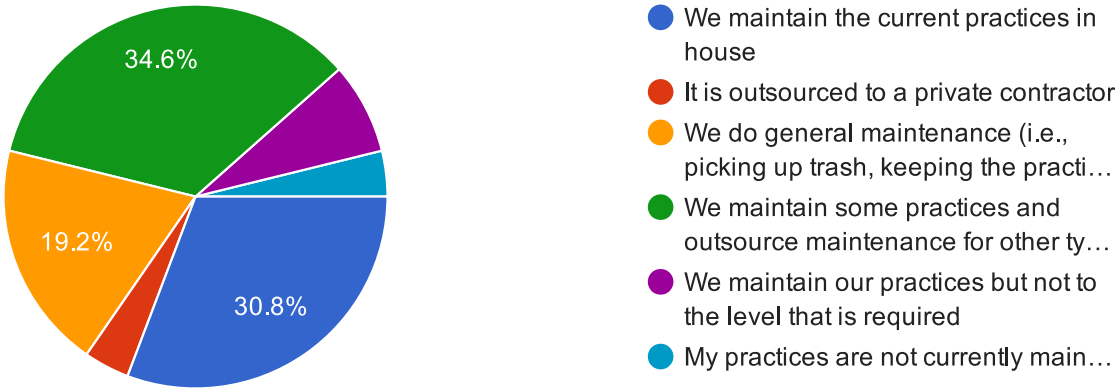
5. If you are currently maintaining the GI (or stormwater best management practices) you are responsible for, how reliable is the source of funding you are using for operations and maintenance (O&M)?

(26 responses)

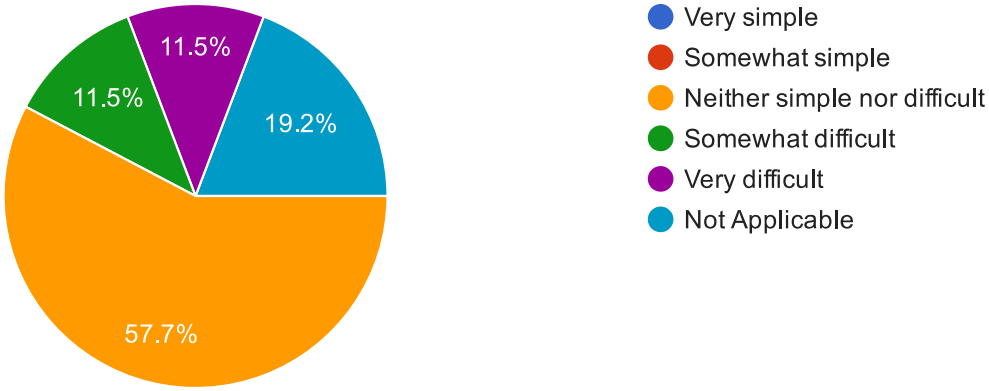


6. How is O&M occurring for the GI (or stormwater best management practices) that you are responsible for maintaining?

(26 responses)

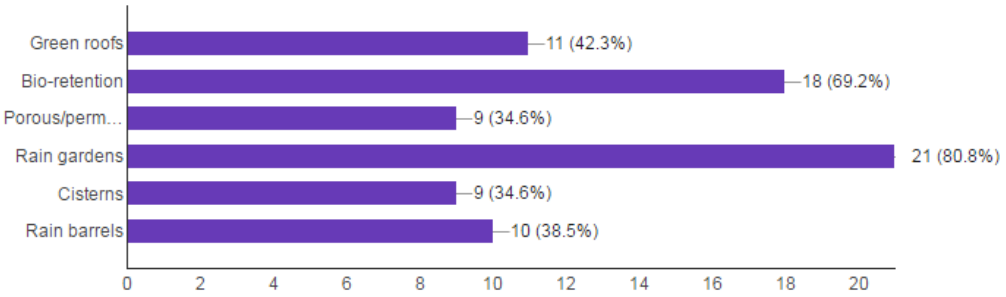


7. How difficult is it for you to procure additional funding for GI maintenance? (26 responses)



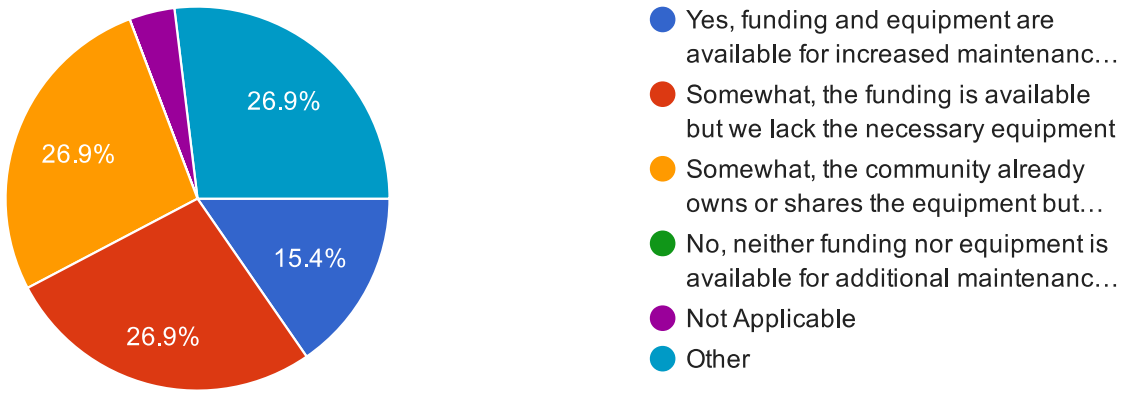
8. What GI strategies do you have the O&M equipment to maintain? Check all that apply:

(26 responses)



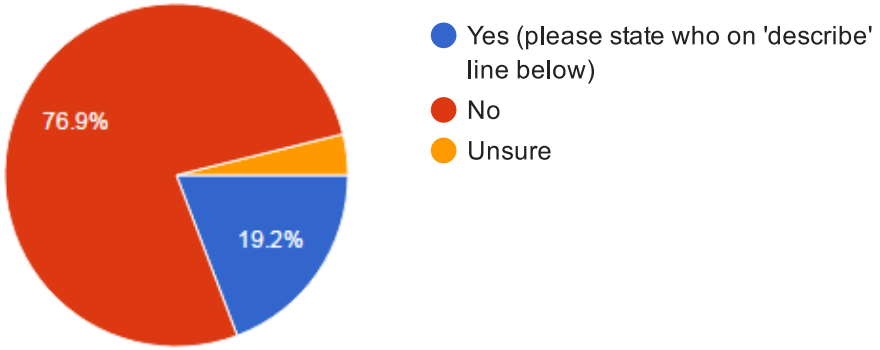
9. As more GI is implemented, does your community have the capability for maintaining additional practices?

(26 responses)



10. Does someone besides you/your community maintain the GI practices you are responsible for maintaining (e.g., a neighborhood group, a non-profit, a business improvement district)?

(26 responses)

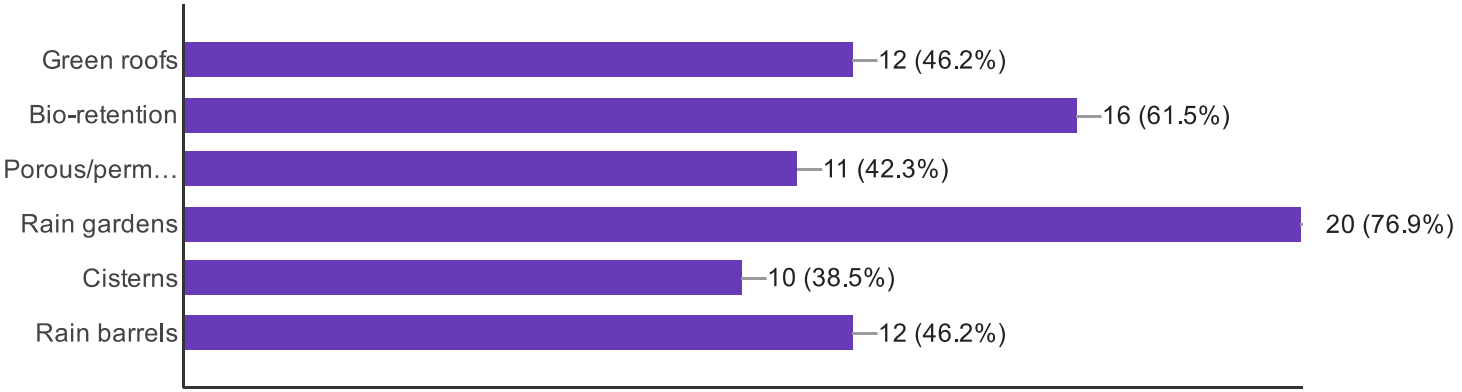


Describe: (11 responses)

na
n/a
We tried to get a BID at DTS but didn't work out and woudl be loss of control
none
N/A
We a private business
student volunteers
in 2008 we had a business group to maintain bio beds, but was not a success
Property Owners
contractor, Grounds staff & students
If GI is required per storm water requirements than the private property owner is required to sign and agreement to maintain. If they do no we retain storm water fees to do so.

