Green Infrastructure in Michigan: An Integrated Assessment of Its Use, Barriers & Opportunities

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TABLE OF CONTENTS

List of Figures

List of Tables

1.0 EXECUTIVE SUMMARY

Green Infrastructure in Michigan: An Integrated Assessment of Its Use, Barriers, and Opportunities Project was conducted by Lawrence Technological University, Environmental Consulting & Technology, Inc., and Dr. Avik Basu of the University of Michigan. The project focused on developing an understanding of drivers leading to the successful implementation of green infrastructure (GI) in the state of Michigan including identifying specific challenges and highlighting key initiatives and pilot projects.

In addition to synthesizing the state of GI in Michigan, the project identified key barriers to extensive implementation of GI and strategies to overcome those barriers. This was accomplished through an extensive community engagement process that included focus groups with professional and community organizations, visioning sessions in specific communities, a stakeholder survey, and professional presentations. Overall, over one thousand community leaders, professionals, and engaged citizens across the state were engaged through this process.

Key barriers to GI implementation included conflicting codes/ordinances, cost, lack of financing, maintenance, municipal and public acceptance, lack of regional planning, and uncertainty in performance. Opportunities for removing those barriers include:

- Revising local codes and ordinances to allow for and/or promote GI and establishing funding mechanisms for both implementation and maintenance.
- Identifying and cultivating local leaders (both elected and civic) who can advocate for GI implementation.
- Determining local values (such as wildlife, habitat, aesthetics, climate resiliency, etc.) and develop GI implementation strategies that align the benefits of GI with those values.
- Establishing programs for simplified long-term monitoring and maintenance of GI.
- Developing a framework to integrate local and regional planning and policies to encourage coordination across agencies and jurisdictions.
- Conducting public education and outreach projects to assist public works professionals and citizen with understanding the role of GI in their communities.

Finally, the views and opinions expressed in this report are those of the authors and do not necessarily reflect the official policies or position of Michigan Sea Grant.

2.0 PROJECT BACKGROUND

This Integrated Assessment research project was funded by Michigan Sea Grant under a contract to Lawrence Technological University (LTU), Environmental Consulting & Technology, Inc. (ECT), and Dr. Avik Basu of the University of Michigan. The project focused on developing an understanding of drivers leading to the successful use of green infrastructure (GI) in the state of Michigan. This included highlighting key projects that are already implemented, the agencies leading them, obstacles to implementation, and the challenges that are unique to Michigan. The geographical focus is the state of Michigan, although findings presented herein have applicability elsewhere in the country and especially in the Great Lakes basin.

> ***Goals of this Project***
>
> *Overall, this project addressed the following:*
>
> - *Summarize the state of successful GI use in the state of Michigan*
> - *Summarize the opinions of stakeholders on the use of GI in the state of Michigan.*
> - *Identify, analyze and recommend means to overcome the barriers to extensive use of GI as a means of controlling stormwater management cost while improving the quality of life.*
> - *Analyze competing interests that may encourage or discourage local, state, and regional stakeholders from implementing widespread GI.*
> - *Identify the suite of management actions and local policies and initiatives — as well as relevant state and federal policies and programs — that could collectively accelerate a sustainable GI strategy for Michigan's communities.*

According to the U.S. Environmental Protection Agency, GI "uses vegetation, soils, and natural processes to manage water and create healthier urban environments." At the urban or neighborhood scale, green infrastructure refers to stormwater management systems that mimic the natural hydrologic cycle. As such, the term green stormwater infrastructure (GSI) is becoming more widely used and is perhaps a more accurate description of many efforts in Michigan. ***In the context of this research and report, there is no distinction between GI and GSI***. Used correctly, GI is an effective method to improve stormwater management efficiency, reduce flooding, and increase quality of life and safety for the surrounding community. Utilizing both natural and engineered systems, a comprehensive GI program can cleanse stormwater, conserve ecosystem functions, and provide a wide array of benefits to people and wildlife.

The current approach to stormwater management is unsustainable. The existing stormwater infrastructure for many, if not most, communities is rapidly-degrading because of past development and under-investment. At the same time, these communities are now confronting increasing regulatory requirements. In addition, while the courts have defined the municipal responsibilities, regulatory expectations and liabilities associated with drainage, flood control, and in-stream water quality, the financial implications of failing to fulfill these responsibilities/expectations make municipalities very cautious when considering "new approaches." Thus, many public works professionals have been resistance to change.

Public works professionals recognize the need substantial investment in stormwater management. Their existing drainage system is often inadequate to address flooding while reducing the available groundwater and transporting pollutants to the lakes and streams of the region. Before rebuilding and/or expanding their "gray solutions," many have looked to green infrastructure to reduce costs while reducing the negative impact of the past practices. These communities have begun using a range of natural and built systems/processes as key parts of their stormwater management programs.

GI has also begun to gain acceptance as part of climate resiliency strategies as communities and industries plan for projected increases in volume and intensity of precipitation, higher temperatures, the need for carbon mitigation, severity of droughts, etc. (Reeve & Kingston 2014). GI can retrofit into existing grey stormwater infrastructure systems and capture the first inch or two of rain. Thereby alleviating the pressure on existing stormwater systems. This is especially important when the existing infrastructure represents a combined sewer system. Broader GI applications, such as wetlands or riparian buffers can mitigate flooding associated with increased precipitation events. As an added benefit, GI also reduces the urban heat island effect which mitigates increased temperature making a community more resilient and healthier in the future (EPA 2014).

In Michigan, many public, private, and non-profit institutions have implemented GI ranging from small-scale projects, like rain barrels and rain gardens, to larger-scale projects incorporated into existing infrastructure systems. Despite its many benefits, however, implementation of GI is not common. While technical concerns are often cited, the largest challenge is funding this nontraditional approach to stormwater. Additional challenges include a lack of an all-encompassing strategic vision to address the many parameters, including:

- Competing policy frameworks;
- Competing regulatory drivers;
- Design approaches;
- Lack of goals and metrics;
- Lack of upfront capital to build GI;
- Lack of sustained funding for and understanding of how to maintain GI;
- Lack of incentives for private land owners to build GI on their property; and,
- Lack of regional-scale comprehensive analyses.

Moving forward will require a sustained financial commitment. But beyond dollars and cents, there are many additional benefits that can help communities justify this financial commitment. For GI to be more widely accepted, there is a need for a cohesive effort that better explains the natural science, social science, and policy. Natural science allows GI efforts to properly address water quality and ecosystem services issues. However, social science allows communities to integrate GI into the fabric of their community as a lifestyle choice. Most importantly, bold policy, innovative codes and sustainable funding is needed to allow GI to evolve into mainstream stormwater management.

Overall, this project addressed the following:

- Summarize the state of successful GI use in the state of Michigan.
- Identify and analyze the barriers to extensive use of GI as a means of controlling stormwater management cost while improving the quality of life.
- Analyze competing interests that may discourage local, state, and regional stakeholders from implementing widespread GI.
- Identify the suite of management actions and local policies and initiatives — as well as relevant state and federal policies and programs — that could collectively accelerate a sustainable GI strategy for Michigan's communities. These actions and policies/initiatives could include:
    - Programs that would support the implementation of long-term maintenance, monitoring, and fiscal responsibilities;
    - A framework to integrate local and regional planning and policies to encourage and coordinate jurisdiction of departments and agencies to move GI into mainstream stormwater management; and,
    - Public education, forums, and outreach projects, which would further assist public works professionals with gaining GI's acceptance with the communities they serve.

In this report, Chapter 3 presents a summary of GI, its triple-bottom-line benefits, a review of implementation barriers, and its use on public and private lands. Chapter 4 is an overview of the effective use of GI in Michigan, including an overview of regulations and ordinances that promote and/or prohibit GI and a preliminary review of some key GI opportunities. Several financing options are also discussed. Chapter 5 is focused on the broad stakeholder and community engagement that was conducted as part of this project. Chapter 6 presents the results of the statewide survey and the final integrated assessment research summary is presented in Chapter 7.

3.0 GREEN INFRASTRUCTURE: OVERVIEW, TRIPLE-BOTTOM LINE BENEFITS, BARRIERS & ITS USE ON PUBLIC-PRIVATE LANDS

This chapter identifies significant barriers to widespread implementation and some solutions for each. Our research shows that key categories include:

- The stormwater challenges of every community are unique; thus, the infrastructure solution must address those community-specific challenges.
- The costs of green infrastructure are becoming better known but the benefits remain difficult to quantify. Cost-benefit analyses of GI projects within the traditional municipal structure often fail to include non-financial benefits – particularly those thought to be the responsibility of other agencies/departments.
- Triple-Bottom Line (TBL) frameworks are used to allow socio-environmental benefit concepts to be evaluated and present them in a manner comprehensible to a wider range of decision makers and stakeholders.
- Preconceived notions of GI costs, effectiveness, and potential liabilities restrain acceptance by public works professionals and other decision makers.
- GI construction on private land – through requirements, incentives, or public investment – remains difficult. Available land (either public or private) often does not coincide with the locations prioritized in stormwater plans.
- Widespread GI implementation requires municipalities to find ways to engage private citizens to fully implement a GI vision. This can take the form of: 1) stormwater fees that incentivize GI implementation, 2) stormwater ordinances that demand capture and controlled release of peak flows while encouraging infiltration, evapotranspiration, and/or reuse, and 3) grant programs building and maintaining GI on private property.

Various communities across Michigan as well as the United States have successfully applied GI at a variety of scales, customizing it for their own needs and resources. Many recognize the advantages of capturing peak storm flows near where they fall and restraining the amount/rate of runoff. Some of the projects have been funded through grant programs. Some have resulted from progressive stormwater management ordinances. Some communities are using it to address very specific concerns, and others are making it integral to their long-term capital plans. This flexibility allows communities to implement community specific solutions that reflect their physical conditions, soil types, and levels of development.

Defining GI, Green Space, Neighborhood Landscapes, & Greening
(_Reproduced from Lichten et al 2017_)

GI refers to systems that use vegetation, soils and other natural processes to retain, detain, infiltrate or evapotranspire stormwater at its source rather than removing runoff from the site through a municipal stormwater system (EPA 2016). By this definition, GI may incorporate aspects of greening or green space, but it has a separate and distinct fundamental purpose: to manage stormwater.

Greening describes efforts to increase the amount or quality of green space in a neighborhood landscape by planting or maintaining trees, shrubs, grass or other vegetation. Vacant lot greening refers to planting and maintaining vegetation or structures (e.g., gardening beds, fences, or signs) on vacant lots.

Green space is land that is "partly or completely covered with...vegetation" (EPA 2016). While commonly given examples of urban green spaces include parks, community gardens, cemeteries, playgrounds, the term may also refer to residential yards and other vegetated areas. Green space can occur on private or public land.

Neighborhood landscape refers to all the outdoor spaces of a neighborhood that can be seen by residents. Neighborhood landscapes include streets, buildings, trees, yards, parks, and vacant lots. Green spaces and green infrastructure are part of the the neighborhood landscape.

3.1 Analyzing the Benefits of Green Infrastructure: The Triple Bottom-Line (TBL) Framework

Triple bottom line (or otherwise noted as TBL or 3BL) is an accounting framework with three parts: social, environmental (or ecological) and financial. Many organizations have adopted the TBL framework to evaluate their performance in a broader perspective to create greater business value. This is now also frequently used in the context of individual or a set of projects as they allow a broader definition of a project's gains into public consciousness by introducing full cost accounting.

The Center for Neighborhood Technology (CNT) and American River's produced a guide laying many of the different types environmental, economic and social benefits of GI and scenarios of how to quantify the benefit through different measurements (CNT 2010). Environmental benefits are related to improve water and air quality through the distributed use of projects which manage stormwater in a manner that is can be cheaper to construct and maintain than traditional hard engineering projects (Foster 2011, Sinha et al 2017). Additionally, GI captures and/or manages pollutants and contaminants that pass through traditional, gray-infrastructure-reliant systems (Odefey et al 2012) that can cause downstream water quality problems like algae blooms. Economic benefits are focused upon financial gains (or losses) due to a project that could include local job gains, an increase in property values after installation of GI (Madison 2013), energy savings, air quality (Barwise and Kumar 2020, Hewitt et al 2019), etc. Finally, social benefits rely on societal benefits that could include crime per capita, life expectancy, increased through recreation opportunities, sense of place and neighborhood beautification, etc. (CNT 2010, Clements & St. Juliana 2013, Chan and Hopkins 2017, Coutts and Hahn 2015). These benefits have also been described as "co-benefits" to a community such as beautifying neighborhoods, cooling and cleansing the air, reducing asthma and heat-related illnesses, lowering heating and cooling energy costs, and creating "green-collar" jobs.

The universe of metrics that form the basis of the TBL analyses, is shown in Table 3-1 (Slaper and Hall 2011). Note that in the context of GI, only a subset of the metrics shown in Table 3-1 are quantifiable and relevant to green infrastructure. They include job growth, sulfur dioxide and nitrogen oxide concentrations, selected priority pollutants, excessive nutrients, change in land use/cover, unemployment rate, violent crimes per capita, health adjusted life expectance, etc.

Among the earliest examples of the use of TBL framework includes an assessment of Philadelphia Water Department's sewer control measures indicated that in addition to financial benefits, the distributed GI approach provides a wide array of important environmental and social benefits to the community (Stratus 2009). This report clearly showed that these benefits are not generally provided by more traditional "gray" alternatives (Stratus 2009). Another high-profile example is the TBL Analysis completed for New York City (Jones et al 2017) who developed a GI co-benefits calculator for the city. Key benefits include carbon sequestration, reduction of the heat island effect, and ecosystem services.

In Michigan, Ann Arbor provides an example of the application of TBL framework as detailed in an ECONorthwest report (2011). Their analysis showed that the Ann Arbor GI projects have very significant value-add to the community. At the time the report was published, Ann Arbor had yet to perform long-term visioning of GI use, which forced ECONorthwest's analyses to rely only on the existing projects. A summary of Ann Arbor GI projects is outlined in Table 3-2, and a summary of their TBL benefits are presented in Table 3-3.

Table 3-1: The universe of metrics that can be used to quantify TBL benefits

(Slaper and Hall 2011, http://www.ibrc.indiana.edu/ibr/2011/spring/article2.html)

Economic Measures	Environmental Measures	Social Measures
Personal Income	Sulfur dioxide concentration	Unemployment rate
Cost of underemployment	Concentration of nitrogen oxides	Female labor force participation rate
Establishment churn	Selected priority pollutants	Median household income
Establishment sizes	Excessive nutrients	Relative poverty
Job growth	Fossil fuel consumption	Percentage of population with a post-secondary degree or certificate
Employment distribution by sector	Solid waste management	Average commute time
Percentage of firms in each sector	Hazardous waste management	Violent crimes per capita
Revenue by sector contributing to gross state product	Change in land use/land cover	Health-adjusted life expectancy

Table 3-2: Summary existing and potential GI projects in the city of Ann Arbor

(ECONorthwest 2011)

Project	Description	Stormwater runoff reduction (gallons per year)
Sylvan Avenue	Permeable pavement	0.2-0.7 million
Easy Street	Permeable pavement Bioswales	3.3-13.3 million
Mary Beth Doyle Park	12 acres of wetlands	1.5 billion
Rain Gardens	50 rain gardens	0.9 million

Table 3-3: Summary of benefits from existing and potential GI projects in the City of Ann Arbor (ECONorthwest 2011)

Economic Measure	Existing ($/year)	Potential (50-year NPV)
Value of avoided infrastructure costs	$2.0 million-$7.0 million	$53.2-$184.6 million
Reduced flooding	Not Quantified	Not Quantified
Total value of improved air quality from emissions reductions	$17,000-$18,000	$0.5 million
Total value of reduced carbon emissions	$10,300-$54,000	$0.3-$2.4 million
Heat island effect	Not Quantified	Not Quantified
Community livability	Not Quantified	Not Quantified
Value derived from wetland habitat	$48,000	$1.3 million
Public education benefits	Not Quantified	Not Quantified
Total	**$2.0-$7.0 million**	**$55.3-$187 million**

Overall, TBL frameworks allow abstract concepts to be evaluated in a way that makes them comprehensible to the wide range of decision makers and stakeholders needed to initiate the types of policies and/or ordinances needed to implement large scale GI. The analysis allows communities to make more informed choices about GI in providing a sustainable future. This is increasingly important as more communities focus on climate resiliency and the role of GI in adapting to future climatic extremes (Demuzere et al 2014, Foster et all 2011, and CNT 2010).

3.2 Challenges and Barriers to the Use of Green Infrastructure in Michigan

Adoption of GI has not been universal, and even in the regions it has been used, it is mostly sporadic. When grants have been available, most municipalities have accepted the occasional project. However, when GI projects are competing for local capital and/or O&M funds, public officials have been reticent to proceed. Key challenges associated with adoption and implementation of GI are summarized and presented below (also see WEF 2011, Kramer 2014, and EPA 2017).

3.2.1 Perception that Performance and Value is Unknown

Although they have been around for several decades, GI practices are still often perceived as emerging technologies with a limited track record and the value added to the community/property after their installation is often not understood.

This perception is due in part to the difficulty of measuring the value of GI. This difficulty stems from different challenges that include the following aspect of GI:

- Diverse range of GI types and applications making it difficult to streamline a single value for each type of application;
- Location and situational dependent performance value for each application; and
- Other performance values that are indirectly tied to benefits from GI such as positive effects on human health (see Oregon Health and Outdoors Initiative 2018).

While these are significant challenges, they have inspired many efforts to produce methods to determine the value of green infrastructure such as the Cost-Benefit Matrix developed by Green Roofs for Healthy Communities (Peck & Javet 2015) and the aforementioned Triple Bottom Line tools that have been developed. These efforts also help to address the misperception that measuring performance of GI has been done and is possible. Still, many local government officials remain skeptical of GI performance and prefer to rely on familiar pipe-and-pond approaches. Some municipalities perceive GI as untested in their location, with their soils and climate. Unfortunately, there are examples of poorly designed, poorly constructed and poorly maintained GI projects that have not performed well. However, when properly designed, constructed and maintained, GI has been proven to be cost effective and sustainable while also delivering the additional benefits detailed in the TBL analysis.

3.2.2 Programmatic & Budgeting Challenges

Municipalities are under financial pressure and the list of needed projects is long. Drainage systems, being poorly defined in the municipal budget, are under even more financial pressure. Thus, before initiating a GI capital program, a public works professional must decide which capital project must be further delayed.

Many capital plans are tied to a community specific Capital Improvement Plan (CIP) often tied to a bond. Changing these long-term programs are difficult. These programs focus on large projects such as large collection systems and/or widespread drainage improvements. Retargeting these budgets to allow integration of GI can be complicated. However, the EPA developed a guide for local government officials and municipal program leaders to into work they are doing already in public spaces in an effort to demonstrate ways that projects can be modified to incorporate GI at a relatively low cost (Frey, et al 2015). Communities must also prioritize their capital investments to areas of most need – e.g. failing infrastructure and/or flood abatement. This often precludes investment in lower cost, longer term solution made on a watershed-scale basis. The result is a capital plan that relies on traditional solutions as opposed to utilizing GI to maximize the impact of stormwater management within their communities.

3.2.3 Procurement/Funding/Cost Structure of Implementing Green Infrastructure

Communities have a high comfort level with traditional engineered solutions, their funding mechanisms are well understood, and the procurement process is well established. On the other hand, GI has a different cost structure with lower upfront capital (often on private property) with continuing operation and maintenance costs that may or may not be present in traditional gray systems. In addition, many municipal procurement systems can not recognize the long-term cost savings through GI life-cycle costs.

Funding for green infrastructure can come from many different avenues including taxes and general funds, grants, bonds, municipal state revolving funds, public-private partnerships and/or a stormwater utility. Securing a local funding mechanism (stormwater utility, etc.) that can secure long term support of GI in a community can be one of the greatest assets for success of GI in a community (Hall 2010).

3.2.4 Perception of Higher Costs

Public Works professionals prefer to build what they perceive as durable over the long-term even if it is expensive. This capital-intensive approach works against lower cost programs that have additional maintenance requirements. Many municipalities are reluctant to integrate GI into their capital projects or policies because they suspect that it will cost more than gray infrastructure in the short and/or long term, and the risk of spending public dollars on a (perceived) unknown method that may not perform as well is more risk than they are willing to undertake.