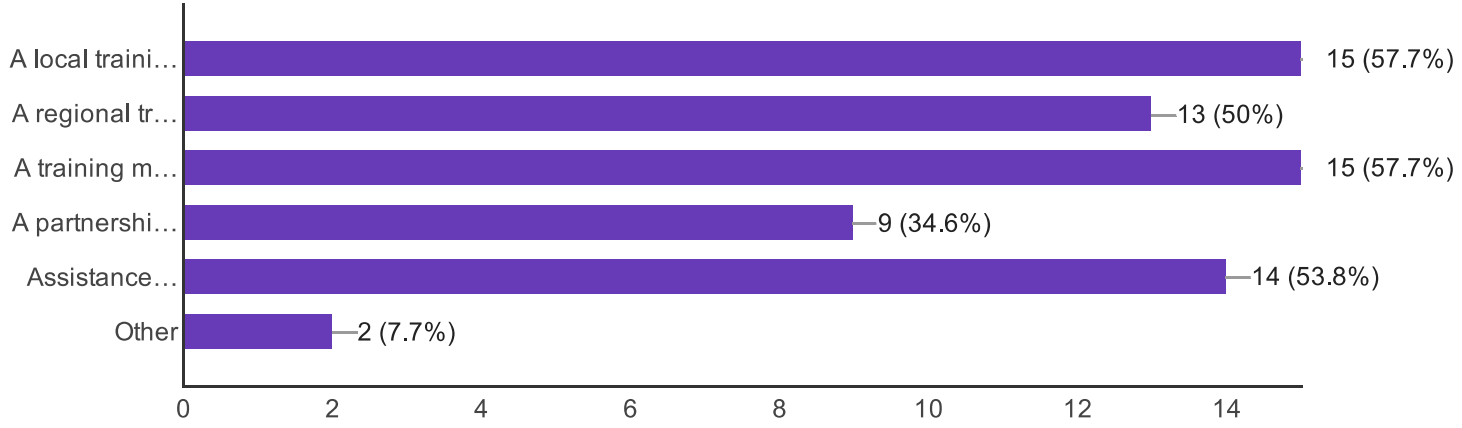
11. What types of GI do you have the skills and capabilities to maintain? Check all that apply:

(26 responses)



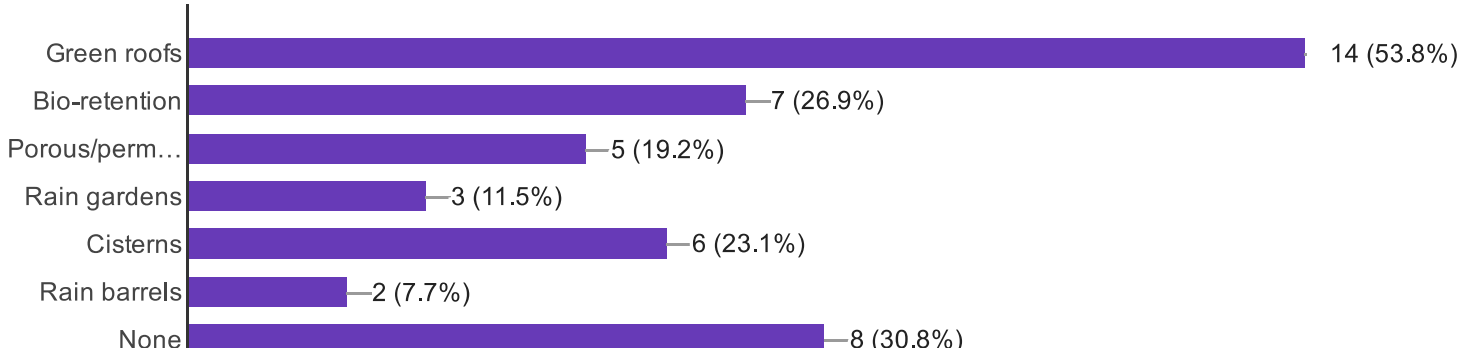
12. If you do NOT have the skills/capabilities to maintain existing GI within your authority, would any of the following be considered helpful for obtaining the necessary skills? Please select your top 3:

(26 responses)



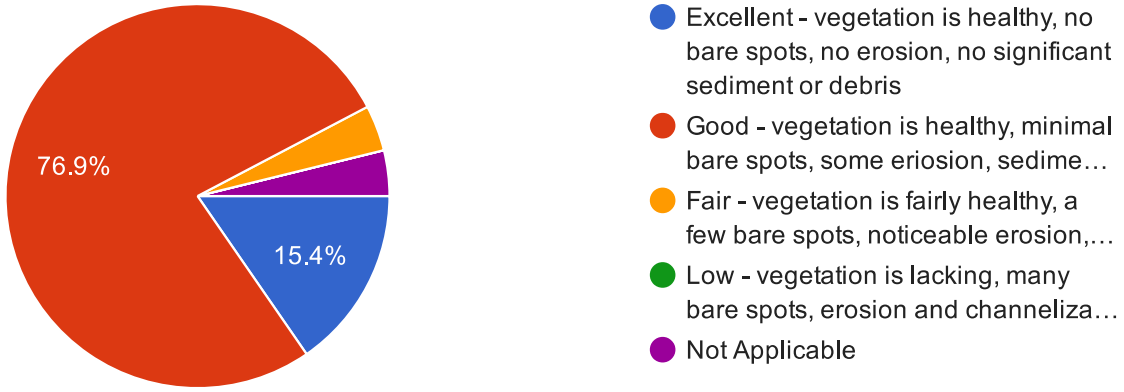
13. Is there a GI practice you would prefer to outsource for maintenance? Check all that apply:

(26 responses)



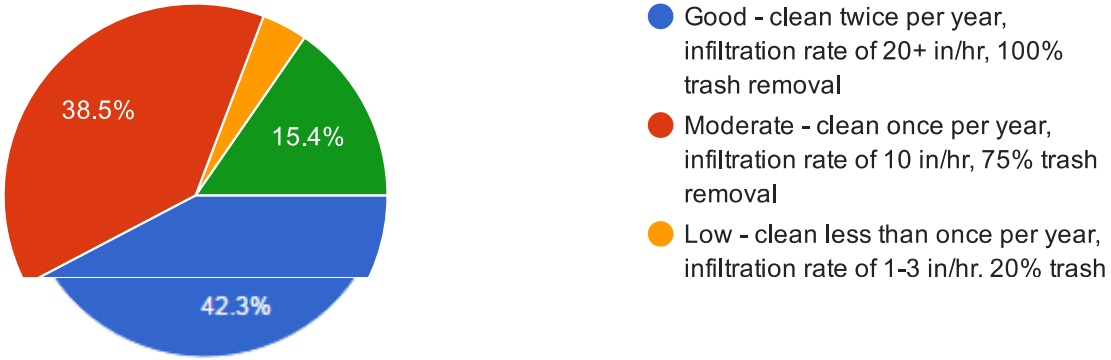
14. For vegetated GI practices (rain gardens, bio-retention, etc.) you are responsible for maintaining, what level of service do you expect and would be willing to pay for?