3.2.5 Perception of Resistance within Regulatory Community

For many parts of various regulatory agencies, the permitting process targets individual entities and promotes solutions that have long, proven track records and widespread acceptance that were developed for drainage "improvements" and flood control. Use of GI as a control technology is relatively new for some of these applications (Philadelphia 2011). However, institutional support is building for GI within the regulatory sphere as this perception has proven to be largely inaccurate. The challenge now is to integrate green infrastructure into permit compliance requirements that goes beyond the public works departments (that hold the permit) into other entities that manage and control much of the drainage system (roads, schools, private property). By using a diverse set of policies across different regulatory scales (regional, watershed wide, neighborhood and the individual site) communities can fully integrate green infrastructure into the fabric of the built environment (Hall 2010).

Key Barriers to GI

- *Perception that performance is unknown*
- *Programmatic and budgeting challenges*
- *Funding/cost structure of implementing GI*
- *Perception of higher costs*
- *Perception of resistance within regulatory community*
- *Perception of resistance among municipal staff, local leaders, and practitioners*
- *Perception of design and construction hurdles*
- *Unfamiliarity with maintenance requirements and costs*
- *Perception of conflict with principles of smart growth*
- *Conflicting codes and ordinances*
- *Lack of staff capacity and resources*
- *Challenges from developers*

3.2.6 Perception of Resistance Among Municipal Staff, Local Leaders & Practitioners

In Home Rule states, like Michigan, most of the site-specific decision making is made at the local level. As a result, change to long-standing practices is difficult. Planning Commissions can strongly influence what can and cannot be done on private property have little hydrologic background which is further complicated by the rapid turnover experienced in most commissions. Widespread GI adoption can sometimes be heavily hampered by lack of familiarity among decision makers within many communities. Municipal entities at all levels need to be exposed to timely, relevant information that allows them to gain sufficient knowledge to facilitate decision-making processes that reflect the current state-of-the-art rather than past practices and promote the incremental policy adoption that leads to fuller and more widespread adoption of GI over time in their communities (Hall 2010). It has also been found that decisions, policies, projects that can easily result in buildout of GI is a great way to build confidence in continued implementation of GI (Hall 2010).

3.2.7 Perception of Design & Construction

There are also many misconceptions of GI performance by the residents that live in proximity to GI installations. Many fear mosquitos, rodents, odors and other nuisances that are not associated with well-designed green infrastructure. Designing GI goes beyond incorporating site-specific conditions and must include citizen input to produce effective treatment installations that also enhance community placemaking. Standardized documents for design/implementation (local examples include manuals published by SEMCOG (2008), Credit Valley Conservation (2012), DWSD (2018)) and guidance materials for practitioners is a good first step but it does not replace consistent, open communication with affected residents.

There are many GI and LID design and construction manuals available to address issues of proper sizing, location assessment, etc. (SEMCOG 2008, Credit Valley Conservation 2012, DWSD 2018, etc.).

3.2.8 Unfamiliarity with Maintenance Requirements & Costs

GI that is not maintained becomes a nuisance, an eye-sore, and in many cases, ceases to perform. Organizations that don't have experience with GI often are unfamiliar with the processes for maintaining the infrastructure. Poorly maintained GI practices subsequently make it more difficult to implement new GI. The Neighborhood, Environment, and Water Research Collaborations for GI (NEW-GI) compiled a report analyzing five cities in the United States that broke down their approaches to sustainable maintenance practices for GI and made them available in table form for as a reference for other municipalities (Dewar, M., et al 2018). It is worth noting that all forms of infrastructure require maintenance, and maintenance personnel can be educated on the proper care of GI.

3.2.9 Perception of Conflict with Principles of Smart Growth

Many planners believe that the focused development of smart growth is incompatible with the perceived need for large areas of open space to manage stormwater onsite. However, technology has been developed to allow stormwater management as well as tradition land uses. Many control technologies work hand-in-hand with development and integrate seamlessly with the urban landscape.

3.2.10 Conflicting Codes & Ordinances

Codes and ordinances in many communities were designed to rapidly drain land for development, provide parking for all events, and reduce local flooding. The result is a system relies heavily on underground, gray infrastructure. These ordinances lead to unintended impediments to implementing green infrastructure. Wisconsin Sea Grant developed a local codes and ordinances audit workbook developed a workbook that will help communities review, revise and prioritize their local codes and ordinances to promote and advance green infrastructure implementation (Noordyk 2017). A few examples of codes/ordinances that encourage hard surfaces and discourage infiltration include:

- Zoning density standards
- Storm sewer connection requirements
- Minimum parking and road widths
- Raised parking lot islands
- Required turf-grass and unclear "weed" ordinances

3.2.11 Lack of Staff Capacity & Resources

Many municipalities cite lack of resources as one of the most common and significant barriers to implementing stormwater improvements of any kind let alone GI. Large scale implementation of GI will require staff and funding for updating development codes; educating builders, developers, and the public; and inspecting and maintaining stormwater facilities.

3.2.12 Challenges from Developers

While many progressive developers have embraced GI, there remain developers that are unaware of the potential for cost savings from GI projects. Even when developers are aware of the potential for cost savings, some find it impossible to reconcile GI approaches with other codes and standards. Accordingly, many municipalities are crafting ways to educate the developers to allay these concerns.

Identifying these hurdles is the first step to providing effective roadmaps and strategies to increase adoption of GI among Michigan communities. Many communities would benefit from better documentation of GI's benefits and how their communities' codes and ordinances may be inhibiting the use of new stormwater technologies. Finally, explicit endorsement of "green" solutions by state and national-level regulatory agencies could address some of the most pressing concerns about implementation of green stormwater technologies.

3.3 Contrasting the Use of Green Infrastructure on Public versus Private Land in Michigan Communities

Capturing and treating rainwater where it lands reduces the need for large, costly collection systems. However, most of the land is privately owned. If every private property owner does their share of stormwater control, the need for large public facilities is reduced. But drainage facilities -both green and gray – will always be needed to protect the health, safety, and welfare of the public. To provide cost effective publicly owned GI requires sufficient land close to the area that has generated the runoff to recognize scaling efficiencies. This presents a problem for cities that have depended on centralized collection networks. In addition, much of the urban areas are encumbered physically by previously-developed land, construction, or by legal structures (such as right-of-ways, easements, or ordinance restrictions) making it difficult for communities to effectively access and modify land area needed for GI implementation. To solve this, communities have turned to two methods: repurposing public areas to serve as stormwater control structures, and engaging private parties to install large scale green infrastructure on private properties which generate stormwater capture/treatment for other developed properties in exchange for a fee or credit. By combining coordinated public plans with frameworks encouraging private efforts, communities can expedite the creation of distributed, effective stormwater management systems.

<u>3.3.1 Green Infrastructure in Public Spaces: Repurposing Parks & Roadways</u>

Public spaces are attractive locations for GI because of their ubiquity. Communities are beginning to recognize their parks' potential as stormwater infrastructure and have begun to integrate them into their long-range master plans. For example, the Green Grand Rapids master plan included updating Joe Taylor Park (see Figure 3-1) as a large GI area complete with rain gardens and below-surface stormwater storage capable of holding and filtering up to 270,000 gallons of stormwater. The master plan sketch of the park illustrated both how the green space was to be used to provide recreation and how GI integrated effectively into a densely developed urban setting, helping drain more than 40 acres of paved surfaces. The construction of this park and its integrated GI was completed in 2010.

Land Use in the City of Detroit: Opportunities & Challenges

A home once to more than 2 million people, Detroit is an enormous city of 139 square miles. As its residents frequently like to quote, that land area is larger than the combines areas of Boston, Manhattan, and San Francisco. Of course, with less than 700,000 current residents and large abandoned areas, nearly 40 square miles are considered open space. The city has chosen to concentrate its investments in nodes of strength and repurpose its underutilized land in order to survive, stabilize and grow.

The land-use patterns of Detroit are clearly forming into areas of concentrated assets surrounded by areas of very low density – a form of urban stew. Many urban planners have proposed that Detroit capitalize on this pattern to create a more intentional and guided framework based on "urban villages" – built-up clusters or nodes of activity separated by green space, forested land and other low-density uses.

Overall, Detroit presents a very exciting opportunity for the use of GI on a large-scale. Key themes currently pushed by the city include the following:

1. *Restore of urban ecology*
2. *Re-use of vacant properties through greening and arts*
3. *Pursue urban agriculture*

In addition to parks, city-owned roadways and streets can also serve a similar function. These "green streets" employ a variety of processes to help intercept stormwater before it ever enters storm sewer systems. The Southeast Michigan Council of Governments (SEMCOG) compiled examples of road projects using green infrastructure into the "Great Lakes Green Streets Guidebook." This guidebook highlights several Michigan green streets projects (SEMCOG 2013). The Chicago Department of Transportation (CDOT) implemented a "Green Alleys" program to manage urban flooding and runoff. Older alleyways were

Figure 3-1: A repurposed schematic of Joe Taylor Park in Grand Rapids
(http://grcity.us/design-and-development-services/Planning-Department/Documents/GGR_REPORT_3_1_12_low%20rz.pdf)

typically not connected to the storm-sewer system so CDOT retrofits these alleyways to serve as infiltration corridors for stormwater runoff instead of constructing costly connections to the existing storm-sewer system, assisting with groundwater recharge and a reduction in urban flooding (CDOT 2007).

3.3.2 Green Infrastructure on Private Land: Working with Private Parties

Strategic installation of GI on privately-owned land is a key aspect of meeting a community's goals (NRDC 2013). First, in most urban areas, most of the land is owned by private parties. Secondly, in cities with ambitious stormwater control programs relying on GI installations, public lands alone are simply insufficient, and the widespread implementation of GI will require participation from private property owners (NRDC 2013). For example, Milwaukee Metropolitan Sewerage District's regional GI vision requires 42,000 total acres of GI to be installed by 2035. An analysis of its service area shows that nearly 70 percent of the land is privately owned. Accordingly, installation of GI on private land is required for MMSD to meet its 2035 regional vision (MMSD 2014).

Incentivizing private infrastructure installation requires a framework that: 1) requires stormwater capture, 2) limits the rate at which runoff leaves the site, and 3) encourages infiltration, evapotranspiration, and reuse. Michigan's Washtenaw County stormwater ordinance provides a legal framework and creates minimum detention requirements related to runoff and total volume that can be met using a variety of tools but is structured to allow GI. The county has created a handbook with calculations and sizing information to explicitly lay out steps to full compliance (Pratt 2016).

In addition to ordinances establishing mandatory practices, stormwater utilities can be implemented that provides financial incentives for private landowners to manage their stormwater effectively and implement GI practices on their properties. Only seven Michigan municipalities have the utilities (WKU 2016). In cities that have them, such as Detroit and Ann Arbor, private and public landowners are assessed fees based on their contributions to the stormwater system. The fee can be reduced if the volume and rate of runoff is reduced to target levels. The result is an incentive for private landholder to install smart stormwater practices and maintain those practices over the long term.

By creating a system that leverages private interests to maintain a public good, communities can maximize the benefits created over time.

Use of GI on private land in urban areas requires a careful look, if its use is to have a significant impact. In Milwaukee region, for example, as 70 percent of MMSD's service area is owned by private parties, the region has but little choice to ensure that processes are crafted that encourage use of GI on private lands.

4.0 GREEN INFRASTRUCTURE IN MICHIGAN

Several Michigan communities have already begun the process of changing their stormwater management practices. In most instances, the decision to invest in GI has been locally driven. Recognizing the needs of their member communities, regional governmental consortiums have assisted the process.

This chapter presents a summary of the successful use of GI across Michigan. It first discusses the support of regional units of government and follows it by presenting summaries of GI use and its drivers in six communities located in various parts of the state. Financing remains a key to implementing GI and the various funding mechanisms currently being used in Michigan are discussed. Finally, the chapter summarizes the regulatory drivers across Michigan communities.

4.1 Incorporating GI in Michigan Communities: A Snapshot

Many cities in Michigan have started to consider GI as a key component of their existing stormwater infrastructure programs. GI implementation across Michigan is not uniform and the conditions and level of familiarity vary greatly. Indeed, even the benefits of individual GI projects are site dependent (ASLA 2011). However, the benefits of numerous aggregated projects can provide lower costs and more efficiency than expected from gray infrastructure solutions (Sinha et al 2017). Similarly, in cities with significant vacant land availability, such as Detroit, GI is on an upward trajectory, while built-up urban areas have been slower to adopt.

Many Michigan communities have undertaken extensive visioning exercises to create intermediate and long-range GI vision and plans, and a few such efforts are described in the following sub-sections.

4.1.1 Work by Regional Consortiums

The state of Michigan is divided into 14 regions, each covered by a council of government (COG). In addition, in some regions, a metropolitan council serves this purpose as well. Of the 14 Michigan regions, six COGs have engaged in some level of comprehensive GI visioning/planning (Table 4-1). These plans typically contain inventories of existing green spaces, thus focusing on preserving the existing assets before creating a plan to enhance these systems. The other COGs are not currently engaged in regional green infrastructure planning. Beyond the COGs, though, some regional metropolitan planning organizations such as the Grand Valley Metropolitan Council and the Macatawa Area Coordinating Council have provided environmental planning leadership to their service areas.

In southeast Michigan, the Southeast Michigan Council of Governments (SEMCOG) has led several key GI initiatives for their member communities. According to the Green Infrastructure

Table 4-1: A summary work by regional planning organizations across Michigan

Name	Key Environmental Planning Document	Web Address	Year
Southeast Michigan Council of Governments	1. GI Vision for Southeast Michigan 2. Low Impact Development Manual 3. Great Lakes Green Streets Guidebook	1. http://www.semcog.org/Reports/GIVision/index.html 2. https://www.semcog.org/desktopmodules/SEMCOG.Publications/GetFile.ashx?filename=LowImpactDevelopmentManualforMichiganSeptember2008.pdf 3. https://www.semcog.org/desktopmodules/SEMCOG.Publications/GetFile.a	1. 2014 2. 2008 3. 2013

Name	Key Environmental Planning Document	Web Address	Year
		shx?filename=GreatLakesGreenStreetsGuidebookSeptember2013.pdf	
Northeast Michigan Council of Governments	Presque Isle County GI Plan	http://www.discovernortheastmichigan.org/docview.asp?did=133	2007
Networks Northwest	1. Planning with Green Infrastructure: an Implementation Resource of the New Designs for Growth Guidebook 2. A Framework for Natural Resources in Northwest Michigan	1. http://www.networksnorthwest.org/planning/planning-policy/environment/environmental-stewardship-and-economic-opportunity/ 2. https://www.networksnorthwest.org/userfiles/filemanager/2253/	1. 2010 2. 2015
West Michigan Shoreline Regional Development Commission	Muskegon County Green Infrastructure Inventory	http://wmsrdc.org/wp-content/uploads/2015/08/MuskegonCo_GreenInv_final.pdf	2010
Southwest Michigan Planning Commission	Berrien, Cass, and Van Buren Counties Potential Conservation Areas	http://www.swmpc.org/downloads/growgreen/GI_finalreport.pdf	2007
Tri-County Regional Planning Commission	Greening Mid-Michigan Poster Plan	https://mitcrpc.app.box.com/v/GreeningMidMichigan	2010
Grand Valley Metro Council	Natural Connections: A Vision of GI for the Lower Grand River Watershed	https://lowergrandriver-organizationof.squarespace.com/rainscaping	2007
Macatawa Area Coordinating Council	Macatawa Watershed Green Stormwater Vision	http://www.the-macc.org/wp-content/uploads/MACC_Green_Stormwater_Vision_8.21.18.pdf	2018
Western Upper Peninsula Planning & Development Regional Commission	None		
Central Upper Peninsula Planning & Development Regional Commission	None		
Eastern Upper Peninsula Regional Planning & Development Commission	None		
West Michigan Regional Planning Commission	None		
Southcentral Michigan Planning Council	None		
East Michigan Council of Governments	None		
GLS Region V Planning & Development Commission	None		
Region II Planning Commission	None		

Vision for Southeast Michigan (2014):

"Green infrastructure includes parks, lakes, wetlands, and trees, as well as constructed green roofs, bioswales, and rain gardens. Southeast Michigan is home to over 180,000 acres of public parks, over 900,000 acres of trees, the only international wildlife refuge in North America, and the largest coastal wetland system in the Great Lakes."

SEMCOG categorizes GI in two broad categories: natural, undisturbed environment, such as wetlands, trees, prairies, lakes, rivers, and streams; and constructed or built GI, such as rain gardens, bioswales, community gardens, and agricultural lands.

Related to GI, in addition to the Vision, SEMCOG has worked over the last decade to produce the following reports:

- Low Impact Development manual for Michigan (2008)
- Great Lakes Green Streets guidebook (2013), and
- Green Infrastructure Vision for southeast Michigan (2014)

Collectively, these documents provide a road map to:

- Benchmarking GI in southeast Michigan,
- Where the region may seek to go, and
- Regional policies on how to get there.

Similar to SEMCOG, Networks Northwest (formerly Northwest Michigan Council of Government) has taken leadership in a number of key environmental areas and its focus has been on protecting the natural resources that not only drive much of the region's revenue but also simultaneously create more resilient infrastructure (Environmental Stewardship and Economic Opportunity, n.d.). These efforts fall into three broad categories:

Environmental Stewardship and Economic Opportunity: With support from the State of Michigan's Coastal Management Program, Networks Northwest was able to fund the creation of eleven environmental stewardship assessment reports for the communities within the planning region. These reports were coupled with training for municipal leaders on best management practice implementation and maintenance.

SEMCOG's leadership on GI topics in southeast Michigan is exemplary. SEMCOG has led visioning workshops and published three related documents that have a strong relevance in the region and can serve as prototypes for the rest of the state. As only six out of 14 COGs have led similar exercises, there is room for parallel efforts.

Betsie River/Crystal Lake Watershed Management Plan (WMP) for Betsie River/Crystal Lake: The Betsie River/Crystal Lake WMP represents an assessment of the threats faced by an important watershed in northern Michigan. Network's Northwest created a steering committee that helmed this multi-year effort, creating a plan that covered the watershed from 2016-2026. With this plan, any work being carried planned in the watershed can be made to serve the ultimate goals of the WMP and the plan can serve as a guide for future greening projects.

Coastal Resiliency: Many of the towns and cities in Networks Northwest's planning regions are coastal and have to contend with constantly shifting dunes and erosive forces. To give these communities as many tools as possible, Networks Northwest assembled a document titled "Planning for Coastal Resiliency in Northwest Michigan's Dunes" which presents case studies, model ordinances, and other information that communities can implement to enhance their resiliency in the fact of an unstable physical environment.

Finally, the West Michigan Shoreline Regional Development Commission (WMSRDC) has chosen to provide environmental planning services for several counties in west Michigan. The services offered by the commission reflect the local characteristics of the region with a focus on solutions at the watershed level. These efforts have been community based and have involved coordinating between multiple agencies with differing priorities to achieve outcomes that protect the environment in west Michigan.

One of the largest efforts championed by the WMSRDC has been to create sustainable funding mechanisms for watershed management plan implementation. The WMSRDC has worked with the Macatawa Area Coordinating Council and the Grand Valley Metro Council to create a guidance document on how these funds could be set up.

Overall, COGs can step in and play a central role in GI planning that crosses traditional jurisdictional lines and foster broader cooperation within Michigan communities.

4.1.2 Green Infrastructure in Key Michigan Cities
This section provides an overview of GI initiatives, overarching drivers, and expected future visioning towards GI carried out in the following six cities. These cities represent a variety of community sizes and different regional conditions throughout the state:

- Ann Arbor
- Detroit
- Grand Rapids
- Grand Traverse Bay Region
- Holland

Each city has developed its own approach to creating GI plans, regulations, and financing methods to control stormwater.

4.1.2.1 City of Ann Arbor
Located in southeast Michigan, the city of Ann Arbor has a population of 121,477 (Census, 2017), and a land area of 18,544 acres of which 32.8% is impervious.

Washtenaw County has over 400 GI projects that have been installed in the various communities within its boundaries. Of these projects, 300 have been installed within the borders of Ann Arbor. Table 4-2 documents the number of each GI type in Ann Arbor.

Local Drivers
The city of Ann Arbor has many drivers that encourage GI's use:

- *Regulatory driver*: As a municipal separate storm sewer system (MS4) community, Ann Arbor has compliance needs and have chosen to include GI in their options to effectively control stormwater volume and quality. The city has passed some of these responsibilities onto landowners through a series of local ordinances.
- *Local ordinances*: These include:
    - Washtenaw County's stormwater ordinance specifies the volume stormwater to be captured and the rate at which water may leave the site for specified design storms.
    - Ann Arbor tree ordinance. aims to reduce runoff and encouraging infiltration and evapotranspiration. The tree ordinance helps to maintain the city's tree canopy and preserve the cooling impact that trees have in an urban setting. The ordinance assesses fees (as a disincentive) whenever a healthy, city-owned tree is taken down to help fund the replacement and maintenance of Ann Arbor's canopy.
- *Financial drivers/ability*: The city is one of only seven cities in the state that has a stormwater utility. This fee charges Ann Arbor residents based on a tiered structure, reproduced in Table 4-3, and charges commercial customers $595.45 per impervious acre per quarter with an additional service fee of $3.91 per customer per quarter. Residents can reduce their fee by constructing GI on their property. Thus, this fee directly incentivizes installations of GI on private properties. The city currently collects nearly $6 Million a year and could increase to $10 Million a year by the year 2030 if current trends hold. (Lawson communication 2017).
- *Other conservation drivers*:
    - Ann Arbor is also participating in the Conservation Fund's Greenbelt Program, a voter-approved tax to help preserve natural areas and farmland around the city. This money is expected to generate $80 million in funds over the next 30 years and provides a readily available source of funding to preserve Ann Arbor's natural resources.

Table 4-2: A summary of GI projects in Ann Arbor (Washtenaw, 2016)

Project Categories	Projects
Underground Water Quality Structures	6
Native Restoration	9
Green Roof	12
Infiltration Projects	17
Retention/Detention	14
Community Rain Gardens	85
Residential Rain Gardens	179
Total GI Projects	**322**

Table 4-3: A summary of stormwater user fees in Ann Arbor

Single-Family & Two-Family Residential	
Measured Impervious Area	**Quarterly Charge***
Up to 2,187 square feet	$28.43
> 2,187 to 4,175 square feet	$49.75
> 4,175 to 7,110 square feet	$85.27
> 7,110 square feet	$149.24

Since 2003, the Greenbelt program has protected over 5,060 acres of farmland and open space surrounding the city of Ann Arbor, and has leveraged over $24 million through grants, landowner donations and other locally funded programs (https://www.a2gov.org/greenbelt/Pages/greenbelthome.aspx).

- In 2014, Ann Arbor adopted a resolution creating "Green Streets Program" that helps refocus municipal efforts on more sustainable stormwater solutions. Every time the city constructs or reconstructs a road, it must look for solutions that incorporate more green techniques to manage stormwater runoff. This has the practical response of shifting the costs of stormwater management onto the roads effort which is the largest generator of stormwater runoff in the city.

Future of GI

Ann Arbor does not have a unifying GI vision document for its future use in the city.

4.1.2.2 City of Detroit

Located in southeast Michigan, the city of Detroit has a population of 673,104 (Census, 2017), and a land area of 91,474 acres of which 59.4% is impervious.

In the city of Detroit, GI has been implemented because of the generous donation of the philanthropic community as well as projects required under the Detroit Water and Sewerage Department (DWSD) state-issued national pollutant discharge elimination system (NPDES) permit. That permit requires DWSD to develop and implement a GI plan for 17 specific outfalls along the Rouge River. The permit requires DWSD to invest $15 million in GI between 2013-2017 to reduce 2.8 million gallons of stormwater flow (during the two-year design storm). The permit language identifies several specific green stormwater infrastructure project types, including downspout disconnections, demolition and removal of vacant structures, bioswales along roadways and parking lots, tree planting, and other projects.

An important strategy for implementing GI in the City of Detroit is the development of *The Detroit Stormwater Hub*. The Detroit Stormwater Hub is a tool for individuals and organizations to understand, collaborate around, and track the city-wide progress and impact of Green Stormwater Infrastructure. Their website (www.detroitstormwater.org) is the result of the partnership between the city of Detroit, technical experts, non-profits, community organizations and local institutions. The Stormwater Hub aims to increase awareness of existing GSI practices throughout the city of Detroit, build community support around GSI solutions, advance coordination and implementation of GSI practices throughout the city, and demonstrate the success and impact of GSI in the community.

Table 4-4 shows the number of projects in the Detroit Stormwater Hub as of January 2020.

Table 4-4: Detroit Stormwater Hub Projects

Project Categories	Number of Projects
Disconnected Impervious	71
Downspout Disconnections	31
Bioretention	19
Multiple Practices	15
Residential Rain Garden	11
Rainwater Harvesting	11
Bioswale	7
Permeable Pavement	4
All Stormwater Stays on Site	2
Green Roof	2
Surface Detention	2
Constructed Wetlands	1
Subsurface Detention	1
Subsurface Infiltration	1
Other	1
Total GI Projects	**182**

DWSD Projects implemented to date include the following:

- *Tree Plantings:* From 2010-2015, DWSD in conjunction with its partner, The Greening of Detroit, planted more than 7,117 trees in the Upper Rouge Tributary area.
- *Demolition and Greening Vacant Properties:* Through demolitions and greening of vacant properties from 2010-2016, DWSD and other city departments, agencies, and organizations have removed approximately 3,141 acres of impervious cover citywide, with approximately 1,399 acres of impervious cover reduced in the Upper Rouge Tributary area (see Nassauer, J.L., et al 2019, and Burton, G.A., Jr., et al 2018).
- *Downspout Disconnections:* Since 2011, DWSD, in conjunction with its partner, The Greening of Detroit, has hosted nearly 64 workshops on "how to" disconnect and provided free materials to nearly 440 participants (https://detroitmi.gov/departments/water-and-sewerage-department/stormwater-management-and-drainage-charge/green-infrastructure-projects).
- *Roadways and Parking Lots:* DWSD is currently working with the Detroit Department of Public Works (DPW) on several green stormwater infrastructure projects that integrate with planned road resurfacing projects.
- *Municipal Properties:* DWSD encourages the use of GI at municipal facilities and schools. DWSD selected Ludington Magnet Middle School and Charles Wright Academy for green stormwater infrastructure projects that are in the design phase and will be constructed in 2017.
- *Municipal Parks:* DWSD is working with the Parks and Recreation Department, with support from the General Services Department, to integrate green stormwater infrastructure into Detroit's parks to manage stormwater runoff from the park and adjacent roads. Stoepel Park and Viola Liuzzo Park have GI projects in-progress, that were complete in late fall 2017.

Local Drivers

Detroit has numerous regulatory and non-regulatory drivers that promote GI solutions, that include:

- *Local Resources:*
  - *A Detroit Property Owner's Guide to Bioretention* (Detroit Future City 2019) is a guide targeted at non-residential property owners in the City of Detroit to be able to manage stormwater on their property using GI – specifically bioretention – and receive DWSD drainage credit for it. It also provides a baseline understanding of the DWSD drainage credit.
  - *Detroit Green Stormwater Infrastructure Workforce Assessment* is a report developed by Detroit Future City (2019) highlighting the economics of GI in the city.
  - *City of Detroit Stormwater Management Design Manual* (DWSD 2018) outlines the methods and standards that developers and property owners need in order to plan and build projects in compliance with city regulation, and lists GSI as the preferred method for managing stormwater.
- *Regulatory drivers*: The city is both a CSO community and an MS4 community. Both permits require improved management of stormwater. The city also has a consent decree for sewer overflows worded in a manner which creates unique conditions that make GI attractive.
- *Redevelopment needs:* The city is concurrently pursuing a massive program repurposing derelict and abandoned properties for GI purposes. Between 2010 and 2016, over 3,000 acres of impervious area was converted to greenspace throughout the city.
- *Financial driver/ability*: In 2016, Detroit enacted a substantial stormwater drainage fee that offered reductions of up to 80% if they install a GI practice on their own properties (DWSD 2017). The fee applies to all private and public properties.
- *Local ordinance*: In addition to the financial incentive put in place by the drainage fee, the post-construction stormwater ordinance was approved by the board of water commissioners and the Detroit city council in 2018. The ordinance requires regulated projects to install controls to manage the amount of stormwater which enters the city's infrastructure and the rate at which this stormwater enters the system.

Future of GI

GI's popularity in Detroit will only increase as DWSD uses it to meet their regulatory needs. Combined with efforts from SEMCOG and various foundations, Detroit is rapidly executing a regional vision for GI as both a stormwater solution and a way to remediate blight.

Detroit holds a lot of potential with regards to GSI and generating a sustainable GSI workforce. Detroit Future City has strategized how to activate a GSI workforce in Detroit in their GI workforce assessment report (Detroit Future City, et al 2019) Throughout the whole process, making sure including public input on decision making for large and local projects in the city is crucial for public buy-in and gaining public trust.

4.1.2.3 City of Grand Rapids

Located in west Michigan, the city of Grand Rapids has a population of 198,829 (Census, 2017), and a land area of 28,991 acres of which 43.9% is impervious.

Grand Rapids is a community that depended on a CSO system but has completed a long-term control plan to create an alternative stormwater control system. Grand Rapids has installed many GI projects, detailed in Table 4-5, including some explicitly mentioned in the city's stormwater master plan.

Table 4-5: A summary of GI projects in Grand Rapids (Grand Rapids 2013)

Project Categories	Number of Projects
Permeable Pavement	10
Native Restoration	6
Green Roof	20
Subsurface Storage	4
Rain Garden	15
Infiltration Installations	3
Hydrodynamic	2
Total GI Projects	**60**

This list is not comprehensive, many other projects have been completed since this plan was initially published in 2013.

Some particularly significant projects include (EPA 2016):

- Joe Taylor Park—Was identified as an area in need of change by neighborhood residents. The city worked with local stakeholders to design, fund, and implement a stormwater retention project.
- Mary Waters Park—Was identified as an 80-acre area that could serve as a detention basin. Storage was developed for 720,000 gallons with 11 million gallons infiltrated annually.
- Tremont Avenue—Planted a rain garden in an area prone to recurrent flooding. The city obtained a FEMA grant and designed a 4,000 square foot rain garden with 15 plant varieties. The rain garden was planted by city staff members and volunteers.
- Plainfield Bioretention Islands—Using an MDOT enhancement grant,
- bioretention islands were designed as water quality islands for area businesses. Neighbors were engaged during the process, while students conducted measurements on rainfall.

Local Drivers

- *Regulatory drivers:* Similar to Detroit and Ann Arbor, Grand Rapids is regulated as an MS4 community and thus needs to meet water volume/quality control requirements. However, Grand Rapids has completed its long-term control plan, removing CSOs as a driver for GI implementation.
- *Local ordinances:* These include:
  - Grand Rapids passed a stormwater ordinance, which stipulates how stormwater must be handled within city limits.
  - Grand Rapids has also passed a tree ordinance, which helps to preserve tree canopy within the city, regulating the manner in which removals can take place, and how the replacement of trees is accomplished.
- Green Infrastructure Standards reference document outlines the specifications for installation, performance and maintenance of various green infrastructure applications.
- Grand Rapids Vital Streets program is an initiative to improve the safety and usability of Grand Rapids streets through continued renovation, and includes standards for including green infrastructure like bioswales, tree canopy and permeable pavement.
- Green Infrastructure Portfolio Standard (GIPS) Pilot Project with the Center for Neighborhood Technology (CNT) is a plan to measure additional green infrastructure the City of Grand Rapids will construct and count toward the goal of 1 percent more stormwater infiltrated through green infrastructure every five years.

- *Other conservation drivers*: The Grand Rapids sustainability plan explicitly tasks the community with preserving tree canopy, as well as managing stormwater runoff with GI practices, on 100 percent of new sites (Page 19, Goal 5 of the city sustainability plan explicitly says "LID treats 100% of stormwater in new facilities")This plan also serves as Grand Rapids' roadmap for the future of GI.

Future of GI

While Grand Rapids does not have a specific stormwater volume retention goal in its Green Grand Rapids plan, it does have a goal to restore the tree canopy cover to 40 percent and has laid out general guidelines related to implementation in the city. The city identified priority streets for implementing streetscape low-impact development (LID) practices and integrated LID and GI with road updates and other policies, spreading responsibilities across departments.

4.1.2.4 Grand Traverse Bay Region

The Grand Traverse Bay watershed presents a unique case study of green infrastructure projects both being driven by an entity other than a municipality as well as being installed on a watershed-scale. A nonprofit watershed group called The Watershed Center Grand Traverse Bay (TWC), whose mission is to protect and advocate for water quality in Grand Traverse Bay, has been the local driver for green infrastructure projects in the Grand Traverse Region for the past several years.

The Grand Traverse Bay watershed drains approximately 976 square miles of land and is home to more than 110,000 people. Population densities are the greatest in the Traverse City region, along the Bay's shoreline, and along the large lakes in the Elk River Chain of Lakes. By far, Traverse City and its surrounding townships are the most highly populated areas of the entire region, with population densities reaching up to 1,730 people per square mile. The Grand Traverse Bay region is currently experiencing tremendous population growth and development pressure, with a predicted 40% increase in population by 2020.

Even though land use and land cover in the watershed is predominantly forest (50%) and agriculture (20%), urban locations like Traverse City, Elk Rapids, and Suttons Bay, often produce greater amounts of stormwater flow due to the increased amount of impervious surfaces compared to more rural settings within the watershed. Stormwater entering the Bay and its tributaries from storm drain outlets contributes a significant amount of pollution, and, when added up, inputs from all these small inputs of stormwater can result in a massive amount of pollution entering Grand Traverse Bay. TWC has recognized stormwater as a major threat to water quality in the watershed and has focused efforts on reducing impacts from stormwater to the Bay using green infrastructure methods whenever possible.

TWC has executed several successful grant-funded green infrastructure projects in the last several years, one of the largest being their Kid Creek Restoration Project. This large-scale project incorporates green infrastructure practices into an urbanized watershed in Traverse City with goal of reducing the impact of stormwater and sedimentation on Kids Creek and its tributaries so it can be removed from the State's 303(d) Impaired Waters List. To date, TWC has received more than $4.7 million in state, EPA-Great Lakes Restoration Initiative (GLRI), and private funding for green infrastructure based BMPs in the Kids Creek Restoration Project.

Additional TWC-led green infrastructure projects focusing on near-shore water quality in Grand Traverse Bay have been implemented in coastal communities such as Suttons Bay and Northport using EPA-GLRI funds.

Local Ordinances and Other Drivers

- Regulatory drivers: No municipality in the Grand Traverse Region qualifies as an MS4 community so there are no state-driven regulations surrounding stormwater requirements.
- Local initiatives:
  - TWC routinely encourages GI planning and implementation in new developments throughout the region and regularly meets with developers during the planning phase
  - TWC works with local municipalities to incorporate GI into planning and management and encourages the adoption of strong stormwater ordinances that highlight the use of GI
  - The city of Traverse City has passed its own stormwater ordinance, which regulates how stormwater can be dealt within the city.

Future of GI

- GI installation dependent grant funding
- TWC working with municipalities to incorporate GI planning into local policies and planning
- For the foreseeable future grant funded efforts led by TWC, such as the Kid's Creek restoration project, are the most likely approach for GI implementation.
- In the future there are organizations within the region that may offer regional planning documents that help individual efforts contribute to greater overall goals.

4.1.2.6 City of Holland

Located in southwest Michigan, the city of Holland has a population of 33,327 (Census, 2017), and a land area of 11,157 acres of which 34.1% is impervious.

Holland has implemented several GI projects throughout the city that are shown in Table 4-6.

Table 4-6: A summary of GI projects in Holland (MACC 2017)

Project Categories	Number of Projects
Permeable Pavement	5
Bioswale	5
Rain Garden	3
Total GI Projects	**13**

These projects help fulfill the environmental goals set in the city's master plans that prioritized LID and GI. The city also produced a numerous maps and other documents to help illustrate areas where GI installation has the greatest potential to be successful and have the greatest impact.

Local Drivers

- *Regulatory drivers:* In addition to the MS4 permit that covers the city of Holland, the city is also contending with large algal blooms of Microcystis, which have many of the same characteristics as the blooms in Lake Erie. This issue has reached the point where the lake has been put under further regulations to control the phosphorus entering the system.
- *The Macatawa Watershed Green Stormwater Vision (2018)* is a framework that guides the promotion and implementation of green stormwater infrastructure throughout the Holland-Zeeland urbanized area. The vision established a common language to discuss green stormwater infrastructure, visions opportunities for increased green stormwater infrastructure, and outlines a strategy for public outreach and implementation of projects on public land. The vision explains green stormwater infrastructure, its benefits, how it relates to water quality and transportation, the importance of maintenance, public education and marketing strategy for GI, and opportunities for funding and partnerships.
- Finally, Holland straddles Allegan and Ottawa counties and so both county drain

commissioners have some level of responsibility and control over stormwater within the city.

Future of GI
While the city is still getting a handle on how it can use GI effectively within its boundaries, the completion of its regional GI strategy will provide a vision for future implementation.

4.2 Financing of GI in Michigan
The drainage infrastructure across the state has suffered from over-development and under funding. This funding gap has restricted the introduction of GI in many communities. As GI use has become prevalent only fairly recently, as of 2017, a patchwork of funding sources typically enabled their implementation across Michigan. These sources can be categorized in six general categories (Laduca & Kosco 2014) and are presented in subsequent sections

4.2.1 Federal sources: Federal programs, such as Clean Water State Revolving Fund (SRF) money or Water Infrastructure Finance and Investment Act (WIFIA) funds, can provide significant funding for local GI programs. Access to these funding sources rely on the ability to repay the loan – i.e. a well-defined funding source. The communities that have been most successful at obtaining these grants/loans have a stormwater fee that can be committed to repayment.

Local governments may be eligible for federal grants administered by a range of departments and agencies. Federal funding can come in multiple forms: some in competitive grants, and some in formula programs that local governments are already likely to be receiving. Federal grants may be used to supplement money available to local governments through traditional budgeting or financing. However, federal grants can be highly competitive, may require lengthy application, are limited in size and scope, and are awarded on a one-time basis.

4.2.2 State Sources
Michigan has loans and/or grant programs that may be used to fund GI projects and programs, such as the following:

- *Strategic Water Quality Initiatives Fund (SWQIF) loans*: Assists municipalities in funding wastewater treatment system improvements, stormwater treatment projects, and nonpoint source pollution control projects. Funds capital costs only (planning, design, construction), not operation and maintenance costs. In 2017, $10-20 million in loan funds was available.
- *Downtown Development Infrastructure Grants:* Provides for downtown infrastructure improvements tied to new commercial/mixed-use development activities that require additional infrastructure to create new economic opportunities and position creation activity. In 2017, $4 million was available with a minimum of $30,000 and a maximum of $750,000 for each successful applicant community.
- *Michigan Transportation Alternatives Program*: Funds projects that increase and improve Michigan's transportation system. Projects can include facilities for pedestrians and bicyclists, viewing areas, historic preservation and rehabilitation, and environmental mitigation efforts. Grants can be applied to treating or reducing stormwater runoff from transportation facilities and structures. As of 2017, $16.5 million was available every year.

4.2.3 Local Funding
Local governments can pay for GI using local revenue sources, including the government's general fund appropriations and capital budget or through user fees or stormwater utility fees. These local funding sources, if implemented, may be more flexible for GI project application. General funds are difficult to obtain for GI projects; the local competition for these funds is very, very high.

Divert general fund to a GI project present a strain on municipal budgets because GI projects compete y with other projects without an increase in revenue. Local funding sources in Michigan include:

- *Michigan Drain Code (County level)*: Provides legal authority to counties to create a public corporation to address stormwater management. Funds are generated through a levy of special assessment to each parcel within the drainage district.

Establishment of special assessment district: These are separate units of government established to manage specific resources within defined boundaries. Can levy taxes, fees, or special assessments and can issue debt independently of state and local governments.

- *Development impact fees*: Developers are assessed a one-time fee on building projects.
- *Stormwater utility fees*: Utility fees are implemented by a municipality to generate funds for stormwater management.