(26 responses)



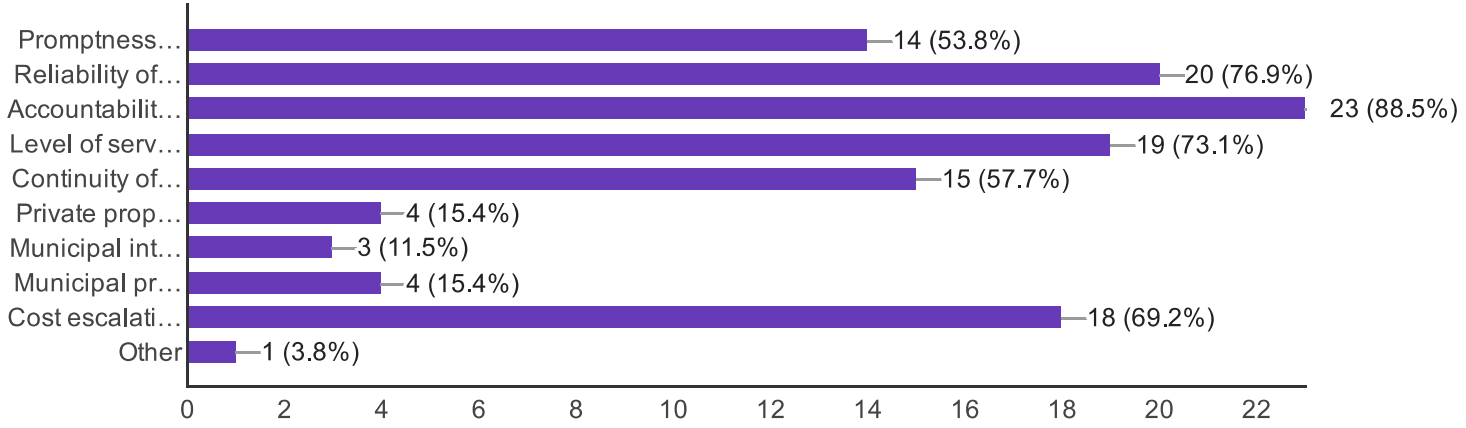
15. For GI practices you are responsible for maintaining, what level of service do you expect and would be willing to pay for, for porous pavement infrastructure practices?

(26 responses)



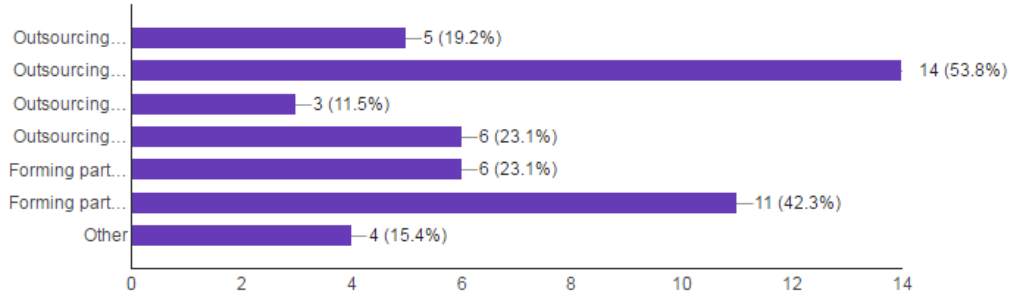
16. If someone would maintain the GI you are responsible for, what would your top concerns be? Please check up to 5.

(26 responses)



17. Would you be interested in any of the following for maintaining the GI you are responsible for? Check all that apply:

(26 responses)



18. Under what circumstances would you be willing to let another entity maintain the GI you are responsible for? Fill in below:

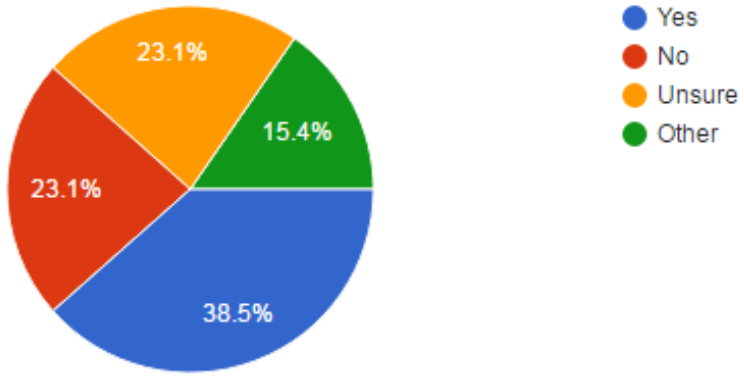
(25 responses)

If the cost of the maintenance was free.
If the cost of the maintenance was free.
MOU
When specialized knowledge or equipment is required
would depend on cost, responsiveness, and maintaining a level of local control over level of service and timely response
if something was highly specialized and requires lots of maintenance/service
If the savings was significant
Grant funding, shared responsibility
better service at a lower cost
If they can do it as well or better than we can and for less would be great
If it becomes to large for us and we needed to outsource the maintenance. If the partners were well trained, prompt and insured we would look into it.
funded.
If additional GI is used in the Village that would require specialized maintenance, i.e. cisterns or permeable pavement.

Only if there is a significant savings to the City of Brookfield and they maintain them to our standards
Meaningful cost savings and specialized equipment.
None
Extreme cost savings or state/permit mandate
If the cost for the maintenance was free.
If I was physically unable to maintain a setup, or if the tools/machines required to do so, were something I didn't , couldn't borrow need
If it was out of my control, i.e., funds, staff, risks
Specialized maintenance like green roofs and cisterns or if a partnership could be made like with the Audubon Society or UEC to bring opportunities to students.
If it was free, otherwise, not practical
with clear specifications
If the cost was less.
If they had the equipment & experience. We have this type of relationship now with other things. We trade.

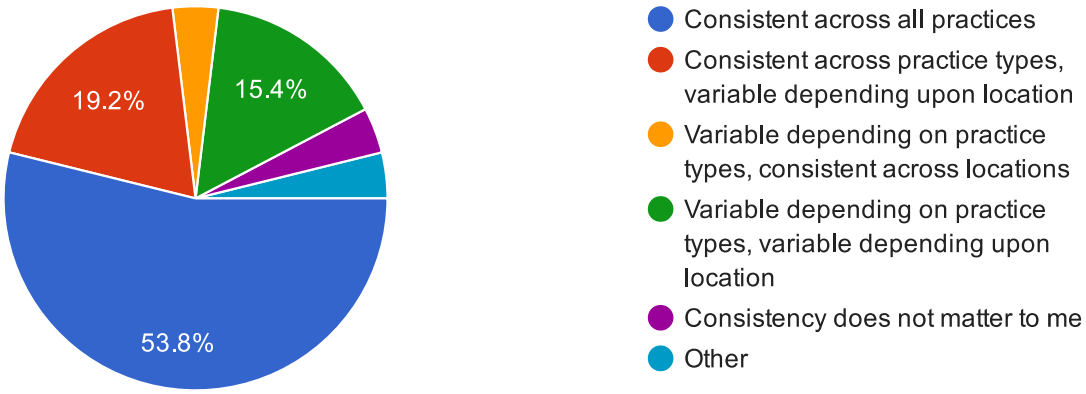
19. If you/your community maintains the GI you are responsible for, are there standards and/or regulations that govern that maintenance?

(26 responses)



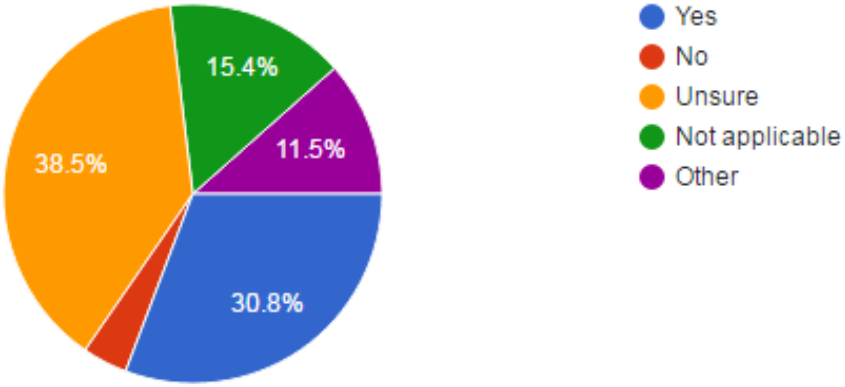
20. Is the level of service you expect (and are willing to pay for) consistent across all practices or is it variable depending upon location?

(26 responses)



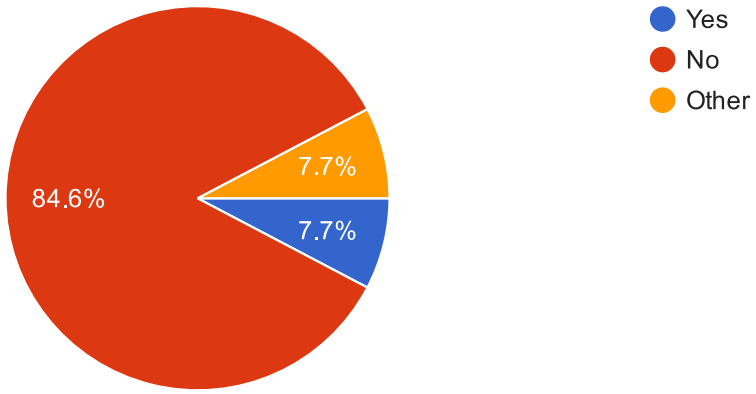
21. If you represent a municipality or county do you expect to have increased GI operations and maintenance in the future?