Stormwater Utilities (SWUs) in Michigan

Most of the current Michigan SWUs were established prior to the "Bolt Decision" (Bolt v. City of Lansing, 1998). In December 1998, the Michigan Supreme Court ruled that Lansing's stormwater utility charge was an illegal tax, rather than a fee, and, therefore, in conflict with the Headlee Amendment – a 1978 amendment that precludes new taxes without the vote of the people. The Lansing stormwater fee was subsequently rescinded. In making this ruling, the Michigan Supreme Court referenced a three-part test to distinguish between a fee and a tax:

- *A user fee serves a regulatory purpose rather than a revenue-raising purpose*
- *A user fee is proportional to the necessary costs of the service*
- *A user fee must be voluntary – property owners must be able to voluntarily refuse or limit the use of the commodity or service.*

The Michigan Supreme Court decided that the Lansing fee failed the first two parts of this test. Thus from 1997 to 2010, no new Michigan stormwater fees were implemented. In 2011, Jackson implemented a user-fee-funded stormwater utility, but the city was sued in 2013 and subsequently lost. While there is some resistance to such fees, it is highly dependent on a community. This stigma can change if community stakeholders are well-informed of the benefits of stormwater fees. There are also ongoing efforts to create legislation that will provide a framework for communities to use in establishing equitable and transparent fee structures to pay for stormwater infrastructure.

An initiative led by Jim Nash, the Oakland County Water Resources Commissioner, began in 2015; this initiative has resulted in legislation that may soon enable communities to create stormwater utilities without the fear of legal reprisal.

Michigan Drain Commissioners and their role in advancing Green Infrastructure: Spotlight on Oakland County Water Resources Commissioner

In Michigan, drain commissioners (sometimes called water resources commissioners) seek to protect the state's water resources by administering laws involving flood protection, stormwater management, and soil erosion and water quality. Unique to Michigan, this is a powerful political role and many drain commissioners have taken proactive roles in promoting the use of green infrastructure. Description below provides a summary of the Oakland Country Water Resources Commissioner's (OCWRC) related work.

Why did OCWRC decide to make green infrastructure a focus of its efforts: OCWRC is a strong advocate of GI implementation which can effectively complement traditional grey infrastructure and includes other important environmental and social benefits as previously mentioned. Additionally, the County's Municipal Separate Stormwater System permit requires that stormwater standards be updated to include GI implementation. Specifically, in 2014, the Michigan DEQ introduced new Post-Construction Standard Guidelines requiring that MS4 regulated public entities manage runoff volume in addition to runoff rates which have traditionally been managed.

Activities/accomplishments that OCWRC has supported:

- *Since 2018, OCWRC has facilitated more than thirty regional stormwater meetings with Oakland, Wayne, Macomb and Livingston Counties to develop consistent regional standards, which embrace LID and GI. The group continues to work closely with EGLE in this endeavor, meeting every three weeks to finalize, refine and update these new standards which are expected to be implemented in late 2020.*
- *In March 2020, the OCWRC will begin community and stakeholder rollout of its proposed new stormwater standards incorporating GI.*
- *In 2019 OCWRC prepared a GI Triple Bottom Line Study and Code Audit for the fourteen communities in the GWK Drainage District. This report was presented to the communities for comment in February 2020 and meetings will occur on an ongoing basis to facilitate GI implementation.*
- *In 2019, The OCWRC's Norton Creek Drain and City of Wixom GI Study Project was completed consisting of construction of a rain garden, bioswale and streambank improvements to enhance water quality. This project was facilitated by the HRWC who obtained grant funding for project design and construction.*
- *In 2017, Oakland County successfully implemented GI on the County's newly constructed Animal Control and Adopting Center where bio-retention and infiltration swales were constructed along with flood control detention.*
- *Since 2014, the OCWRC has become a networking nexus of stakeholders that seeks a bill that will help clarify how communities can establish dedicated funding sources for managing their stormwater systems including GI BMP's.*

Amount of money spent on GI: As of 2017, the OCWRC had spent over $300,000 over the past 3-years to support and promote GI implementation, education and standards.

Key barriers OCWRC is trying to deal with:

- *Overcoming the lack of community and staff knowledge about GI including design standards, construction and long-term O&M requirements;*
- *Lack of a dedicated stormwater funding source within communities; and*
- *Stakeholder buy-in of TBL benefits which include economic, social and environmental benefits.*

What OCWRC believes would help the state of Michigan implement green infrastructure:

- *Fund an ongoing GI workgroup focused on education and updates to the State of Michigan LID Manual which is the primary GI information source in Michigan.*
- *The state should support House Bill 4691 and encourage communities to adopt designated stormwater funding sources which are based on site impervious area.*
- *Provide more GI implementation grant funding sources.*

4.2.4 Public Finance

Municipal governments typically are also be able to use public financing methods, such as municipal bonds, to pay for green infrastructure projects. Local governments may be able to use SRF and WIFIA to finance green infrastructure projects. However, municipal bonds, SRF and/or WIFIA all require a dedicated repayment stream. However, local governments can explore strategies that capture the value created by installing GI, such as tax increment financing.

4.2.5 Private Finance

Communities may also explore innovative strategies to leverage limited municipal funds to attract private capital. One approach that is common to

Promoting Green Infrastructure: by Erb Family Foundation

Mission of Erb Family Foundation: To nurture environmentally healthy and culturally vibrant communities in metropolitan Detroit, consistent with sustainable business models, and support initiatives to restore the Great Lakes Ecosystem.

Why did the Foundation decide to make green infrastructure a focus of its philanthropic efforts?

One of the Foundation's desired outcomes is improved water quality in the Great Lakes basin, especially the watersheds impacting metro Detroit and Bayfield, Ontario, through the elimination of polluted runoff and other threats, resiliency to climate change, and individual and institutional stewardship. We do this by promoting green stormwater infrastructure. It not only eliminates polluted runoff but engages community members, elevates equitable practices, beautifies neighborhoods, incorporates art, creates jobs, and aligns with principles of sustainable development.

Three accomplishments that the Erb Foundation has supported:

1. *Role of a convener: Since 2013, the Foundation has convened representatives from nonprofit organizations, state and municipal governments, universities, and community development organizations to work together in implementing green stormwater infrastructure at a citywide scale with the ultimate goal of a robust coordinated citywide program that improves water quality, builds resiliency, and enhances quality of life.*
2. *Help build projects: With the Foundation's support, we estimate that nearly 27 million gallons of polluted runoff were managed in the metro Detroit area by various sized green stormwater infrastructure projects (scales varying from a residential rain garden to a 100-acre park).*
3. *Support related organizations: The Foundation has supported many organizations that play a role in incorporating green stormwater infrastructure into the conversation around new development and redevelopment in Detroit. Their work is showing impact as green stormwater infrastructure is being considered in community planning, greenway, green alley, and bike lane projects.*

Amount of money spent on green infrastructure by the foundation in the last three years:

Between 2014 and 2017, Erb has spent $12,464,731 to build 76 green stormwater infrastructure projects by working with 34 organizations.

Key barriers the Foundation is trying to deal with:

1. *No citywide plan for green stormwater infrastructure in Detroit*
2. *Widespread community understanding, acceptance, and enthusiasm*
3. *Proper installation of green stormwater infrastructure projects*
4. *Maintenance*
5. *Workforce development*
6. *Attractive designs*

What would help the state of Michigan implement green infrastructure:

1. *Removal of funding and policy barriers*
2. *Understanding which BMPs and products work best*
3. *Building public will*
4. *Recognizing it as infrastructure (especially in asset management) and funding accordingly*

infrastructure projects, but has been limited in green infrastructure stormwater management, is public-private partnerships (P3s). P3s provide access to private capital and may provide a means to rapidly scale up green infrastructure project installation; however, local governments must identify the source of repayment and assure the citizens that this is the appropriate/right use of these funds.

4.2.6 Other Sources, Such as Private Foundations
Specially in Michigan, many foundations have played a key role in funding and promoting the use of GI. These include the Erb Family Foundation, the Kresge Foundation, Wege Foundation, and others such as various Michigan Community Foundations.

4.3 Regulatory Drivers for Michigan Communities

Regulations at the federal level provide broad incentives to implement GI with water quality related programs that include CSO control and MS4 programs.

4.3.1 Combined Sewer Overflows and Sanitary Sewer Overflows
CSOs occur when combined sewage (sanitary sewage and stormwater) in a sewer designed to carry both, exceeds the capacity to transport the flow to wastewater treatment plants. Sanitary sewer overflows (SSOs) are caused when stormwater enters a sewer designed to carry only sanitary sewage causing the flow to exceed the carrying capacity. An SSO is typically introduced to prevent basement flooding. These events are more common in older communities or cities where infrastructure is old, constructed to poor standards, and in poor repair.

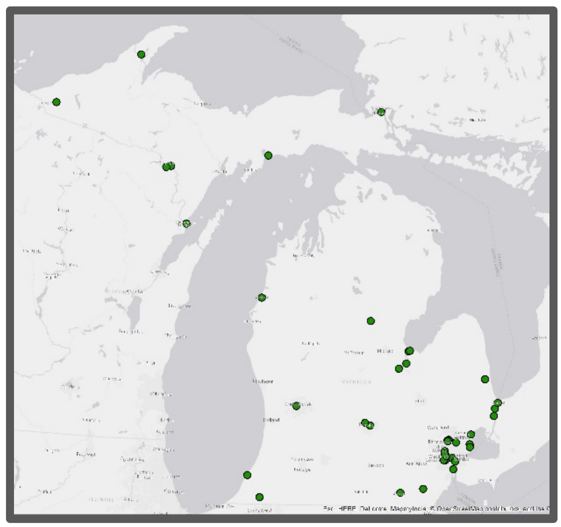
CSO can be permitted but require compliance with CSO control programs usually involves the development of a long-term control plan that reduces the frequency, amount, and quality of the overflows.

SSOs cannot be permitted and SSO control programs expect the complete elimination of SSOs.

In both CSO and SSO control programs, traditional programs relied on large scale control facilities including huge upgrades to the city's gray infrastructure. Often these programs are the single largest financial transactions experienced by a local municipality. Thus, alternative approaches – including GI implementation – have been studied by municipal governments. In fact, since 2011, the U.S. Environmental Protection Agency (EPA) has allowed the cities of New York and Philadelphia to employ GI as the primary control technology for their compliance plans, opening the door for other communities to follow suit and choose the lowest cost compliance option for them and their constituents.

Michigan has 42 communities, shown in Figure 4-1, that must address their CSOs and the "nine minimum controls" that represent a mix of best practices and heightened monitoring and treatment capabilities to help protect the public and mitigate the worst impacts of combined sewer systems.

Figure 4-1: 42 Municipalities with CSO permits in Michigan
(sources: active CSO permits and NPDES permittees)



In these communities, the city of Detroit has arguably the most complex CSO permit in the state. This is directly related to both the size of the system, which dwarfs that of other cities, and its age of nearly 200 years. Completely redoing the entire system to create a separated sewer would be astronomically costly so the city continues to use a mixture of best practices and technology installations. As mentioned previously, Detroit's CSO consent decree requires DWSD to invest $15 million in GI between 2013-2017 to reduce 2.8 million gallons of stormwater flow (during the two-year design storm). The permit language clearly identifies specific green stormwater infrastructure project types, including downspout disconnections, demolition and removal of vacant structures, bioswales along roadways and parking lots, tree planting, and other projects.

Grand Rapids, on the other hand, has fully completed its long-term control plan. Its permit was last re-issued in 2006 but since then the city has removed all ten of its outfalls, and what remains is a single retention treatment basin. Accordingly, no clear CSO related drivers are present in Grand Rapids that can promote the use of GI.

4.3.2 Municipal Separate Storm Sewer Systems (MS4) Permits

The National Pollutant Discharge Pollutant Elimination System, first established in 1987, created new legal structures around municipalities that have municipal separate storm sewer systems (MS4s). MS4 regulations created a national benchmark that followed several local-level efforts to institute site development standards primarily to control flooding. Like elsewhere in the country, the focus led to the creation of a large number of detention basins in Michigan, structures designed to only come online during wet weather events that exceed the design capacity. The MS4 standards further influenced a recognition of water quality stewardship in many communities, precipitating the development and implementation of local codes that enhanced protections for aquatic environments. The evolving understanding of best practices have moved state-of-the-art technology away from dry and wet detention basins to other systems, such as GI.

Within the NPDES system, four key regulations affect the permitting under the national program. They are:

- Post-development stormwater management controls.
- Stormwater pollution prevention for industrial activities.
- Sediment and erosion control for construction activities.
- Total Maximum Daily Load (TMDL) implementation.

The post-development stormwater controls and TMDL segments of the regulation have the most direct bearing on GI and can greatly incentivize its implementation.

4.4 GI Ordinances in Michigan

In Michigan, ordinances that impact GI are as varied and diverse as the municipal entities that implement them. Some ordinances are explicitly designed to regulate GI, while others only incidentally impact GI. To review relevant sections of a municipality's ordinances, standards and specifications, policies, and procedures, EPA uses an infrastructure code and policy evaluation tool called The EPA Water Quality Scorecard. Developed by EPA, points are assigned to various GI elements with the goal of creating an overall score that local governments could use as a baseline and to track progress over time.

To date, no comprehensive analyses of GI ordinances is available for the entire state. However, individual examples exist, such as a project carried out by the EPA for the Macatawa Area Coordinating Council (MACC) that led to a GI assessment of five partner agencies within four localities. These five partner agencies all operate in the Macatawa Watershed and are: the City of Holland, City of Zeeland, Ottawa County Drain Commissioner, Ottawa County Road Commission, and Allegan County Drain Commissioner.

The five goals that comprise the EPA Scorecard are:

- Goal #1: Protect Natural Resources and Open Space.
- Goal #2: Promote Efficient, Compact Development Patterns, and Infill.
- Goal #3: Design Complete, Smart Streets That Reduce Overall Imperviousness.
- Goal #4: Encourage Efficient Parking.
- Goal #5: Adopt Green Infrastructure Stormwater Management Provisions.

Specific suggestions to meet each of these goals can be found in the EPA report. A set of recommendations were common to all five agencies and are presented below:

- Require site plans or stormwater plans to include tree preservation.
- Conduct and/or advertise educational sessions for builders and developers regarding appropriate tree protection techniques and/or publish a technical tree protection manual.
- Allow streets with GI to count towards stormwater requirements.
- Sponsor/approve pilot programs to determine appropriate pervious materials for different

paving areas (e.g., permeable concrete for sidewalks, permeable pavers for driveways), as well as processes for installation and maintenance.
- Incorporate pilot project results into standard practice for all new paved areas and retrofits of existing paved surfaces.
- Adopt policy to replace impervious materials with pervious materials where practical.
- Create and provide a GI workshop or training program, with collaboration from other watershed partners, for internal and external reviewers to ensure that the stakeholders who use this tool will have the ability to understand and use it effectively.
- Review and change regulations, where necessary and in conjunction with other watershed partners, other local regulations (e.g., other county departments, townships) to ensure that all local government departments/agencies have coordinated with one another to ensure that GI implementation is legal and encouraged.
- Credit GI practices towards required controls for stormwater runoff.
- Encourage/require a pre-site plan meeting with developers to discuss stormwater management and GI approaches.
- Identify and prioritize retrofit projects within the sewersheds that will utilize GI stormwater management techniques.
- Establish system that allows/requires payment-in-lieu fees for off-site stormwater management facilities. Fees should be set sufficiently high as to cover the true cost of off-site management. Consider limitations on amount of off-site management allowed (more for infill areas, less for greenfield sites).
- Require long-term maintenance agreements that allow for public inspections of the management practices and account for transfer of responsibility in leases and/or deed transfers.
- Conduct inspections every 3 to 5 years, prioritizing properties that pose the highest risk to water quality, inspecting at least 20 percent of approved facilities annually.

Project team is unable to find any comprehensive State of Michigan document that clearly outlines a pathway to incorporating green infrastructure in ordinances of Michigan communities. Usually, a code audit is the first step to making changes. An excellent example of code audits is a recent project report that was jointly funded by the Michigan Sea Grant and the National Oceanic and Atmospheric Administration.

5.0 STAKEHOLDERS & COMMUNITY ENGAGEMENT

Community engagement associated with this project included community engagement sessions, stakeholder focus groups, and presentations for local government officials and professional associations. These sessions were undertaken both to educate the population on GI but also to identify barriers to GI implementation and approaches that could be used to address those barriers. This chapter will describe the community engagement sessions and stakeholder focus groups.

5.1 Community Engagement Sessions

One common barrier to GI implementation is public acceptance, or at a minimum perceived public acceptance. If the public is vocal against GI, then it is harder for a municipality to implement. To address public acceptance, a community could hold citizen focus groups, visioning sessions or design charrettes to investigate the perceived public concerns with GSI Implementation. In this project, public engagement sessions were held in the following communities:

- Zeeland/Holland (various dates – 2018 & 2019)
- Elk Rapids (17 September 2018)
- Royal Oak (28 November 2018)
- Arcadia (10 – 12 October 2019)

Each of these communities were engaged differently depending on the needs of the community and the desire of local leadership. Zeeland focused on GI renderings for a commercial core that were presented to municipal staff and leadership in conjunction with broader regional capacity building efforts. Royal Oak and Elk Rapids followed identical formats and the community engagement sessions had broad community participation. Both of those communities had public sessions with two exercises (a community value exercise and a community GI visioning session) and a presentation to council. Finally, Arcadia was engaged in a three-day design charrette that included a broader triple bottom line sustainability focus.

<u>5.1.1 Zeeland/Holland</u>

Macatawa Area Coordinating Council (MACC) sponsored a series of community engagement sessions in the cities of Zeeland and Holland. The MACC was engaged throughout the project in an advisory capacity, sponsored a focus group, and co-hosted several GI presentations in the region to educate municipal staff and citizens including:

- Green Stormwater Infrastructure (GSI) 101: GSI for Decision-Makers (9 December 2019)
    - ½ day workshop for council members, planners, commissioners and other regional decision-makers
- Making the Case for Green Infrastructure (15 August 2019)
    - All day workshop for professionals, regulators and elected officials
- Zeeland GSI Visioning (25 October 2018)
    - Final visioning session with City of Zeeland elected officials
- MACC GSI Seminar (22 August 2018)
    - All day workshop for professionals, regulators and elected officials

As such, community engagement in the region is robust and is building capacity for GI implementation. One outcome of the partnership with the MACC was the production of graphical renderings of GI to be integrated into a proposed road realignment in the City of Zeeland. This represents an example of opportunity recognition. Municipal leadership was in the process of redesigning a road and the MACC saw an opportunity to incorporate GI into the planning phases of the project while also educating local officials on GI.

<u>5.1.2 Elk Rapids</u>

The Village of Elk Rapids and The Watershed Center of Grand Traverse Bay engaged with the project team to host a community visioning session on 17 September 2018 (Figure 5-1). The session included a community mapping exercise

Figure 5-1: Elk Rapids Community Engagement Flyer

Green Infrastructure Implementation

PLANNING FOR A SUSTAINABLE FUTURE

CORE QUESTION: What are the strategies that will enable Elk Rapids to begin the wide-spread implementation of green infrastructure?

ELK RAPIDS GREEN INFRASTRUCTURE

Lawrence Technological University (Southfield MI), Environmental Consulting & Technology, Inc. (Ann Arbor MI) and the University of Michigan-Ann Arbor are collaborating on a project to investigate barriers to green infrastructure implementation in Michigan. The project includes multiple approaches to stakeholder engagement including an online survey, focus groups, and community green infrastructure visioning meetings.

Elk Rapids was selected by the project team to host a community visioning meeting based on its location, demographics, and potential for success. The vision meeting provides an opportunity for an open community discussion and participation in exercises that focus on the core project question.

Community participation exercises include identifying opportunities for green infrastructure implementation and sharing opinions on value of natural systems in the downtown and waterfront area.

Please join us in the Old Council Chambers at the Governmental Center (315 Bridge Street) from 4pm to 6pm on Monday, September 17 to participate. No RSVP necessary.

Any questions related to this project or this process may be directed to Donald Carpenter (248-763-4099 or dcarpente@ltu.edu).

For more information about the Grand Traverse Bay Watershed and efforts to preserve and protect this natural resources, please contact Sarah U'Ren, Program Director, The Watershed Center Grand Traverse Bay (231) 935-1514 or suren@gtbay.org.

COMMUNITY ENGAGEMENT MEETING

OLD COUNCIL CHAMBERS AT THE GOVERNMENTAL CENTER — 315 BRIDGE STREET
MONDAY, SEPTEMBER 17, 2018

4:00	Community Definition & Mapping Exercise (Strengths, Opportunities, Connections, and Definitions)
5:00	Community Voting Exercise (Voting on Green Infrastructure Techniques)
6:30	Presentation to Commission on "Removing Barriers to Green Infrastructure Implementation"

michiganseagrant.org/research

Michigan Sea Grant helps to foster economic growth and protect Michigan's coastal, Great Lakes resources through education, research and outreach. A collaborative effort of the University of Michigan and Michigan State University, Michigan Sea Grant is part of the NOAA-National Sea Grant network of 33 university-based programs.

In Local Partnership with The Watershed Center Grand Traverse Bay and the Village of Elk Rapids.

and a community GI vision voting session focused on their downtown and waterfront area. Figure 5-2 and Figure 5-3 are example renderings that the community was asked to vote on. Outcomes from the session were the foundation for two federally funded grant proposals submitted and subsequently awarded to the Watershed Center of Grand Traverse Bay on behalf of the Village of Elk Rapids.

5.1.3 Royal Oak

Royal Oak formed a stormwater task force that recommended the promotion of GI, revising the detention ordinance to allow GI, and the development of a stormwater utility (Royal Oak, 2018). Simultaneously, the City of Royal Oak commissioned an evaluation of using Green Infrastructure (GI) to reduce runoff entering the City's stormwater system (Wade Trim & Drummond Carpenter, 2018). The project included an analysis of existing conditions at representative pilot locations that could be retrofit with green infrastructure to serve as a planning guide for the City of Royal Oak. While the report was fairly comprehensive and included incorporating GI into various typologies, the project did not include a community engagement process. Therefore, Royal Oak engaged with the project team to host a community visioning session on November 28, 2018 (Figure 5-4). The session included both a community value exercise and a community GI visioning session focused on parks.

For the community value exercise, participants were asked which benefits of GI they value the most in the context of their community based on series of defined values. These values included Beauty, Economics, Ecosystem Services, Education, Mental Health, Physical Health, Recreation, Sense of Place, Social Value Tourism and Wildlife. Based on their responses, members of the Royal Oak community valued the role that GI can have on Economics, Ecosystem Services, and Sense of Place (Table 5-1) the most. In other words, citizens are interested in how GI can provide critical ecosystem services while also reaping the financial benefits of widespread implementation of GI.

The community visioning exercises consisted of two components: the first was to identify which areas of the city were most natural or "green" and conversely which areas of the city could benefit from more nature; the second was to vote on graphical renderings of GI integrated into parks. Overall, GI renderings were produced at four municipal parks with Figure 5-5 providing an example of graphical renderings of GI and Figure 5-6 showing the citizen voting on those options. A complete summary of results is available on the project website (https://www.michiganseagrant.org/topics/resilient-coastal-communities/green-infrastructure/).

5.1.4 Community Engagement Discussion

Education on GI is critical both for public acceptance and building local capacity. One solution to addressing public resistance to GI implementation is to determine what they "value" about their community and subsequently designing a GSI implementation strategy based on those values. A value sort is where a community is asked to rank what they value about their community (for example wildlife habitat). The value sort exercise can be performed by individuals, small groups, or based on perceptions

Table 5-1: Most and least important GI values based on Royal Oak community responses

MOST IMPORTANT (TOP THREE RESPONSES)	**Economics – 14** *Financial benefits or cost savings from green infrastructure or natural systems.*
	Ecosystem Services – 11 *The land's ability to support human wellbeing by regulating threats (e.g. pollution) and providing services (e.g. clean water).*
	Sense of Place – 8 *The special connection one feels to a place.*
LEAST IMPORTANT (BOTTOM THREE RESPONSES)	**Tourism – 9** *Attraction of a place as a destination by non-residents*
	Mental Health – 8 *Opportunities to cultivate stillness, connection, spirituality, and/or emotional wellbeing.*
	Wildlife Habitat – 7 *The landscape's ability to support the wellbeing of animal lives.*

Figure 5-2: Elk Rapids Marina Community Vision Poster

Figure 5-3: Elk Rapids Downtown Community Vision Poster

Figure 5-4: Royal Oak Community Engagement Flyer

Green Infrastructure Implementation
PLANNING FOR A SUSTAINABLE FUTURE

CORE QUESTION: What are the strategies that will enable Royal Oak to begin the wide-spread implementation of green infrastructure?

Royal Oak Green Infrastructure

Lawrence Technological University (Southfield MI), Environmental Consulting & Technology, Inc. (Ann Arbor MI) and the University of Michigan-Ann Arbor are collaborating on a project to investigate barriers to green infrastructure implementation in Michigan. The project includes multiple approaches to stakeholder engagement including an online survey, focus groups, and community green infrastructure visioning meetings.

Royal Oak was selected by the project team to host a community visioning meeting based on its location, demographics, and potential for success. The vision meeting provides an opportunity for an open community discussion and participation in exercises that focus on the core project question.

Community participation exercises include establishing community values, identifying opportunities for green infrastructure implementation and sharing opinions on value of natural systems in residential and park areas.

Please join us in Room 106 of the Royal Oak Senior/ Community Center on 3500 Marais Avenue from 6pm to 8pm. No RSVP necessary.

Any questions related to this project or this process may be directed to Donald Carpenter (248-763-4099 or dcarpente@ltu.edu).

For more information about Royal Oak's stormwater management and green infrastructure efforts, visit **https://www.romi.gov/1361/Green-Infrastructure**.

Community Engagement Meeting

Wednesday, November 28, 6pm - 8pm

Royal Oak Senior/Community Center 3500 Marais Avenue
Room 106

Royal Oak

michiganseagrant.org/research

Lawrence Technological University

ECT Environmental Consulting & Technology, Inc.

Sea Grant Michigan

NOAA

MICHIGAN STATE UNIVERSITY

UNIVERSITY OF MICHIGAN

Michigan Sea Grant helps to foster economic growth and protect Michigan's coastal, Great Lakes resources through education, research and outreach. A collaborative effort of the University of Michigan and Michigan State University, Michigan Sea Grant is part of the NOAA-National Sea Grant network of 33 university-based programs.

Figure 5-5: Graphical rendering of GI in Red Run Park in Royal Oak

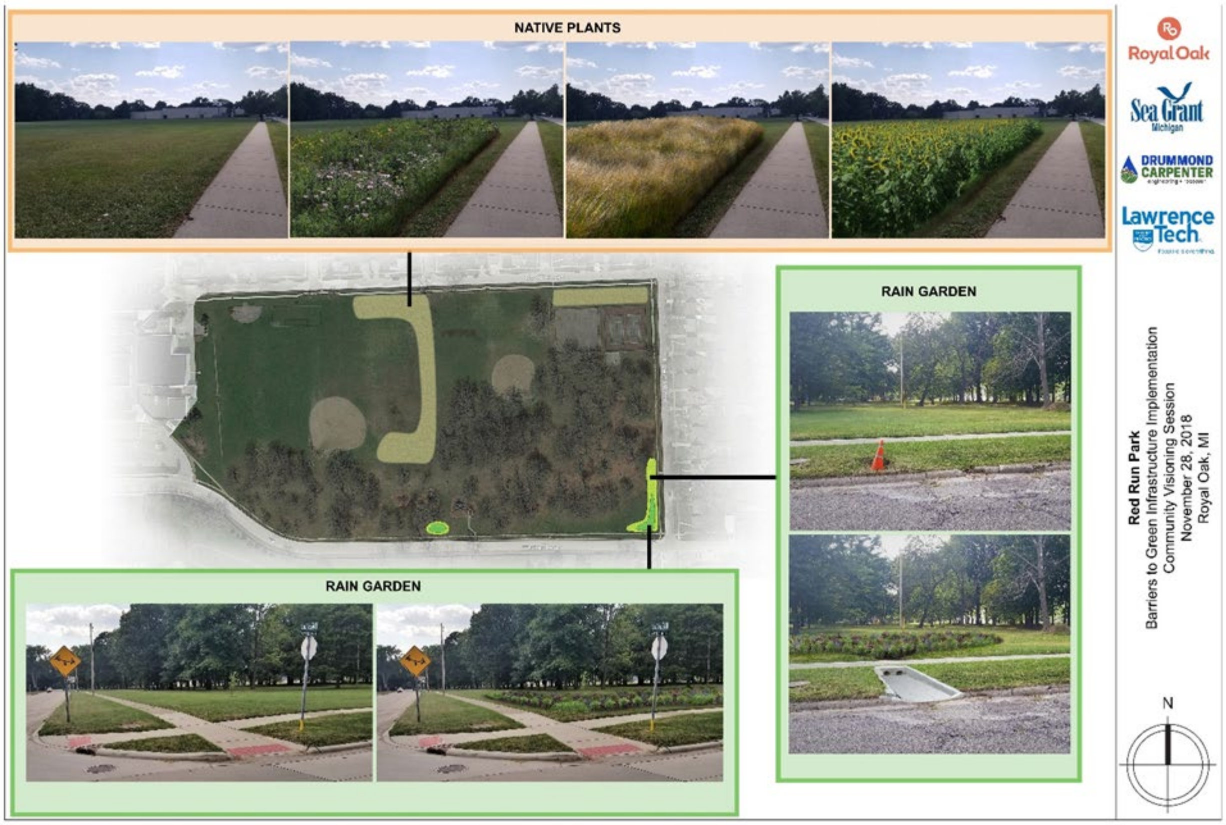
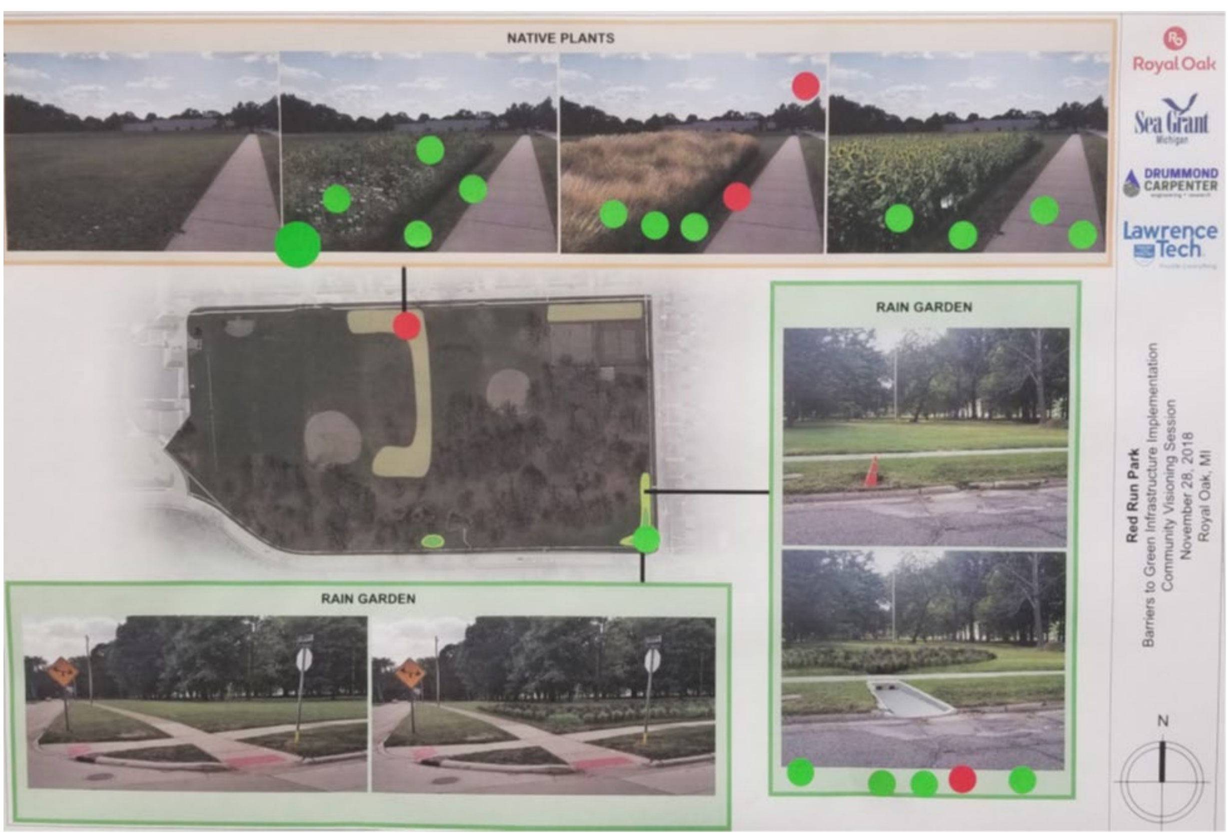


Figure 5-6: Community voting for Red Run Park in Royal Oak



of overall community values. An example of this technique was show in Section 5.1.3 Royal Oak. Citizens of Royal Oak identified economics and ecosystem services important values that GI can provide their community. As such, a GI implementation for Royal Oak could revolve around educating the community on how GI can reduce neighborhood flooding and improve water quality in the Red Run Drain (the local damaged watershed). The recommended strategy would also focus on how GI can alleviate pressures on their aging infrastructure and reduce taxpayer funding. Conversely, demonstrating how GI would improve wildlife habitat or improve ecosystem tourism would not be as effective for Royal Oak. However, Elk Rapids, as a tourist destination on Lake Michigan, values the role GI can play on improving the visitor experience to their downtown and waterfront.

Another common technique used by the research team is demonstrating graphical renderings (i.e. future visions) and having community members vote on their preferred alternatives. This technique is a key component of the design charrette process. Through voting, community members coalesce around a common vision for the future. Having a common vision can aid in attracting grant funding (was the case in Elk Rapids) and/or inform local decisionmakers on how resources should be allocated towards GI implementation (as was the case in Holland and Royal Oak). Visioning has also been shown as a means for attracting private investment in GI as local businesses or civic organizations have a vision they can assist in implementing.

Another use of graphical renderings is to evaluate what is acceptable in the context of specific typology. For example, Figure 5-7 shows graphical renderings of three different rain gardens variants and three different water harvesting variants for the same one-story neighborhood house. Participants are asked to identify which versions of GI implementation would make them uncomfortable if this was their neighborhoods house. The key in this exercise is asking the participant not what they would install at their own home, but rather what they would tolerate in their neighborhood. This type of exercise establishes acceptable practices that can than either be encouraged by community incentives or can inform building codes that will either allow or prohibit certain practices. Figure 5-8 is an example from one community where this exercise was performed, and the red dots indicate that large scale rainwater harvesting in the front yard is not acceptable. The community was more tolerant of front yard rain gardens, but tall grasses were not deemed acceptable by some participants. This exercise was also performed at several professional meetings and conferences and in general, technical professionals responded very similar to local community audiences despite having more understanding of GI.

Finally, with regards to community engagement, the most successful examples of GI implementation efforts in the state are because of regional leadership. Highlighted in this section were the roles of regional councils and non-profit watershed organizations in organizing community engagement events and getting local support for GI implementation.

5.2 Stakeholder Focus Groups

The project team hosted focus groups at five state-wide or regional meetings of stakeholders that broadly represent groups interested in GI. The focus groups were between 30 and 90 minutes long and discussed the core research question "what are the long-term sustainable strategies that will enable Michigan communities to begin the wide-spread implementation of green infrastructure and reap triple bottom line benefits?" Each focus group also included a survey and subsequent discussion around three themes:

- Familiarity with GI
- Barriers to GI
- Cost/Benefit Ratio of GI

The survey included statements related to each theme and participants were asked to respond with their level of agreement to establish base line knowledge prior to discussion.

Focus groups were conducted at meetings of the following organizations:

- Michigan Municipal League (MML) - elected officials and municipal staff
    - Summer Workshop, 28 July 2017, Muskegon, MI

Figure 5-7: Graphical rendering of GI in a residential front yard

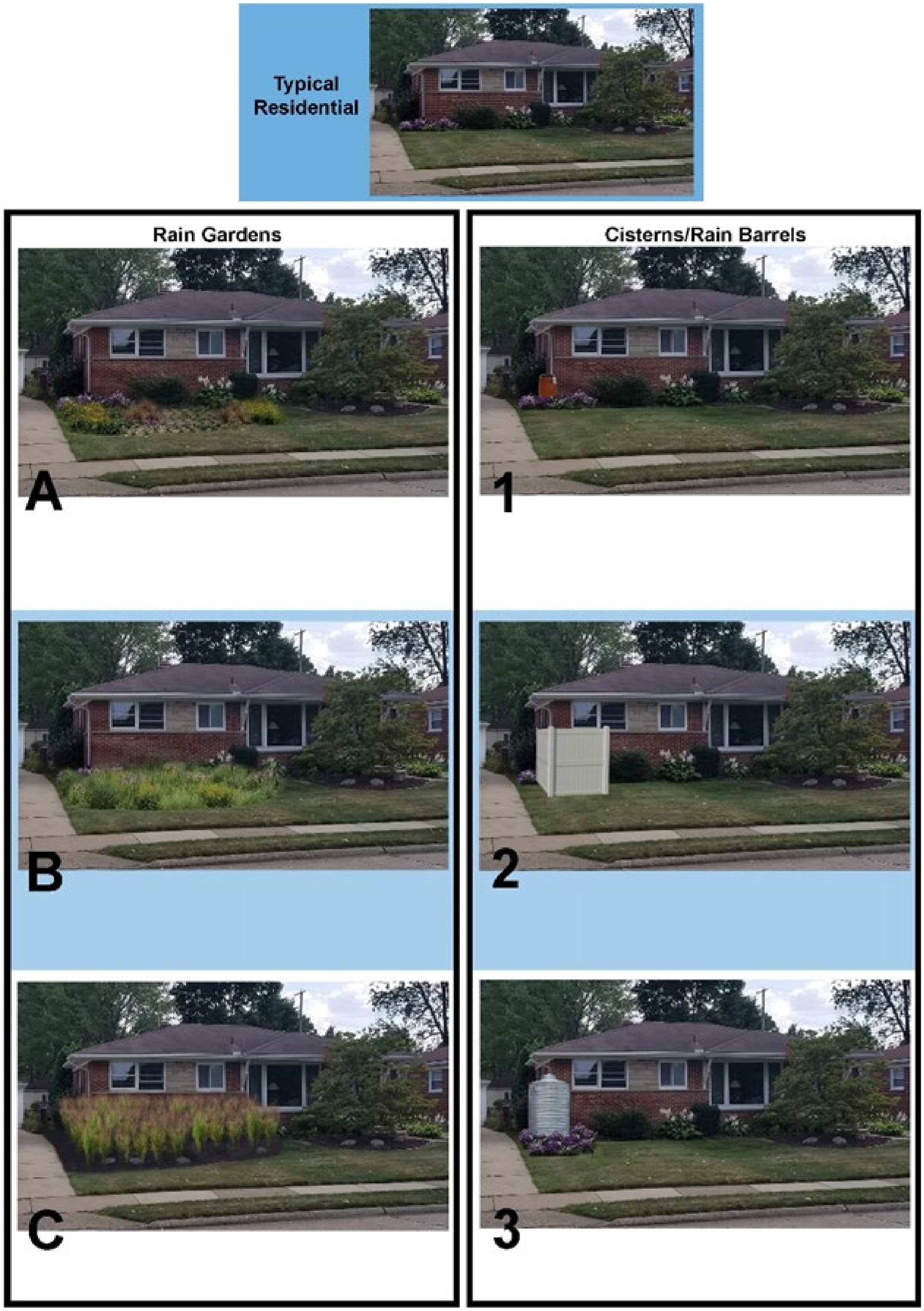
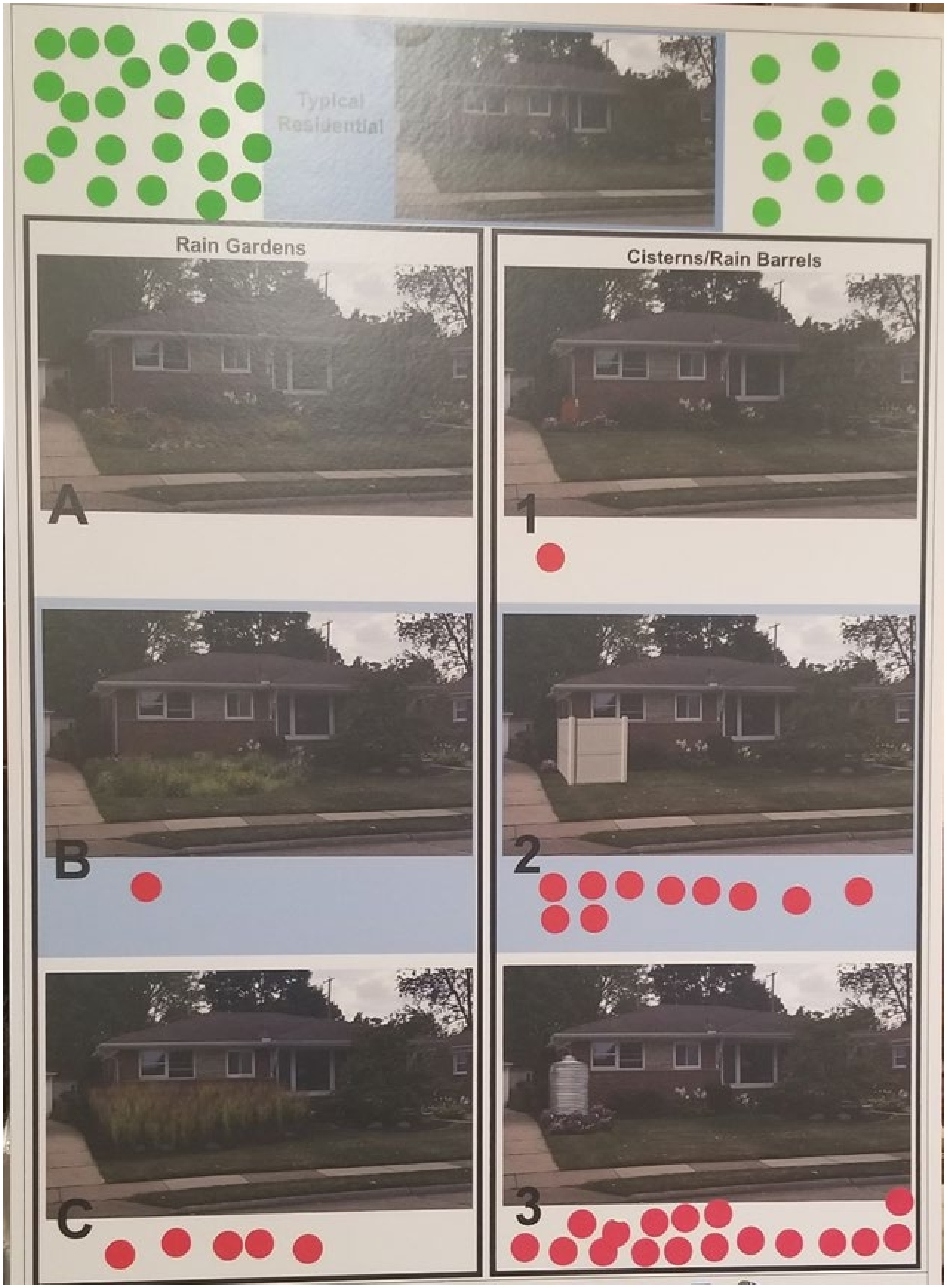