(26 responses)



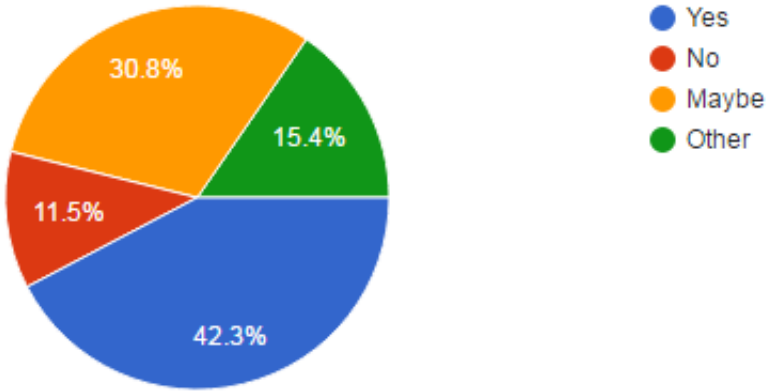
22. If you are currently maintaining your GI, are you partnering with other agencies/neighboring communities to complete the maintenance?

(26 responses)



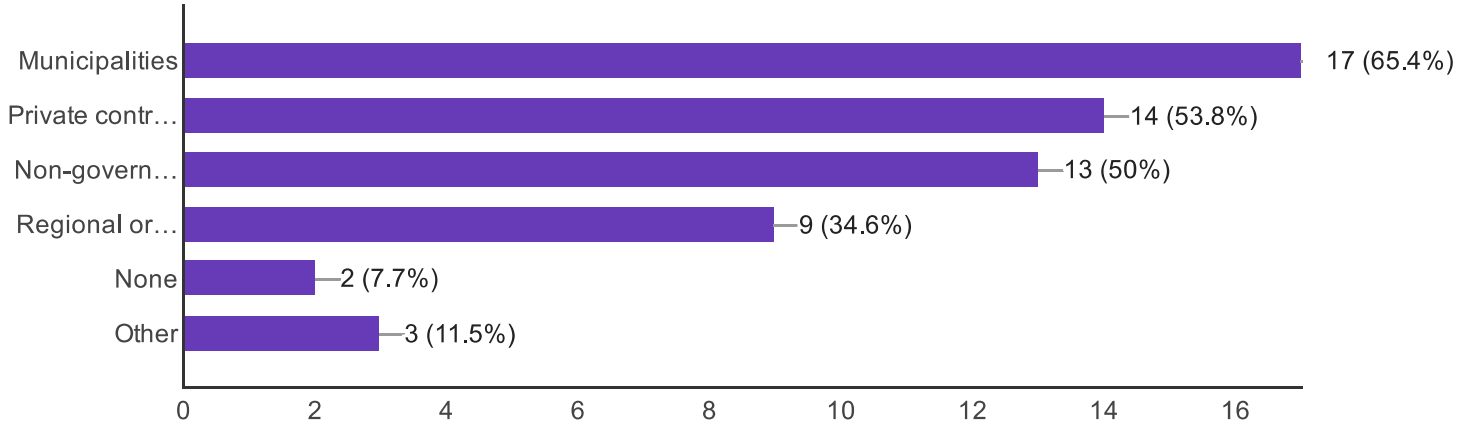
23. Would you be willing to share resources with neighboring communities/agencies/entities to maintain GI practices?

(26 responses)



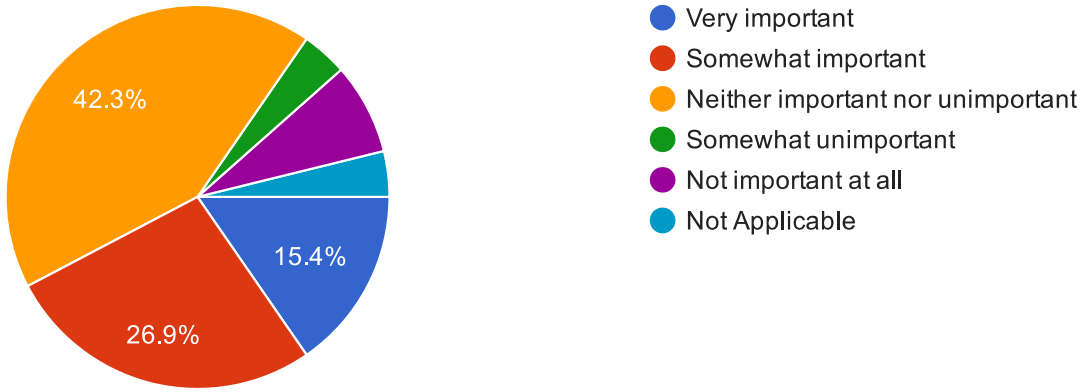
24. Are you interested in partnering with any of the following agencies/entities to better maintain the GI in your area? Check all that apply:

(26 responses)



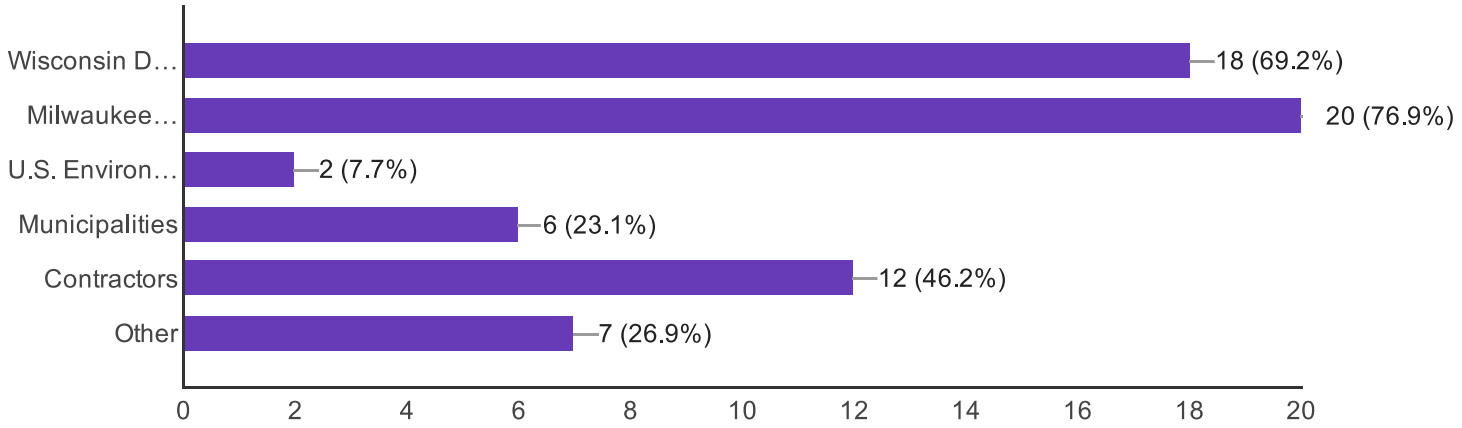
25. How important to you is collaboration between the various levels of local and regional entities for GI maintenance?

(26 responses)



26. Which sources of information do you most often use for information about GI O&M? Check all that apply:

(26 responses)



27.a What role do you think the WDNR should play in GI maintenance in your area? (23 responses)

None
None
None
None
sponsor workshops on installed project; shared experience; research on technologies
Advisory & technical stds.
Advisory. Educate contractors. Providing information and tech support is helpful. Grant funding woudl be very helpful.
typical maintenance procedures to go with the typical details that they provide

Advisory
To have oversight that purpose of various GI is being met through maintenance practices.
none
Information and best practice
none- unless a violation occurs
?
Education and implementation
Training materials / resources
create maintenance standard
Providing technical standards
an informational resource
Minimal They don't regulate in a Combined Sewer Area and they do not fund science as well as they should.
minimal
Standards
Oversight as part of the MS4 permit/Discharge permit

27.b What role do you think the MMSD should play in GI maintenance in your area? (23 responses)

None
None
None

None
sponsor pilot projects to O&M questions
Advisory, sample specs & guidelines
Minimal regulatory role. Educate contractors. Information and support is good, funding support is good, data on how this improves bigger picture for municipal residents (eg reduce floodign, reduce sewer capital costs/rates, etc) is good
ditto the DNR
Funding
Create and maintain a list of credible experts and contractors
none
Information and best practice with pictures and video
teaching and inspections
funding. leading the effort
Education and implementation
Training materials / resources
create maintenance standard/maintenance grants
Providing technical standards/funding opportunities
an informational resource
Large Role- They are a driver, funder, and well informed. The success of sewer overflow reduction depends on the success of GI, which makes them very invested.
minimal
Information and funding
none - too expensive and too much legislation. Once size does not fit all.