Figure 5-8: Community voting on preference of GI in a residential front yard



- Michigan Association of Planners (**MAP**) – professional planners and municipal staff
  - Annual Conference, 29 September 2017, Mackinaw Island, MI
- Michigan Water Environment Association (**MWEA**) – water quality professionals, engineers, and municipal staff
  - Annual Meeting, 19 June 2017, Boyne, MI
- Michigan Association of County Drain Commissioners (**MACDC**) – engineers, county staff, and elected officials
  - Annual Winter Meeting, 15 February 2018, Traverse City MI
- Macatawa Area Coordinating Council (**MACC**) – regional body of professionals, elected officials and staff
  - MACC Regional Meeting, 22 August 2018, Holland MI

5.2.1 Focus Group Survey Responses

5.2.1.1 Familiarity with GI

Table 5-2 shows the average survey results for statements associated with the **Familiarity with GI** theme. In general, participants in the MML and MWEA focus groups were less familiar with GI then the others. Overall, nobody reported GI being prevalent in their communities. All focus groups indicated they had resources available to them but that those resources might not be sufficient for widespread implementation. Finally, all focus groups are interested in using GI instead of traditional stormwater management techniques.

5.2.1.2 Barriers to GI

Table 5-3 shows the average survey results regarding **Barriers to GI** implementation. Overall, a lack of financing is perceived as the largest barrier with all focus groups indicating financing is a moderate to serious barrier. A majority of focus groups also listed maintenance, lack of community acceptance, and a lack of trust as moderately serious barriers to GI implementation. A lack of design tools was also considered at least a minor barrier in all focus groups.

In addition to soliciting responses to the five categories listed in Table 5-3, participants were also asked if there are other barriers to GI Implementation (open response question). Figure 5-9 is a word cloud generated from those responses where the size of the word is directly

Table 5-2: Familiarity with GI focus group responses

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I have a high degree of familiarity with green infrastructure (GI).			MML MWEA	MAP MACC MACDC	
GI is very prevalent in the communities I serve.		MACDC	MML MAP MWEA MACC		
I have plenty of resources at my disposal to implement GI.			MML MAP MWEA MACC MACDC		
I am interested in using more GI instead of traditional SW management tech.				MAP	MML MWEA MACC MACDC

Table 5-3: Barriers to GI focus group responses

	Not A Barrier	Minor Barrier	Moderate Barrier	Serious Barrier
Maintenance		MML	MAP MWEA MACC MACDC	
Lack of Finance			MML MAP MWEA	MACC MACDC
Lack of Design Tools		MML MAP MACDC	MWEA MACC	
Lack of Community Acceptance		MML	MAP MWEA MACC MACDC	
Lack of Trust		MML MWEA	MAP MACC MACDC	

Figure 5-9: Barriers identified by focus group participants

related to the number of times the barrier was listed and every barrier included in the word cloud was identified by more than one participant. The largest barrier listed by participants was overall Knowledge of GI. The other most common responses were Ordinances, Contractors, Aesthetics, Cost, and (lack of) Leadership.

Finally, participants were asked if they believe GI was appropriate for their community and if the community had specific ordinances to assist with GI implementation (Table 5-4). A majority of focus group respondents agreed that GI is appropriate, but most indicated their community does not have specific ordinance that assist with implementation.

5.2.1.3 Cost/Benefit Ratio

The last question of the focus group survey asked participants about their perception of the cost to benefit ratio of GI. The range of responses for this question ranged widely with numerous individuals reporting that the cost of GI was significantly higher than the benefits. On average, the focus groups that consisted of more planners and elected officials (MACC, MML, and MAP) tended to report a higher Cost/Benefit ratio for GI and the focus group with more technical staff reported a lower Cost/Benefit ration of GI (Table 5-5).

Table 5-4: Barriers to GI focus group responses on ordinances

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My community has specific ordinances that assist with GI.		MACC	MML MWEA MAP MACDC		
GI is appropriate for my community.			MWEA	MML MAP MACDC	MACC

Table 5-5: Barriers to GI focus group responses on cost/benefit ratio

	Significantly Lower	Lower	Higher	Significantly Higher
What do you perceive is the cost/benefit ratio of GI		MWEA MACDC	MACC MML MAP	

5.2.2 Focus Group Discussion

As stated previously, each focus group lasted between 30 and 90 minutes. As such, the length and quality of the discussion varied, but general themes that emerged during the discussion are described in this section.

One theme that emerged was life-cycle cost analysis. There was a consensus the true cost associated with GI is unknown; especially when compared with traditional infrastructure. The uncertainty associated with long-term performance and required maintenance made both decision-makers (i.e. elected officials and staff) and consultants (engineers and planners) hesitant for widespread implementation; even though a majority believe in GI and desire additional implementation. Another concern was that GI is perceived as being more expensive to implement (both design and construction costs) which hinders implementation. While it is true many GI techniques (such as porous pavement) might be more expensive than traditional stormwater management techniques, the appropriate comparison should be at a site scale where the extra costs associated with GI at one locations might be offset by savings at other locations on the site. One suggestion was to track GI from planning through future conditions to monitor cost (both implementation and maintenance), required maintenance, and hydrologic performance to accurately assess GI and establish the actual cost/benefit ratio for both short- and long-term timeframes.

Another theme evolved around codes and ordinances. Most permit reviewers see very few instances where GI is included as a stormwater management technique. However, as more communities are implementing stormwater ordinances and MS4 permits are being renewed/implemented, participants expect GI to be more prevalent in order to meet permit requirements. There was a consensus that if a community wants to have widespread implementation of GI, there need to be regulatory drivers. One repeated suggestion was to include more regulatory incentives (i.e. reduced fees or expedited permit processing) for developers who include GI in their plans. Another successful technique employed within several communities is having municipal staff meet early in the design process with landowners and developers to encourage the use of GI and demonstrate how it could be incorporated into a site plan. Another related theme evolved around inspections and enforcement. Municipalities do not have the staff, or perhaps the knowledge, to inspect GI and enforce both construction standards and on-going maintenance of GI. Given those limitations, they are not sure how to implement or enforce new codes or ordinances.

An additional theme centered on aesthetics and public acceptance. Aesthetics is very individual and many GI practices, especially those involving plants, can look unkept or overgrown to the general public. Some communities even reported residents resisting tree plantings because of the increased maintenance associated with leaf litter. Overall, participants thought the public does not understand GI and therefore, it's hard to implement. For example, communities in west Michigan report that GI was widely perceived as a description for alternative energy (i.e. wind turbines and solar farms) and as such was not supported by their communities. Broad based education (of municipal staff, elected officials, and citizens) is considered critical to gain broad based acceptance.

One more theme focused on the design and construction of GI. While there are many technical resources available to engineers, many engineering companies (especially smaller land development firms) do not have the experience with GI and therefore tend to be neophobic. Several participants mentioned there are a few civil engineering companies who are really knowledgeable at GI design, but most are not. The concern around "inadequate" design was amplified when discussing construction. A vast majority of participants cited that contractors are not experienced with the nuances of GI construction. Even worse, the contractors "don't know what they don't know." This lack of experience and competence subsequently leads to GI failures that further hinder widespread implementation. Finally, many communities are experiencing urban redevelopment and need examples of how GI can be implemented with site constraints.

With regards to maintenance, participants cited uncertainty around the type of maintenance required for different GSI practices, the cost associated with prescribed maintenance, and human capacity as reasons why GI is not implemented. Participants requested better maintenance manuals and training for staff on how to maintain GI. They are also interested in examples of alternative maintenance plans or approaches that might reduce costs. For example, some communities have had success with citizen groups maintaining GI through adoption programs and others have not. Determining and articulating why some maintenance plans succeed and other fail was considered important.

Another theme highlighted GI financing. Every focus group had some discussion on grant funding of GI (i.e. who funds GI; what are grant requirements; etc.) and there is a perception that GI is not affordable without grant support. This was cited by some professionals as a significant barrier. There are professionals and elected officials who believe that GI can be a cost effective without grant funding, but that narrative is not communicated well. However, most participants still cited the need to fund pilot projects and demonstration sites to educate people on GI. Finally, a dedicated funding mechanism, such as a stormwater utility, was considered the most important means for GI implementation.

Finally, some focus groups discussed the co-benefits of GI although this topic was not explored in detail during focus group phase. Traditional stormwater management techniques have one purpose while successfully implemented GI can serve multiple purposes including improving quality of life for residents. Articulating co-benefits was mentioned as one means for removing barriers to GI implementation.

6.0 SURVEYING BARRIERS TO ADOPTING GI IN MICHIGAN

6.1 Survey Aims

To better understand the barriers that exist to the adoption of green infrastructure (GI) or, in this context green stormwater infrastructure (GSI) a survey of stormwater practitioners was conducted to gauge their experience with traditional and green stormwater infrastructure, familiarity with successful GSI examples, benefits versus costs of GSI, barriers to adopting GSI, and approaches to overcoming those barriers.

6.2 Methods

6.2.1 Survey Design

Survey questions were designed by drawing on previous research on barriers to green stormwater infrastructure adoption in Michigan (Polich, Pebbles and Carpenter, 2017; Sinha et al., 2017; Miller & Lawson, 2014) as well as through focus groups with statewide stormwater practitioners (see Chapter 5). Previously cited challenges to GSI adoption included implementation costs, regulatory impediments, acceptance amongst practitioners, programmatic challenges, maintenance burdens, design and construction hurdles, conflicting codes and ordinances, lack of municipal staff capacity, challenges from developers, and (mis)perceptions regarding unknown performance, higher costs, conflict with smart growth principles, and resistance within the regulatory community. These items were pared down by pilot testing draft surveys with advisory board members of this project.

The final survey included six categories of questions to assess Michigan stormwater practitioners' perceptions about green and traditional approaches to managing stormwater. First, participants were asked about the role they play with respect to stormwater management and about the primary community with which they engage on these topics. Second, participants were asked their experience with managing stormwater using both traditional and green approaches as well as their experience with managing stormwater using both traditional and green approaches. Third, they were asked about their familiarity with successful examples of GSI. Fourth, participants assessed the short and long-term cost benefits of both traditional and green stormwater infrastructure. Fifth, participants rated the difficulty of various barriers to GSI adoption. Finally, participants were asked to rate the effectiveness and feasibility of approaches that might reduce the barriers to adopting green stormwater infrastructure.

6.2.2 Participants

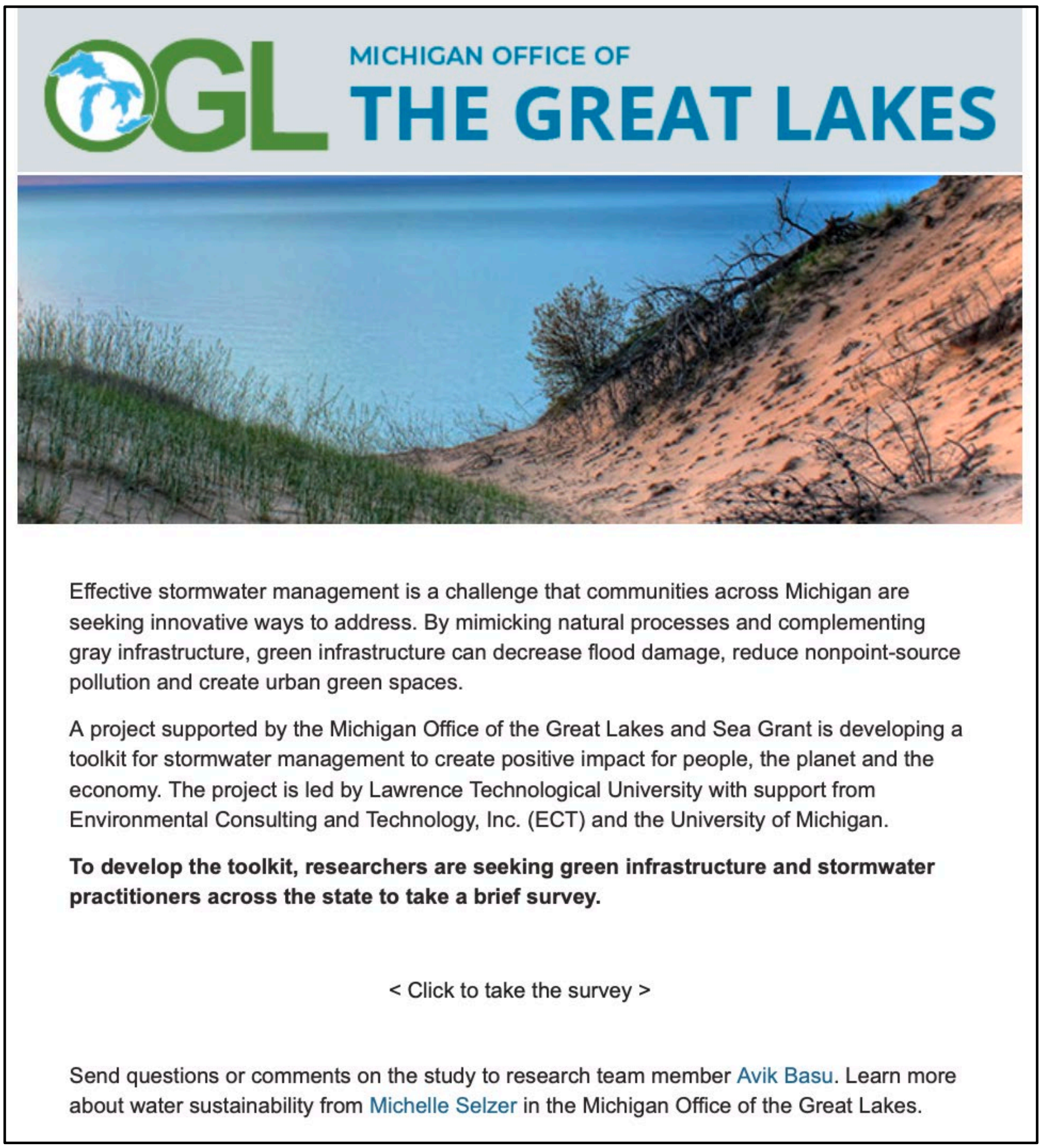
Between January and April of 2018, links to our online survey were sent out by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) - formerly Michigan Department of Environmental Quality, via their Office of the Great Lakes (OGL) email newsletter, which had approximately 9,000 subscribers, and to their Stormwater Update email newsletter, which had approximately 6,000 subscribers. The survey was also sent to the Michigan Association of County Drain Commissioners (MACDC) email list (500 subscribers), State of Michigan Green Infrastructure Conference attendees (240 attendees), Michigan Water Environment Association (MWEA) watershed seminar and annual conference attendees (286 attendees), Michigan Infrastructure and Transportation Association (MITA) email list (2,000 subscribers), the Michigan Municipal League (MML) email list (number of subscribers not reported), and to our project team's stormwater management contact lists. The organizations were chosen to access a broad set of individuals who have a stake in stormwater management, including government (including county drain commissioners and their staff), nonprofits, expert institutions such as universities, and builders across the state of Michigan.

Each organization received a unique survey link to share, which allowed us to track how many respondents came from each of the groups (see Table 6-1). An example of the invitation interface can be seen in Figure 6-1.

Table 6-1: Survey distribution group with subscriber and respondent counts

ORGANIZATION	LIST	SUBSCRIBERS	RESPONDENTS
EGLE	Office of the Great Lakes newsletter	9,000	96
EGLE	Michigan Green Infrastructure Conference attendees	240	23
Project team and advisory board	Network of project team and advisory board	Not reported	20
MACDC	Email distribution list	500	17
MWEA	Annual conference and watershed seminar attendees	286	16
EGLE	Stormwater Update newsletter	6,000	14
MITA	Email distribution list	2,000	2
MML	Email distribution list	Not reported	2

Figure 6-1: Example of survey invitation interface


MICHIGAN OFFICE OF THE GREAT LAKES

Effective stormwater management is a challenge that communities across Michigan are seeking innovative ways to address. By mimicking natural processes and complementing gray infrastructure, green infrastructure can decrease flood damage, reduce nonpoint-source pollution and create urban green spaces.

A project supported by the Michigan Office of the Great Lakes and Sea Grant is developing a toolkit for stormwater management to create positive impact for people, the planet and the economy. The project is led by Lawrence Technological University with support from Environmental Consulting and Technology, Inc. (ECT) and the University of Michigan.

To develop the toolkit, researchers are seeking green infrastructure and stormwater practitioners across the state to take a brief survey.

< Click to take the survey >

Send questions or comments on the study to research team member Avik Basu. Learn more about water sustainability from Michelle Selzer in the Michigan Office of the Great Lakes.

In the emails to prospective participants, we requested their participation in a survey that would help develop a toolkit for stormwater management in Michigan that included innovative approach to green infrastructure. While there is some overlap in the subscribership between these newsletters and email lists, we requested participants to complete the survey only once. The survey took about 15-20 minutes of the participants time.

6.2.3 Data Analysis

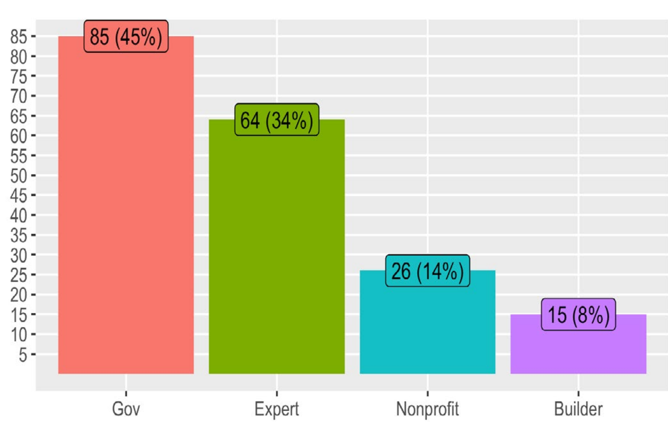
Resulting data was analyzed and visualized using *R* (R Core Team, 2018) in RStudio (RStudio Team, 2015). Data import, cleaning, and transformation was done using the *tidyverse* package (Wickham, 2018). The dimensionality of multi-item questions (e.g., barriers to GSI adoption) was reduced through factor analysis using the *psych* package (Revelle, 2018).

6.3 Results

6.3.1 Respondents' Roles and Communities

190 people responded to the survey. From these respondents, four major categories of stormwater management stakeholders emerged (Figure 6-2). 85 of the respondents (equivalent to 45%) were affiliated with government (e.g., elected officials, drain commissioner's staff, other government employees), 64 (34%) were experts (e.g., consultants and academics), 26 (14%) were from the nonprofit sector, and 15 (8%) were from the building industry (e.g., builders, suppliers, developers).

Figure 6-2: Distribution of roles across the 190 survey respondents



Opportunity

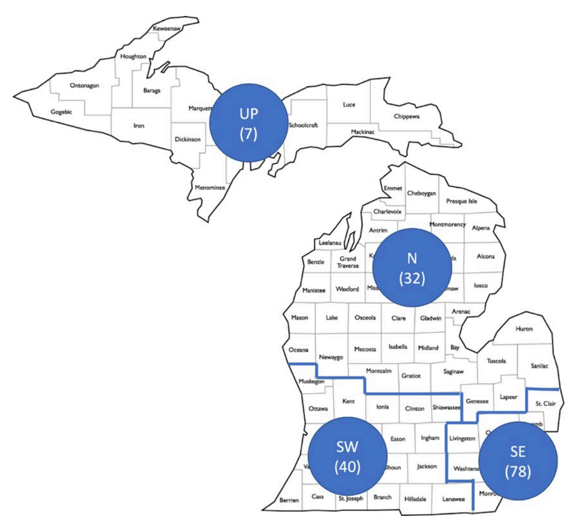
Because nonprofits focus on promoting GSI, better understanding of traditional stormwater infrastructure can help them better advocate a transition from traditional to GSI.

Respondents were asked about the primary community in which they worked on stormwater. While some respondents worked all over the state, most focused on a particular community. These responses were grouped into four geographic regions in Michigan—Southeast, Southwest, Northern, and Upper Peninsula (Figure 6-3). The southeast region corresponded to the counties in the South eastern Michigan Council of Governments (SEMCOG) and 78 respondents reported focusing stormwater efforts there. The southwest region included respondents from the Lansing and Grand Rapids areas and had 40 respondents. Finally, the northern region, with 32 respondents, was limited to the Lower Peninsula and the Upper Peninsula had 7 respondents.

6.3.2 Traditional and Green Stormwater Infrastructure Management Experience

To assess the stormwater management experience of the practitioners surveyed, we asked how much experience each had with traditional and green stormwater infrastructure installation and maintenance. We also asked how much

Figure 6-3: Distribution of respondents across four regions in Michigan



SE=Southeast Michigan (SEMCOG counties), SW=Southwest, N=Northern, UP=Upper Peninsula experience respondents had with educating others about GSI, with acquiring financing for GSI, and for garnering political support for GSI. The experience level statistics for each of the seven topics and the breakdown by role are listed in Table 6-2 and visualized in Figure 6-4.

Table 6-2: Stormwater management experience across seven topics, sorted by group

Question stem: "How much experience do you have with the following?"

TOPIC AND ROLES	MEAN (SD)
Traditional stormwater infrastructure installation	**3.28 (1.43)**
Builder	4.33 (1.15)
Government	3.37 (1.28)
Expert	3.11 (1.62)
Nonprofit	2.50 (1.22)
Traditional stormwater infrastructure maintenance	**3.15 (1.32)**
Builder	3.92 (1.16)
Government	3.33 (1.34)
Expert	2.90 (1.25)
Nonprofit	2.36 (1.08)
GSI installation	**3.14 (1.08)**
Builder	3.67 (1.15)
Nonprofit	3.43 (0.51)
Expert	3.20 (1.15)
Government	2.94 (1.06)
GSI maintenance	**3.01 (1.05)**
Builder	3.25 (1.22)
Nonprofit	3.21 (0.58)
Expert	3.11 (1.13)
Government	2.87 (1.03)
Educating others about GI	**3.40 (1.15)**
Nonprofit (N=26)	4.07 (0.62)
Expert (N=64)	3.53 (1.06)
Government (N=85)	3.28 (1.18)
Builder (N=15)	2.75 (1.36)
Garnering political support for GI	**2.51 (1.18)**
Nonprofit	3.14 (1.10)
Expert	2.57 (0.97)
Government	2.44 (1.26)
Builder	2.00 (1.28)
Acquiring financing for GI	**2.33 (1.05)**
Nonprofit	3.14 (0.77)
Expert	2.32 (0.90)
Government	2.20 (1.11)
Builder	1.83 (1.03)

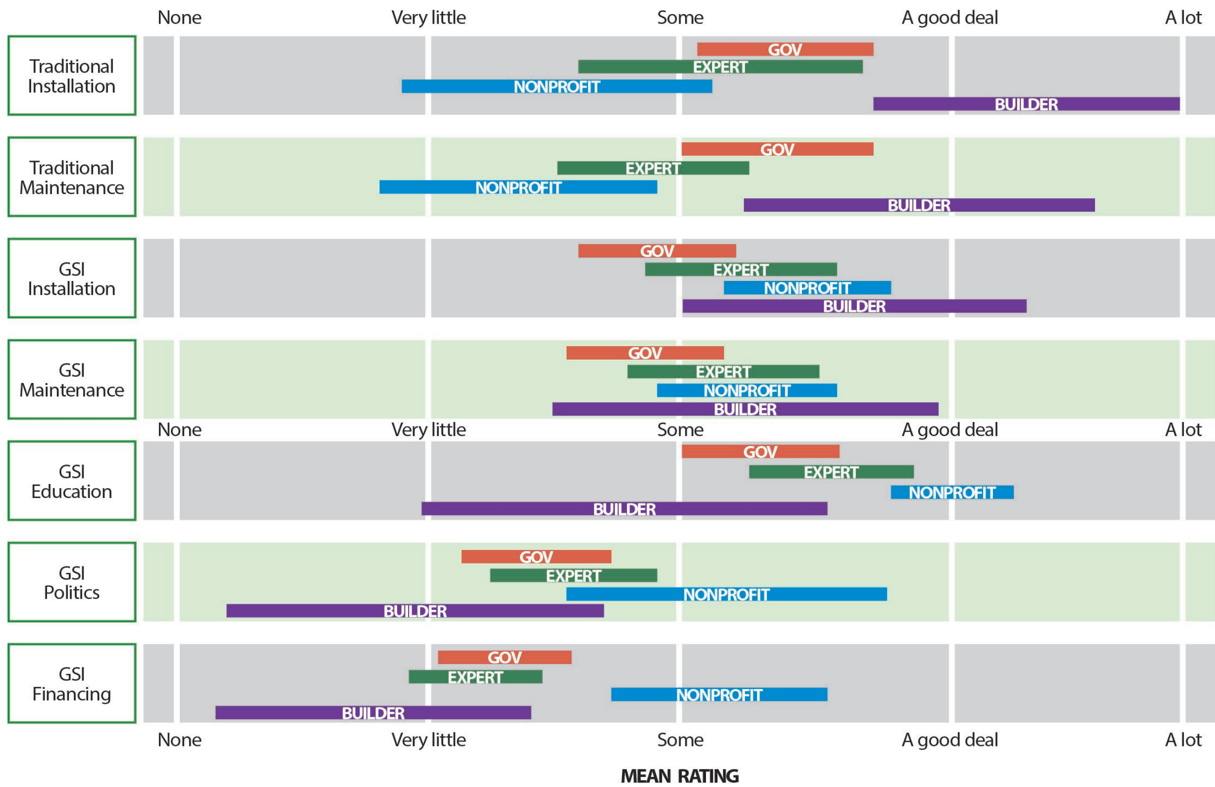
Scale: 1=None, 2=Very Little, 3=Some, 4=A good deal, 5=A lot
SD = Standard Deviation

The range of familiarity across these different topics and roles varied widely. The differences between the groups and topics raise a number of possibilities:

- Builders and government affiliates were more experienced with traditional approaches for stormwater management over GSI. Nonprofits showed the opposite pattern, with more experience for GSI installation and maintenance. Because nonprofits have quite a bit less experience with traditional stormwater management, it may make it difficult for them to communicate with builders and government implementers when making arguments for transitioning to GSI.
- There is slightly less familiarity across all the groups for GSI maintenance than for installation, possibly reflecting the uncertainty of the long-term upkeep of decentralized GSI approaches like rain gardens.
- More than any other group, builders had the most experience installing and maintaining both traditional and GSI but their familiarity with GSI is less than with traditional.
- Government, experts and builders had little experience with GSI education, politics, and funding. Nonprofits had the most experience educating others about, garnering political support for, and acquiring financing for GSI. However, because of the nonprofits' relative lack of experience with the traditional stormwater management approaches that are widely used, their advocacy may not be as effective as it could be. If nonprofits had more experience with traditional approaches that reflect the status quo of how stormwater is currently managed, they may be better positioned to help implementers transition to green approaches.
- Political and financing issues are domains that nonprofits have far more experience with than other groups, suggesting that nonprofits could help close that gap by focus on these two domains in their education efforts.

Figure 6-4: Stormwater management experience visualized across seven topics, broken down by each of the four roles

Question stem: "How much experience do you have with the following?"



Scale: 1=None, 2=Very Little, 3=Some, 4=A good deal, 5=A lot
The bar for each group is centered around the mean and the bar length indicates a 95% confidence interval

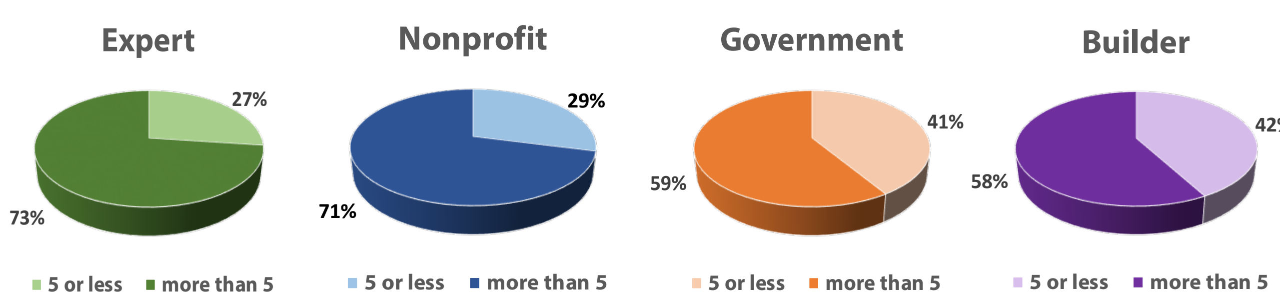
6.3.3 Familiarity with Green Stormwater Infrastructure Examples

Familiarity with examples of GSI reflect a different kind of knowledge than the previous question about experience. Whereas experience is direct or first-hand, familiarity with examples reflects knowledge that may have been acquired from sources beyond first-hand experience. To understand the current state of familiarity with GSI, we asked participants how many successful GSI examples respondents knew about. Figure 6-5 shows the percentage from each group that were familiar with more and less than five GSI examples.

Opportunity

Because 30-40% of respondents across all four groups know fewer than 5 successful examples of green infrastructure, there may be an opportunity to provide education about GSI examples, particularly ones that would work for their specific communities.

Figure 6-5: Familiarity with GSI examples for experts, nonprofits, government, and builders



65% of all respondents knew of more than five successful examples of GSI in Michigan. Over 70% of expert and nonprofit respondents knew more than five examples, however the fraction for government and builders was lower, at 59% and 58% respectively. That 30 to 40% of GI practitioners knew fewer than five successful examples of green infrastructure suggest that developing a library of GSI examples that are relevant to local communities may be helpful. Furthermore, because experts and consultants appear to have a better sense of these examples, their conveying this library of examples to government staff and builders, who are closer to stormwater management implementation but less familiar with GSI examples, may improve GSI adoption.

6.3.4 Perceived Short and Long-term Costs and Benefits of Green Stormwater Infrastructure

Cost benefit analyses are utilized to make determinations on stormwater management approaches. We asked respondents about both the short-term (less than 10 years) and long-term (more than 10 years) benefit-cost ratio of green infrastructure. Figure 6-6 shows the percentage of respondents who find the benefits of GSI outweigh the costs, broken down by group and time frame.

Three main findings from these data are:

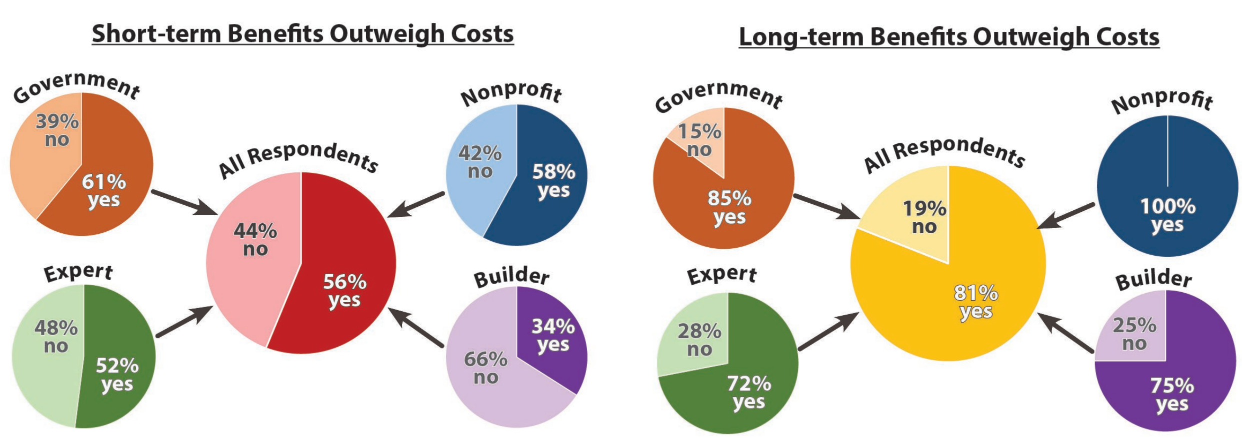
- A majority of respondents felt that both the long-term benefits (81%) and short-term benefits (56%) of GSI outweighed the costs.
- Across all groups, long-term benefit-cost ratio of GSI was perceived to be higher than the short-term benefit-cost, although builders are not quite as optimistic as respondents from the other three groups.
- All but one respondent from the nonprofit sector felt the long-term benefits of GSI far outweighed the costs, whereas nonprofits' perceptions of short-term benefit-cost was mixed.

The findings suggest that many of the benefits associated with GSI are perceived to take longer to realize. Implementing GSI requires short-term action requiring capital for installation and maintenance costs and, perhaps more importantly, confidence that such systems will meet communities' stormwater management needs as well as current traditional systems. Uncertainty about meeting community needs may drive some of the doubt that respondents have about its short-term benefits. Overcoming the status quo approaches may require reducing uncertainty by showing how GSI can have both short- and long-term benefits, both fiscally and functionally.

Opportunity

Many of the benefits associated with GSI are perceived to take longer to be realized, hence the higher long-term benefit-cost ratio. Communicating shorter term benefits might reduce implementation barriers.

Figure 6-6: Benefit-cost comparison for green stormwater infrastructure



Note: Short-term is less than 10 years and long-term is more than 10 years

6.3.5 Barriers to Implementing Green Stormwater Infrastructure

Many barriers exist to implementing green stormwater infrastructure. We proposed 22 such barriers and assessed the relative challenge each posed. Factor analysis of the barriers revealed four categories with six items remaining unfactored (Table 6-3). The four categories were labelled as *Uncertainty*, *Cost and Integration*, *Political,* and *Lack of Resources.* The items comprising each of these categories w ere averaged across all respondents to generate category-level statistics. Both category and item statistics are listed in Table 6-3 and visualized in Figure 6-7.

Opportunity

Moving away from status quo of traditional infrastructure represents a risk that is amplified by uncertainty about GSI maintenance/performance and concerns about costs. Addressing uncertainty about GSI performance and maintenance could be addressed through GSI success stories across a range of different communities or through additional monitoring. Addressing the cost concerns may be reduced if the costs are clearly documented and described. Short-term financing options may also reduce this barrier.

Respondents' answers to questions about GSI adoption barriers showed:

- *Uncertainty,* comprised of issues dealing with maintenance and long-term performance of GSI, was perceived to be the highest barrier.
- In the second highest category of *cost and integration*, installation and maintenance costs were a major concern. Installation costs, in particular, were the highest rated of all the 22 barriers proposed. While uncertainty about GSI was a major barrier, the concern that GSI will underperform traditional stormwater approaches was not perceived to be a major barrier. This may reflect respondents' considering the long-term performance of GSI.
- *Political* issues were rated third highest. The biggest barrier in this category, and the second highest barrier overall, was acceptance among local leaders, municipal staff, and practitioners. Conflicting codes and ordinances were also a major political barrier, while resistance from the regulatory community was less of a barrier.
- *Lack of resources* was perceived to be a medium level barrier, with lack of qualified contractors being a particular concern.
- Of the unfactored items, lack of regional planning and the challenge of implementing

Table 6-3: Barriers to green infrastructure adoption, grouped by factor, ordered by decreasing barrier

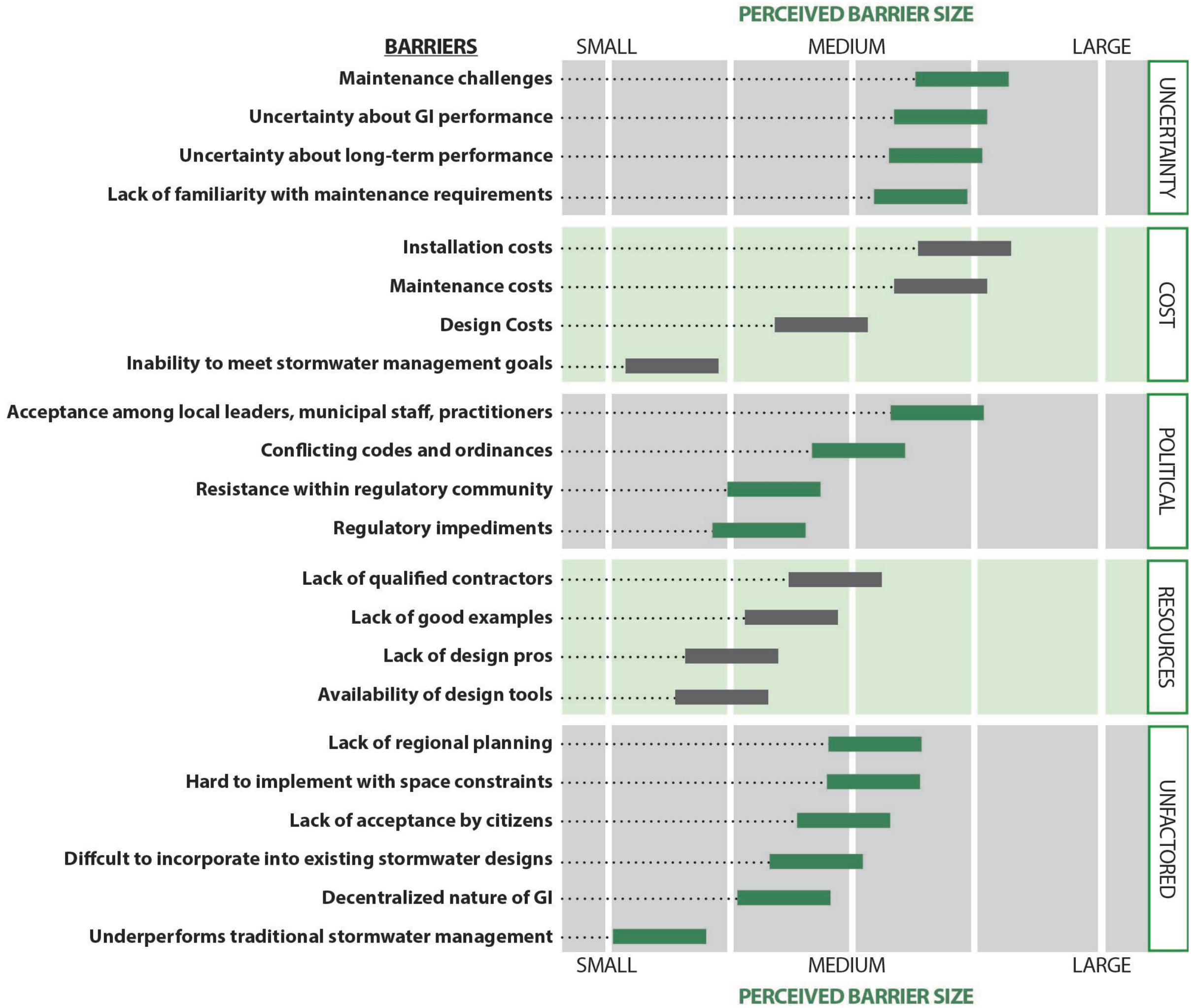
Question stem: "How much of a barrier are the following issues to adopting green infrastructure practices?"