27.c What role do you think the U.S. EPA should play in GI maintenance in your area?

(20 responses)

None
None
None
None
None
None
Advisory
Advisory
none
none
grant funding
ditto- good guidance documents
Provide water quality goal
See a. above
none- unless a violation occures
??
Education and implementation

an informational resource
minimal
Too large of an organization to understand what works in one area doesn't in another so rules have to be state or region dependent.

27.d What role do you think municipalities should play in GI maintenance in your area?

(21 responses)

Each community should handle their own maintenance responsibilities.
Each community should handle their own maintenance responsibilities.
seek out collaborations and establish minimum requirements for maintenance
Advisory and possibly collaboration
Maintain publically owned GI, cooperate with others
maintain muni owned facilities and get annual certifications for private facilities
All GI in municipal ROW and property should be controlled by the municipality
Not sure
none
teaching, inspections, maintenance
funding
Partnering with neighboring communities
Maintain what we have in place
All Control

Assurance of compliance
Each community should handle their own maintenance responsibilities.
an informational resource
Minimal for us
responsible for maintenance of munic
NA
Since municipalities have to answer to the public and know what will work & what doesn't - the municipality takes a huge roll.

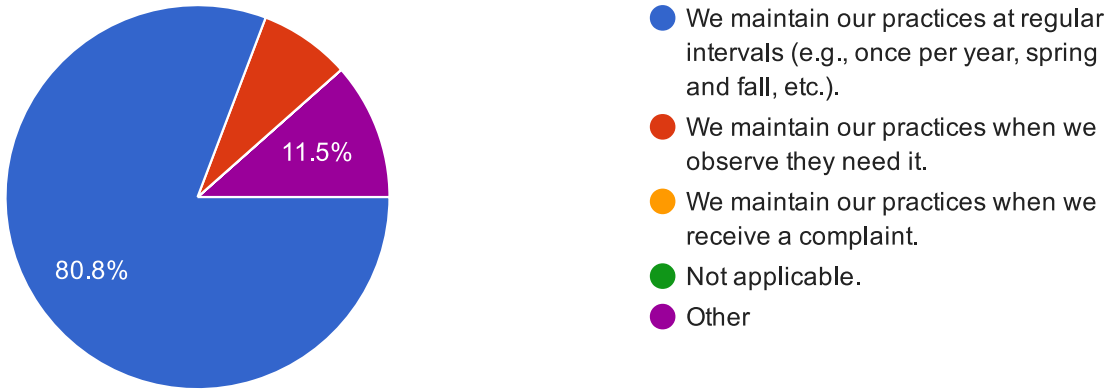
27.e What role do you think contractors should play in GI maintenance in your area?

(21 responses)

Only for specialized maintenance.
Only for specialized maintenance.
Only for specialized maintenance.
if this becomes a growth industry, dont overlook opportunity promote more DBE employment
Advisory and contracted services
educating contractors would be helpful right now only specialized contractors respect the GI or know how to install it.
offer services to private owners
Contractors should be used when cost efective
maintain GI
Great place to offer expert services to develop growth

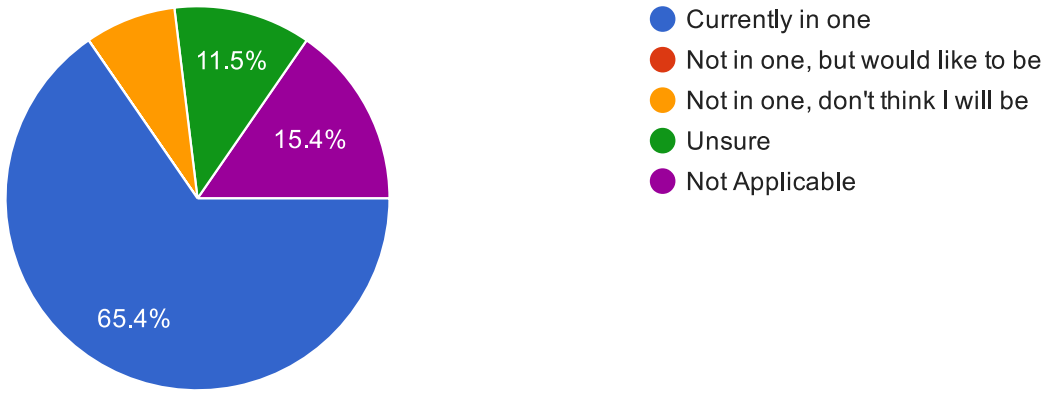
installation, inspections, maintenance
Knowledge on proper practices for maintenance of GI
Assist if hired
share experience
Could play role if needed
Compliant performance
an informational or service providing resource
When trained and under contract
contracted maintenance
NA
Like anything there is a cost benefit to using your own staff and a cost benefit to using a contractor. Contractors have to make a profit - munis don't. So municipal staff have a buy in - contractors do not.

28. How do you decide when to maintain your GI practice(s)? Please fill in below: (26 responses)



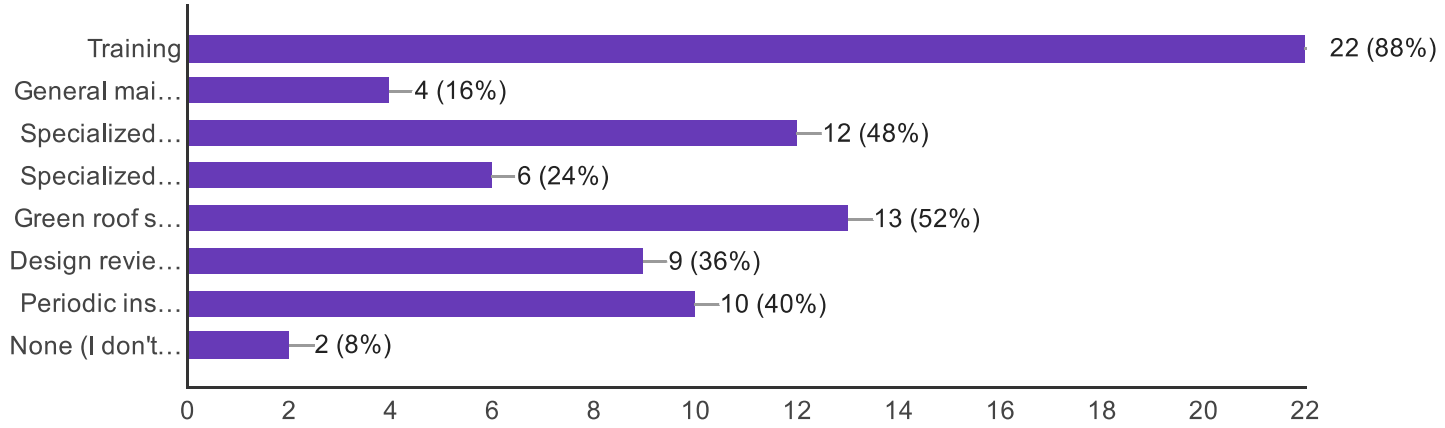
29. Is your community part of a watershed based stormwater permit (expands beyond the boundaries of your municipality)?

(26 responses)



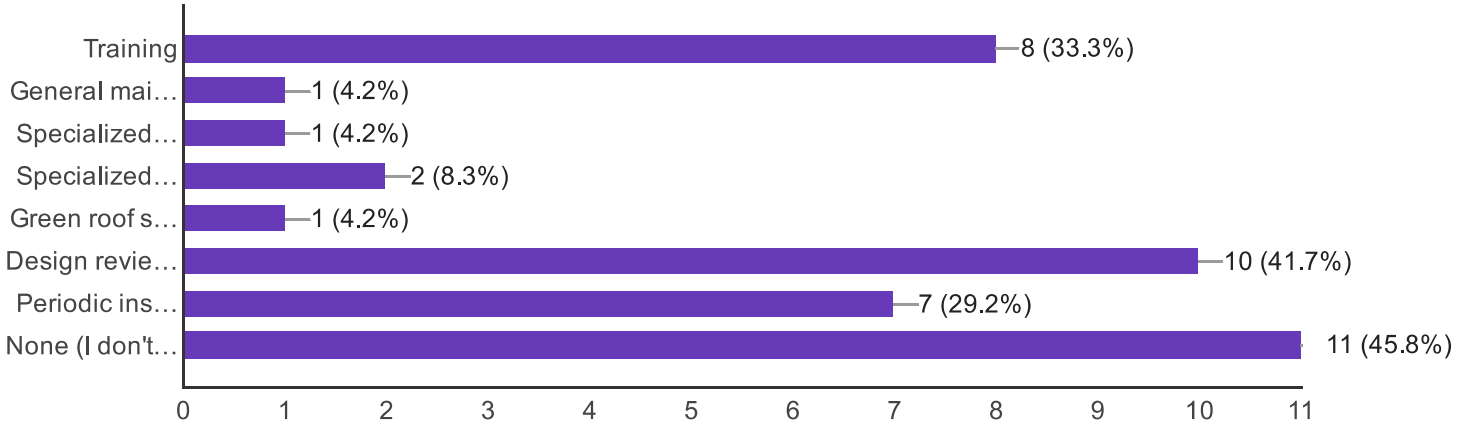
30. If there were a regional GI service center to support some aspects of GI O&M, what services would you like provided? Check all that apply:

(25 responses)

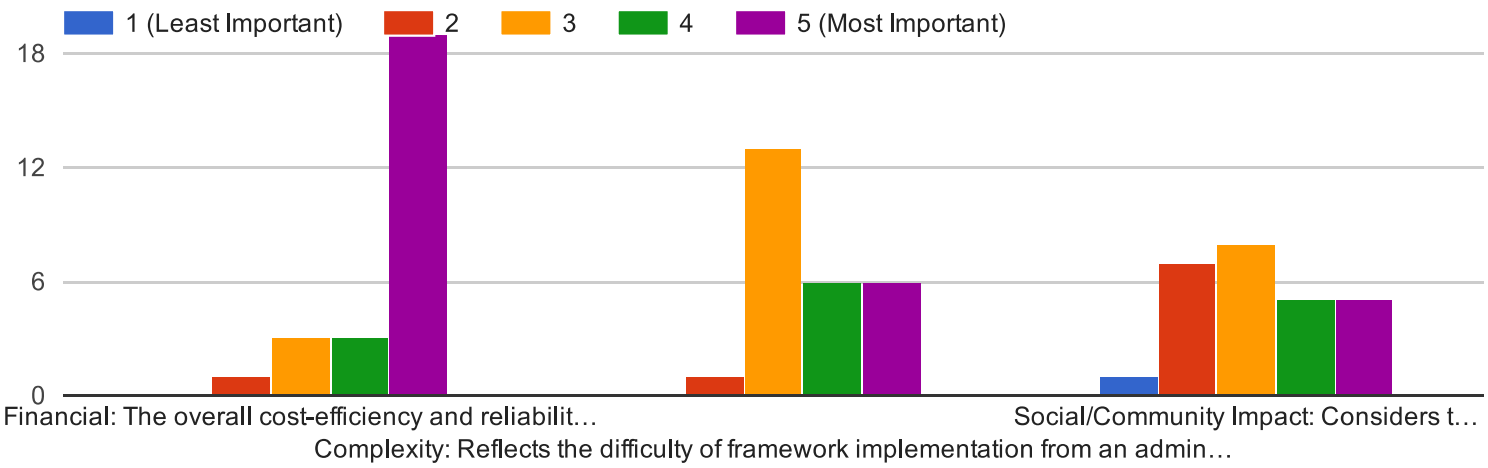


31. If you were to provide services to private property owners in your community to support aspects of GI O&M, what services would you like to provide? Check all that apply:

(24 responses)

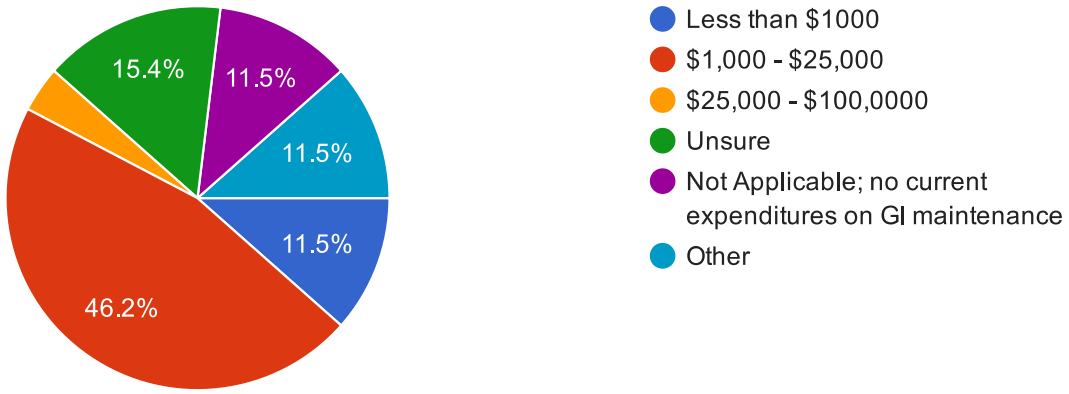


32. Please rate the following three O&M criteria categories for relative importance:



33. If your community is maintaining green infrastructure (GI), about how much do they spend per year on maintenance?

(26 responses)



34. Please describe what existing O&M tracking tools you use for stormwater or GI maintenance that you think would be useful tools for the region:

(14 responses)

CityWorks to some extent, but recent and so not fully tested
Stormwater permit system (Menomonee Falls)
GIS records for maintenance, such as catch basins cleaned, streets swept on schedule continously, etc.
self inspections as part as the development agreements, free training sessions
Annual renewal of stormwater management permits.
Templates or checklist depending on GI
Building Preventative Maintenance Schedules.
None, but if we were to track it would be done using our GIS

tracking data base including photo
None
We have a BMP certification program
I should come up with something
simple internal tracking, not likely useful
GIS and other databases

Appendix C
Decision Matrix Scoring

Appendix C Decision Matrix Scoring

Criteria Scores and Rationale Summary

This appendix documents the sub-criteria ratings used to develop the cost-benefit evaluation. This appendix provides information for each sub-criteria, including a short discussion of the rationale behind the scores, where applicable. The sub-criteria include:

- Financial Sub-criteria
  - Efficiency
  - Funding Reliability
- Implementability Sub-criteria
  - Administrative Needs
  - Training Needs
  - Stakeholder Acceptability
  - Consistent with Capabilities
  - Consistently Maintains Green Infrastructure (GI)
- Social/Community Impact Sub-criteria
  - Encourages Partnerships
  - Includes Workforce Development

Information on each of these sub-criteria follows.

Financial Criteria

Efficiency Score

Crew efficiency was determined based on the total number of crews that would be required to complete the amount of maintenance assumed for an average small, medium, and large community in the region and for each GI strategy. The ability to utilize an entire crew to complete maintenance (more likely in larger communities) will be more efficient than only partially employ a GI maintenance crew.

The number of crews were determined by GI strategy based on the acres of each GI strategy pro-rated to meet the MMSD 2035 Vision across average small, medium, and large municipality sizes. Bioretention and porous pavement were broken out into routine and specialized maintenance, assuming that the amount of time spent and training needed for the two different types of maintenance would require a different number of crews. All maintenance for green roofs was considered specialized. The quantity of GI strategy by municipal size, including private and public GI, is included in Table 5 and Table 6 of the main report. The amount of GI a maintenance crew can maintain and the resulting number of crews by municipality size are included in Tables 8 through 15. Adjustments to O&M crew quantities were made based upon efficiency adjustment factors included in Table 7. The resulting numbers are included in Table C-1.

Economies of scale occur when three or more crews are required. See *Economies of Scale – Maintenance Crews* Section in the main report for additional information. In this case, lower numbers are more efficient.

Table C-1. Crew Efficiency

Crew Efficiency for utilizing GI maintenance crews

No.	Implementation Framework	Efficiency of Maintenance Crews	Criteria Score	Rationale
1	Regional	290	10	This implementation framework realizes the highest efficiency in terms of using crews because a single entity is managing all maintenance, municipality size does not matter here because the entity managing the crews for maintenance is regional.
2	Municipal	372	5	This implementation framework would realize the least efficiency in using crews to complete maintenance because every size municipality is managing its own GI maintenance. Assumed as moderately efficient overall for scoring purposes.
3	Municipal and Private	357	6	This implementation framework is also inefficient in utilizing crews to complete maintenance, but private property owners using contractors would realize more efficiencies .
4	Regional Service Center	322	8	This implementation framework realizes some crew efficiencies where municipalities take advantage of offered services.
5	Regional Training	356	6	This implementation framework only differs from Implementation Framework 3 in who is conducting training, and realizing the same efficiencies/ inefficiencies as that implementation framework.
6	Regional Training and Specialized Maintenance	340	7	This implementation framework realizes efficiencies in utilizing crews for specialized maintenance for the region, while being less efficient than Implementation Frameworks 1 and 4 because municipalities and private property owners are still completing their own general maintenance.

Funding Reliability Score

Funding reliability is determined entirely on the number of entities that are assumed to be funding the GI operation and maintenance (O&M) in each implementation framework. The numbers of funding entities in Table C-2 are equivalent to the assumed number of entities responsible for the GI maintenance in each implementation framework. Fewer entities funding O&M is considered more reliable and therefore receives a higher score. In this case, a lower number is more reliable.

Table C-2. Funding Reliability

Number of entities funding GI O&M for each implementation framework.

No.	Implementation Framework	Number of Entities Funding O&M	Criteria Score	Rationale
1	Regional	1	10	This implementation framework has a single entity responsible for O&M for the entire region which is beneficial for funding reliability. Therefore, the implementation framework receives a score of 10.
2	Municipal	28	7	This implementation framework has every municipality in the region funding their own municipal and private property GI maintenance, which is less reliable than Implementation Framework 1 but more reliable than having thousands of private property owners responsible for funding their own maintenance.
3	Municipal and Private	4,962	1	This implementation framework is the least reliable in terms of funding since all private property owners are responsible for maintaining the GI on their property. The number of entities was determined by considering the total number of private properties by average municipality size, and assuming approximately two practices per private property owner for porous pavement and bioretention. This number was divided in half again because it was assumed half of the private property owners would outsource their maintenance. The total number of municipalities (28) plus the regional entity are also included here. Because so many entities are involved, it receives a very low score.
4	Regional Service Center	4,962	1	This implementation framework is the least reliable in terms of funding since all private property owners are responsible for maintaining the GI on their property, even if they utilize the service center. It has the same number of entities assumed as GI O&M Implementation Framework 3. Because so many entities are involved, it receives a very low score.
5	Regional Training	4,962	1	This implementation framework is the least reliable in terms of funding since all private property owners are responsible for maintaining the GI on their property. It has the same number of entities assumed as GI O&M Implementation Framework 3. Because so many entities are involved, it receives a very low score.
6	Regional Training and Specialized Maintenance	4,962	1	This implementation framework is the least reliable in terms of funding since all private property owners are responsible for general GI maintenance on their property. It has the same number of entities assumed as GI O&M Implementation Framework 3. Because so many entities are involved, it receives a very low score.

Implementability Criteria

Administrative Needs Score

The administrative needs for each implementation framework were determined by the number of entities that would be affected by the implementation framework. A municipality is affected by implementation of an implementation framework if a model would require changes in policy or administration for the municipalities and entities involved. In this case, lower is better and reflective of fewer administrative changes.

Table C-3. Administrative Needs

Number of entities affected by each implementation framework.

No.	Implementation Framework	Number of Entities Affected	Criteria Score	Rationale
1	Regional	29	1	The regional model assumes every municipality and the regional entity would all require administrative changes to implement the implementation framework effectively. This is the highest number of entities affected and therefore receives the lowest score.
2	Municipal	28	2	This implementation framework assumes every municipality would require administrative changes to implement, due to maintaining GI for private property owners. This is only 1 less entity than Implementation Framework 1, and so scores only slightly better.
3	Municipal and Private	0	10	This implementation framework assumes no change from how practices are currently maintained, and so requires no administrative changes to implement. With no entities affected by implementation, this implementation framework receives the highest score.
4	Regional Service Center	15	6	This implementation framework assumes approximately half of the municipalities in the region would use offered services from the service center, requiring administrative changes, and the regional entity itself would require administrative changes to implement.
5	Regional Training	1	8	This implementation framework assumes every entity maintains practices as they are currently maintained like Implementation Framework 3 but would require administrative changes for the regional entity in charge of training.
6	Regional Training and Specialized Maintenance	15	4	This implementation framework assumes the regional entity would require administrative changes for training and specialized maintenance, and that half of the municipalities in the region would use specialized maintenance and would therefore require administrative changes to implement the implementation framework.

Training Needs Score

The training needs sub-criteria of each implementation framework was scored by determining how many entities would be responsible for implementing a training program for any organization that would perform maintenance. In this case, a lower number is better.

Table C-4. Training Needs

Number of organizations responsible for implementing training program.

No.	Implementation Framework	Number of Organizations Operating Training	Criteria Score	Rationale
1	Regional	1	10	This implementation framework assumes a regional entity is responsible for all aspects of GI operations and maintenance, including training.
2	Municipal	28	1	This implementation framework assumes every municipality is responsible for a training program for GI maintenance within their jurisdiction.
3	Municipal and Private	28	1	This implementation framework assumes every municipality is responsible for a training program for GI maintenance within their jurisdiction.
4	Regional Service Center	1	10	This implementation framework assumes the regional entity is responsible for a single training program for the entire region, offered through the regional service center.
5	Regional Training	1	10	This implementation framework also assumes the regional entity is responsible for a single training program for the entire region.
6	Regional Training and Specialized Maintenance	1	10	Along with specialized maintenance, this implementation framework also assumes the regional entity is responsible for a single training program for the entire region.

Stakeholder Acceptability Score

The scores for this category were determined by a stakeholder survey as discussed in the report. This survey asked specific questions of municipal and private stakeholders about their preferences for GI maintenance. The survey results indicated the current method of GI maintenance is most acceptable to the stakeholders involved, while having a single regional entity responsible for all GI O&M within the region is the least acceptable to stakeholders. Based on these and other responses, the implementation framework alternatives were scored based on their assumed acceptability to stakeholders.

Table C-5. Stakeholder Acceptability

Acceptability to stakeholders based on their responses to survey questions 3, 4, 30, and 31.

No.	Implementation Framework	Acceptability According to Survey Responses	Criteria Score	Rationale
1	Regional	Least Acceptable	0	According to many stakeholders, a single regional entity in charge of all GI O&M for the region would not be acceptable. This implementation framework was deemed unacceptable to stakeholders and received a score of 0.
2	Municipal	Somewhat Acceptable	1	This implementation framework was only slightly more palatable to stakeholders, most municipalities indicated they would not want to be responsible for maintaining GI on private property within their boundaries.
3	Municipal and Private	Most Acceptable	10	This implementation framework proved to be the most acceptable model to stakeholders since it is how practices are currently maintained throughout the region.
4	Regional Service Center	Acceptable	5	As long as it is voluntary to use the services, municipalities were interested in a service center that would offer training, some maintenance, and other resources for municipalities and private property owners in the region.
5	Regional Training	More Acceptable	9	Every stakeholder who responded to the survey indicated they would like to see a regional entity provide training and certification for those wishing to maintain GI practices in the region.
6	Regional Training and Specialized Maintenance	Acceptable	5	This implementation framework was acceptable to stakeholders interested in regional training and without the capability of completing specialized maintenance on GI practices within their jurisdiction. Based on survey results, it is assumed to be the same level of acceptable as Implementation Framework 4.

Consistent with Capabilities Score

The scoring for this sub-category was determined based on the stakeholder survey results. Question 11 from the survey asked respondents to state what practices they had the capability to maintain, and based on these responses the implementation framework alternatives were given scores. In this case, more capability is better and results in a higher score.

Table C-6. Consistent with Capabilities

Implementation framework is consistent with the responsible entity's capabilities.

No.	Implementation Framework	Capability According to Survey Responses	Criteria Score	Rationale
1	Regional	Most Capable	7	This implementation framework assumes with a single regional entity responsible for GI O&M, the entity would have the ability to maintain GI well and consistently across the region.
2	Municipal	Least Capable	3	Based on survey results, many municipalities did not feel they had the ability to maintain various types of GI practices. Because of that, an implementation framework relying on municipalities for GI O&M has lower capability.
3	Municipal and Private	Least Capable	3	Based on survey results, many municipalities did not feel they had the ability to maintain various types of GI practices. Private property owners generally do not have as much training and are less prepared for GI maintenance. Because of these factors, the an implementation framework relying on municipalities and private property owners has lower capability.
4	Regional Service Center	Most Capable	8	This implementation framework was scored slightly higher than Implementation Framework 1 because a single regional entity would be responsible for O&M where municipalities and private property owners decided they were not capable. This ability to choose the most capable entity for maintenance allows for some flexibility in the implementation framework itself and also would encourage the entity most capable to be responsible for maintenance.
5	Regional Training	Capable	5	This implementation framework assumes a single entity would be responsible for the training program, meaning anyone performing maintenance would be certified and trained in a consistent manner and would be capable to perform GI maintenance.
6	Regional Training and Specialized Maintenance	Capable	5	This implementation framework has the same assumptions as Implementation Framework 5.

Consistent GI Maintenance Score

This sub-category was scored based on the number of entities required to perform GI practice maintenance. These numbers were based on the number of entities responsible for maintenance with some assumptions made for private property owners who outsource maintenance. In this case, a lower number is better.

Table C-7. Consistently Maintains Green Infrastructure
Number of entities maintaining GI strategies.

No.	Implementation Framework	Number of Entities Responsible for Maintenance	Criteria Score	Rationale
1	Regional	1	10	This implementation framework assumes a single regional entity responsible for all GI O&M throughout the region, which would encourage consistent maintenance practices.
2	Municipal	28	7	This implementation framework assumes every municipality is responsible for the maintenance in their jurisdictions, which includes private property. Because the municipalities are completing the maintenance, it would be consistent across the individual municipalities.
3	Municipal and Private	5,000	1	This implementation framework assumes the largest number of entities responsible for maintaining GI practices and therefore would encourage the least amount of consistency for maintenance. This number was determined by assuming approximately two bioretention and porous pavement practices per property owner, and taking that total throughout the region and dividing by two assuming that half the private property owners would outsource their maintenance. All municipalities were also included in this number.
4	Regional Service Center	1,269	5	This implementation framework assumes entities can choose to utilize the services of a regional entity through a service center, and so would allow for some consistency where entities choose to utilize the services but would also allow for inconsistency where entities do not use the service center. This assumes 75 percent of small municipalities and 25 percent of medium municipalities, plus half of private property owners outsource specialized and routine maintenance to a regional entity; half the remaining private property owners outsource to private contractors which maintain multiple properties.
5	Regional Training	5,000	1	This implementation framework assumes the same number of entities responsible for maintenance as Implementation Framework 3.
6	Regional Training and Specialized Maintenance	4,232	2	This implementation framework assumes a large number of entities maintaining practices throughout the region, but would be more consistent than Implementation Frameworks 3 and 5 due to a single entity completing specialized maintenance throughout the region. This implementation framework has the same number of entities responsible for maintenance as Implementation Frameworks 3 and 5, less the number of private green roof owners that require specialized maintenance and are maintained through the regional entity.

Social/Community Impact Criteria

Encourages Partnerships Score

This sub-category was scored by taking into account the number of entities involved and responsible for maintenance and the number of issues that would be involved in a given implementation framework. Essentially, it takes into account the number of entities and their willingness to collaborate on various aspects, as determined partially from number of responsible entities and partially from willingness to collaborate with neighboring communities as determined from the stakeholder survey results. In this case, a higher number is better.

Table C-8. Encourages Partnerships

Number of entities responsible and number of issues/willingness to partner with neighboring communities.

No.	Implementation Framework	Number of Entities + Number of Issues	Criteria Score	Rationale
1	Regional	1	2	This implementation framework assumes a singular entity responsible for the entire implementation of GI O&M, and does not encourage collaboration between groups.
2	Municipal	56	5	This implementation framework assumes each municipality would be required to create partnerships with private property owners and assumes some smaller neighboring communities would collaborate with each other to ensure appropriate maintenance is completed.
3	Municipal and Private	No Partnerships	2	This implementation framework encourages no partnerships, as every individual property owner and municipality is responsible for maintaining their own practices.
4	Regional Service Center	1,734	8	This implementation framework assumes the largest number of partnerships, as municipalities would collaborate with the regional entity for training and some for completing maintenance. This implementation framework encourages collaboration between the regional service center and private property owners as well. This number assumes half of the regional private property owners would outsource maintenance to a private contractor, a quarter would complete maintenance themselves, and the remaining quarter would utilize the service center.
5	Regional Training	129	5	This implementation framework encourages partnerships between organizations to complete training, but every entity is responsible for its own maintenance.
6	Regional Training and Specialized Maintenance	129	6	This implementation framework encourages partnerships not just for training like Implementation Framework 5 but also for specialized maintenance, so though the number of entities and issues is the same, the partnerships are somewhat more encouraged through the additional maintenance and so scores slightly higher than Implementation Framework 5.

Workforce Development Score

This sub-category was scored by determining the number of entities responsible for organizing training and who would be capable of creating and developing a steady workforce development program. It was assumed that smaller communities would not have the institutional capacity to create a steady and robust workforce. In this case, a lower number is better.

Table C-9. Workforce Development

Number of organizers responsible for a training program.

No.	Implementation Framework	Number of Training Organizers	Criteria Score	Rationale
1	Regional	1	8	This implementation framework assumes a single regional entity is responsible for creating a training and certification program for the entire region.
2	Municipal	16	2	This implementation framework assumes every municipality in the region is responsible for creating a training and certification program for its own maintenance needs, but that the 12 small communities would not be capable of supporting a workforce. This creates smaller individual workforces, but not robust or sustainable workforce development throughout the region.
3	Municipal and Private	16	2	This implementation framework assumes the same as Implementation Framework 2.
4	Regional Service Center	1	8	This implementation framework assumes the same as Implementation Framework 1, creating a more robust and sustainable workforce.
5	Regional Training	1	8	This implementation framework assumes the same as Implementation Framework 1, creating a more robust and sustainable workforce.
6	Regional Training and Specialized Maintenance	1	8	This implementation framework assumes the same as Implementation Framework 1, creating a more robust and sustainable workforce.

Training Needs

The project also evaluated training needs for the different GI O&M implementation framework alternatives. The project assumed some private property owners would outsource or voluntarily use a regional entity for maintenance. The project assumed private property owners conducting DIY maintenance would be required to attend GI training. These private property owner trainees greatly increase the number of people who need to be trained each year. Table C-10 estimates the number people requiring training annually to realize the MMSD 2035 Vision assuming training re-certification occurs every other year.

Estimates of the number of municipal O&M crews, the number of private property owners, and the number of private property owner maintenance contractors to determine the number of people requiring training each year. Maintenance of 50 percent of private property GI was assumed to be outsourced with the remainder of private property owners assumed to conduct their own maintenance for implementation framework alternatives where private property owners are responsible for their own maintenance. Refresher training was assumed to be required every two years. The training number represents the number of maintenance crew staff prior to adjustment by the crew efficiency factor.

Table C-10. Annual Training Estimates at Full Implementation

Number of people requiring annual training by implementation framework.

No.	Implementation Framework	Number of People Requiring Training	Rationale
1	Regional	470	Number of people requiring training directly correlates to the number of crews completing maintenance. With a single entity responsible for all maintenance, the same crews can be used throughout the region and would require re-certification/training every two years.
2	Municipal	470	Number of people requiring training directly correlates to the number of crews completing maintenance. With municipalities responsible for private property maintenance, the total number of people requiring training is consistent with the Implementation Framework 1.
3	Municipal and Private	2,795	Number of people requiring training dramatically increases due to the number of private property owners maintaining practices. It is assumed half of private property owners would outsource to private contractors, so the large number results from the half of private property owners that will maintain their own practices plus the number of private contractors that would require training as well.
4	Regional Service Center	1,810	The number of people requiring training in this model assumes a quarter of private property owners would maintain their own practices, private contractors for half of the private property practices, and the remainder would utilize the services of the service center. A number of crews used by the service center would also require training, resulting in a number less than Implementation Framework 3 but greater than Implementation Frameworks 1 and 2.
5	Regional Training	2,795	The number of people requiring training with this implementation framework is the same as Implementation Framework 3, using the same assumptions.
6	Regional Training and Specialized Maintenance	2,407	The number of people requiring training in this implementation frameowrk assumes the regional entity would employ maintenance crews for specialized maintenance, lowering the required training numbers below that of Implementation Framework 3 and 5 but having more than Implementation Framework 4 due to the number of private property owners maintaining their own practices and municipalities completing their own routine maintenance.

The report assumed a partial implementation condition of 20 percent to evaluate maintenance crew needs prior to fully realizing all of the GI anticipated with the 2035 Vision. Partial implementation will also directly influence the number of people who require training. Table C-11 provides a near-term estimate of the number of people requiring annual training at partial implementation of the 2035 Vision.

Table C-11. Annual Training Estimates at Partial (20 Percent) Implementation

Number of people requiring annual training by implementation framework.

No.	Implementation Framework	Number of People Requiring Training	Rationale
1	Regional	94	See Table C-10 for additional information.
2	Municipal	94	See Table C-10 for additional information.
3	Municipal and Private	559	See Table C-10 for additional information.
4	Regional Service Center	362	See Table C-10 for additional information.
5	Regional Training	559	See Table C-10 for additional information.
6	Regional Training and Specialized Maintenance	481	See Table C-10 for additional information.

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