Barriers	Mean (SD)	Alpha/ Loading
Uncertainty	**3.31 (1.09)**	**α = .80**
Maintenance challenges	3.36 (1.05)	.73
Uncertainty about GI performance	3.33 (1.04)	.73
Uncertainty about long-term performance	3.28 (1.11)	.75
Lack of familiarity with maintenance requirements	3.26 (1.15)	.71
Cost and Integration	**2.98 (1.15)**	**α = .71**
Installation costs	3.46 (1.00)	.72
Maintenance costs	3.26 (1.13)	.61
Design costs	2.89 (1.06)	.60
Difficult to incorporate into existing stormwater designs	2.83 (1.07)	.48
Inability to meet stormwater management goals	2.29 (1.06)	.71
Underperforms traditional stormwater management	2.19 (0.97)	.65
Political	**2.95 (1.15)**	**α = .76**
Acceptance among local leaders, municipal staff, practitioners	3.38 (1.07)	.52
Conflicting codes and ordinances	3.03 (1.11)	.74
Resistance within regulatory community	2.73 (1.24)	.76
Regulatory impediments	2.68 (1.08)	.78
Lack of resources	**2.70 (1.08)**	**α = .75**
Lack of qualified contractors	2.96 (1.13)	.70
Lack of good examples	2.76 (1.04)	.58
Lack of design professionals	2.57 (1.08)	.88
Availability of design tools	2.50 (1.03)	.66
Unfactored items	**N/A**	**N/A**
Lack of regional planning	3.18 (1.12)	
Hard to implement with space constraints	3.05 (1.06)	
Lack of acceptance by citizens	2.90 (1.05)	
Decentralized nature of GI	2.72 (1.06)	

Scale: 1=Not at all a barrier, 2=A small barrier, 3=A medium barrier, 4=A large barrier, 5=An enormous barrier. SD = Standard Deviation. N/A refers unfactored items which do not have a group mean, alpha, or loading

Figure 6-7: Barriers to green infrastructure adoption grouped by factor

Question stem: "How much of a barrier are the following issues to adopting green infrastructure practices?"



Scale: 1=Not at all a barrier, 2=A small barrier, 3=A medium barrier, 4=A large barrier, 5=An enormous barrier. The bar for each item is centered around the mean and the bar length indicates a 95% confidence interval.

GSI within space constraints were seen as medium level barriers.

- Cross-tabulating perceptions of barriers with respondents' familiarity with GSI examples revealed that those with less GSI knowledge perceived cost, lack of resources, and GSI underperformance to be higher barriers than those who knew of more successful GSI examples.

Under conditions of uncertainty, stormwater practitioners are likely to maintain the status quo of traditional stormwater management. Moving away from status quo represents a risk that is amplified by uncertainty about GSI maintenance/performance and concerns about costs. Addressing uncertainty about GSI performance and maintenance could be addressed through GSI success stories across a range of different communities or through additional monitoring. Addressing the cost concerns may be reduced if the costs are clearly documented and described. Short-term financing options may also reduce this barrier.

<u>6.3.6 Approaches to Overcome Barriers to Implementing Green Stormwater Infrastructure</u>

Perceptions of the effectiveness and feasibility of different ways to overcome barriers to GSI adoption can influence which approaches are utilized. We assessed the relative effectiveness and feasibility of 20 such approaches. Using factor analysis, the approaches were grouped into six categories: *aesthetics*, *education*, *incentives*, *regulations and planning*, *human capacity*, and *creative financing*.

The means and standard deviations for the categories and the items are shown in Table 6-4. Figure 6-8 and Figure 6-9 show a zoomed-in two-dimensional representation of the results, with approaches in the upper right corner being perceived as being more effective and more feasible while the lower left corner being perceived as being less effective and less feasible.

These data showed:

- *Incentives*, which included state incentives and water quality incentives, were perceived to be the most effective but only somewhat feasible, suggesting that politics and funding were limiting barriers. The idea that EGLE should provide incentives for GSI was the seen as the most effective of all the strategies, but again only somewhat feasible. Nonprofits were more optimistic about the efficacy of incentives than builders.

Table 6-4: Effectiveness and feasibility of approaches to overcome barriers to GSI implementation (sorted by effectiveness of factors)

Question stem: "Please rate the following approaches in terms of the following: A. How effective do you think each would be at overcoming barriers to implementing GI; AND B. How feasible do you think each approach would be to implement (i.e., logistically, politically, financially)?"

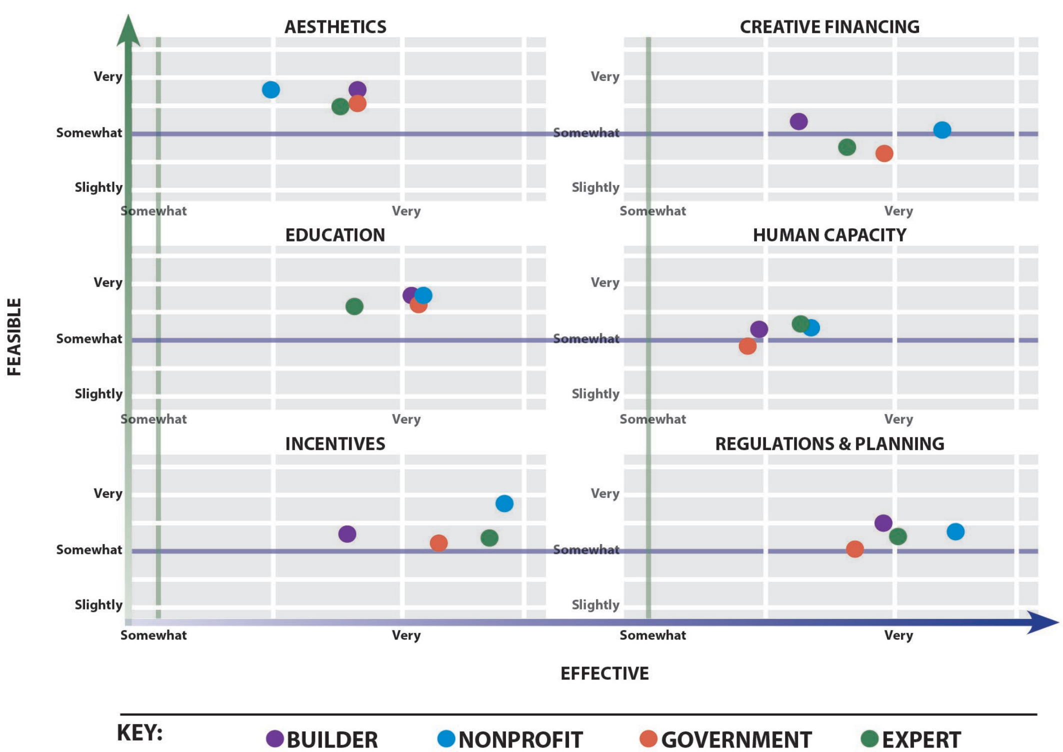
APPROACH TO REDUCE BARRIERS TO GSI ADOPTION	EFFECTIVENESS MEAN (SD)	FEASIBILITY MEAN (SD)
Incentives	**4.21 (1.02)**	**3.18 (1.24)**
MI Environment, Great Lakes & Energy (EGLE) should provide incentives for GI	4.36 (0.98)	3.21 (1.31)
Enact water quality-based incentives for managing stormwater	4.07 (1.05)	3.15 (1.18)
Education	**3.97 (1.01)**	**3.60 (1.03)**
Show that newer technologies are effective, efficient, and can save the community money	4.13 (0.97)	3.51 (1.08)
Demonstrate how GI technology will benefit communities over their current practices	4.08 (0.92)	3.52 (1.00)
Show how new technologies can supplement traditional stormwater systems	4.02 (0.91)	3.64 (0.95)
Train existing staff	3.93 (1.02)	3.73 (1.04)
Public education and outreach to increase acceptance of green infrastructure projects	3.84 (1.12)	3.74 (1.02)
Educate developers about benefits of green infrastructure	3.82 (1.04)	3.48 (1.07)
Regulations and Planning	**3.95 (1.08)**	**3.21 (1.10)**
Incorporate green infrastructure best management practices into development goals	4.18 (0.93)	3.44 (1.04)
Integrate local and regional planning and policies to encourage green infrastructure	4.12 (1.01)	3.27 (1.08)
Enact local stormwater ordinances and standards	4.05 (1.07)	3.41 (1.10)
Simplify and unify stormwater regulations	3.84 (1.14)	2.83 (1.10)
Categorize green infrastructure implementation as a stormwater maintenance cost	3.57 (1.14)	3.11 (1.10)
Creative Financing	**3.92 (1.20)**	**2.74 (1.25)**
MI Department of Transportation should provide funds for GI on roads	4.22 (0.98)	2.97 (1.28)
Create a customer-funded stormwater utility to cover costs of providing GI services	3.85 (1.28)	2.41 (1.23)
Allow for third-party or private funding of GI	3.70 (1.27)	2.83 (1.18)
Aesthetics	**3.73 (1.14)**	**3.59 (1.06)**
Improve the aesthetics of GI	3.73 (1.11)	3.59 (1.06)
Human Capacity	**3.51 (1.21)**	**3.07 (1.20)**
Identify individuals who can champion GI in a community	3.72 (1.08)	3.43 (1.06)
Connect developers, contractors, and landowners at a mandatory meeting at project start	3.71 (1.20)	3.09 (1.24)
Outsource maintenance	3.11 (1.24)	2.70 (1.20)

Scale: 1=not at all, 2=slightly, 3=somewhat, 4=very, 5=definitely, SD = Standard Deviation

Figure 6-8: Categories of approaches to overcome barriers to GSI implementation

Figure 6-9: Approaches to overcome barriers to GSI implementation, grouped by factor & role

Question stem: "Please rate the following approaches in terms of the following: A. How effective do you think each would be at overcoming barriers to implementing GI; AND B. How feasible do you think each approach would be to implement (i.e., logistically, politically, financially)?"



Scale: 1=not at all, 2=slightly, 3=somewhat, 4=very, 5=definitely, SD = Standard Deviation

- *Educational* approaches were seen as the most feasible and also quite effective, but less so than incentives. In particular, showing the fiscal and functional efficiency of GSI technologies were rated the most effective approach, though its feasibility rating was lower. Similarly, effective approaches were demonstrating how GSI can both supplement and do better than traditional stormwater systems. The lower perceived feasibility of these items suggests that some creativity is required in conveying this kind of information to stormwater practitioners. However, experts—who often play an educational role in academia—were slightly less optimistic than other groups about the role education could play in overcoming GSI adoption barriers.
- *Regulations and planning* approaches, such as incorporating best GSI management practices into development goals, integrating local and regional planning, and enacting local stormwater ordinances were seen as very effective. However, as in the case of incentives, they were seen as only somewhat feasible, perhaps because these decisions are often out of the hands of most individual stormwater practitioners. Nonprofits were the most optimistic about the effectiveness of regulatory approaches.
- *Creative financing* approaches, such as creating a customer-funded stormwater utility or private funding of GSI, were seen as having the potential to be effective but were seen also seen as less feasible. In particular, having the Michigan Department of Transportation provide funds for green infrastructure on roads was rated one of the most effective approaches, but rated only somewhat feasible. Among the groups, nonprofits felt that creative financing approaches were more effective while builders were less optimistic. Government respondents felt these approaches were less feasible than other groups, which may reflect their sense of the political limitations of such efforts.
- Improving the *aesthetics* of GSI was seen as both effective and feasible and may provide a way to overcome resistance in the local community. Nonprofits felt this was a less effective approach than other groups.
- *Human capacity*, which included connecting stakeholders and outsourcing maintenance, was seen as reasonably effective and somewhat feasible. Identifying individuals in a community who can champion green infrastructure was the highest rated approach for both effectiveness and feasibility in this category. The four groups were in reasonable agreement about the effectiveness of these human capacity related approaches.

Generally, most approaches were rated higher for effectiveness than for feasibility. The gap between effectiveness and feasibility was highest for *creative financing* and lowest for *aesthetics*. Respondents were pessimistic about the feasibility of *incentives*, *regulations and planning*, and *creative financing*. The gap between effectiveness and feasibility suggests that respondents may be pessimistic about the implementation of "pie-in-the-sky" approaches. Lack of awareness of successful approaches in other communities and states could explain this pessimism.

In cases where feasibility was rated more highly, it may suggest approaches to prioritize. For example, public education and outreach to increase acceptance of green infrastructure projects was rated highest among all 20 approaches for feasibility. Training existing staff members was also one of the most feasible approaches, though the type of training may depend on the practitioner's role. For nonprofits and experts, this may mean gaining a better understanding of traditional stormwater management. For government, it may mean better understanding how to get financial and political support for GSI.

6.4 Discussion

If, as many experts argue, green stormwater infrastructure is superior to traditional approaches, why hasn't it been more widely adopted? One possible explanation comes from the knowledge and perceptions of GSI that practitioners carry which influence the decisions they ultimately make around adopting GSI. Accordingly, this survey examined Michigan stormwater practitioners' knowledge of GSI and their perception of its benefits, barriers to its adoption, and approaches to overcoming those barriers.

This survey was an exploratory study and results should be taken in consideration of its limitations. First, response rates were low and not evenly distributed geographically or across roles. In particular, the number of nonprofits and builders in the sample was small (26 and 15, respectively) which increases uncertainty about group differences. However, the number of responses from non-profits may be reasonable considering the number of individuals employed in that category. It should also be noted that an extra effort was made to recruit builders to complete the survey, but their response rate remained small. Second, because people were invited to take a survey about stormwater management using green infrastructure, people interested in GSI may have been more likely to respond than those less interested. While this could limit generalizing the results beyond Michigan stormwater practitioners who care about GSI, the wide range of experience with both traditional and GSI experience (see section 6.3.2) suggests that even among self-selected survey respondents, there is reasonable diversity of awareness about GSI. Considering these limitations, the data from the survey raise three integrated themes about GSI adoption from a practitioner's perspective.

First, ***inertia, risk aversion, and uncertainty must be overcome to implement green stormwater infrastructure.*** The status quo for stormwater management is traditional infrastructure, often called "grey infrastructure". Because these systems have been in place for decades, they are a known quantity and have a network of experts engaged in implementation. This lends a great deal of inertia to traditional approaches and, accordingly, impedes the adoption of GSI. Risk aversion also impedes GSI adoption. Government officials and staff manage stormwater to prevent flooding and pollution in water supplies that communities depend on. Builders of stormwater systems may see an investment in GSI as having higher risk. Both of these implementers of GSI are appropriately risk averse in that they do not want to take a chance on a new system that, in their perspective, has yet to be proven. As Polich et al (2017) note, most communities do not want to be on the cutting edge. The survey responses showed that uncertainty may be a driver of the reluctance to implement GSI. While respondents recognized that the benefits of green infrastructure outweigh the costs, their uncertainty about costs, functionality, and maintenance suggest that risk-averse stormwater implementers may avoid GSI. Thus, the combination of uncertainty around GSI implementation, the inertia of traditional stormwater management approaches, and the risk aversion of GSI implementers may partially explain why the transition to GSI has been so slow.

Second, ***there may be a divide between implementers and advocates of GSI.*** The survey showed that stormwater implementers in government and the building industry had higher levels of experience with building and maintaining traditional infrastructure while advocates in academia and nonprofits had more experience with GSI education, politics, and financing. Advocates knew of more successful GSI examples than did implementers and advocates were also more optimistic than implementers about the benefit-cost ratio of GSI, particularly in the short-term. These findings suggest that advocates may have more conceptual knowledge about stormwater management, particularly with respect to GSI, while implementers have more practical experience. The scope of one's stormwater experience may explain some of the divide. Whereas implementers are generally focused on one or two communities and have a detailed awareness of local needs, advocates may be working across multiple communities and have a broader awareness of GSI efforts. This experiential divide can hinder communication because advocates may speak conceptually about the advantages of GSI but may not understand or address the local stormwater needs which implementers focus on.

Finally, ***GSI education and policies must be locally relevant and focused on enabling the transition from traditional to green stormwater infrastructure.*** Accelerating the implementation of GSI requires overcoming the inertia of traditional approaches and reducing the risks associated with GSI. In order to do so, education, incentives, and policies need to improve confidence in GSI, both functionally and fiscally.

Making any transition requires knowledge of the starting point (traditional stormwater infrastructure) and the ending point (green

stormwater infrastructure). The survey findings suggest that implementers know more about the starting point, while advocates know about more about the ending point. An effective transition will require both advocates and implementers to share knowledge with each other. Because stormwater management needs vary widely across Michigan communities, advocates who are engaged in outreach and training for GSI need to better incorporate local stormwater needs into their educational efforts. Implementers also need to better convey their local needs to implementers. Additionally, advocates who have a great deal of GSI expertise may need to better understand how traditional stormwater systems work so they can develop more creative transition plans. The survey showed that respondents felt strongly that examples showing how GSI technologies can be effective, efficient, save the community money, and benefit communities over current practices (Table 6-4) would be effective at overcoming barriers to GSI adoption. Examples that show each community how new GSI approaches can work in their specific contexts could help reduce the risk implementers feel about GSI.
Survey respondents were clear that the long-term benefits of GSI outweigh its costs, however there was more doubt about the short-term benefits, particularly for implementers. The relative optimism of nonprofits and academics may result from their understanding of policy or financing mechanisms. The relative pessimism of government affiliates and builders may result from the lack of implemented policies at local, regional, and state governments. Nevertheless, incentives, policies, planning, and financing approaches can serve as a hedge against short-term doubt about GSI and foster the transition. However, current stormwater management is guided by a patchwork of policies that have often not met local needs (Polich et al, 2017). The joint creativity of advocates and implementers could innovate on policy-based approaches that could better meet local stormwater needs.

Many factors have hindered the adoption of GSI. The survey results considered a narrow, but important piece of the puzzle—the role of stormwater practitioners' knowledge and perceptions of GSI. What stormwater practitioners carry around in their heads will drive their decisions around GSI. The study broadly showed that uncertainty around GSI is an important barrier to overcome if GSI is to be adopted. It also showed a divide between stormwater practitioners—those who implement stormwater infrastructure locally and those who advocate for new approaches like GSI more widely. Finally, it showed the need for a clearer vision of how to transition from traditional to green stormwater infrastructure. These findings are broad strokes, but they do paint a picture where innovation in GSI education and policies will play an important role in overcoming the inertia of traditional stormwater management.

7.0 RESEARCH SUMMARY

Green Infrastructure in Michigan: An Integrated Assessment of Its Use, Barriers, and Opportunities Project was conducted by Lawrence Technological University, Environmental Consulting & Technology, Inc., and the University of Michigan. The project focused on developing an understanding of drivers leading to the successful implementation of GI in the state of Michigan. However, much of the information is easily transferrable to the Great Lakes basin and beyond. The goal of all Integrated Assessment (IA) research projects is to use the best available data and analytical tools to answer a research question regarding a specific environmental issue. In the case of this project, the policy-relevant research question was:

> *What are the long-term sustainable strategies that will enable Michigan's communities to begin the wide-spread implementation of green infrastructure and reap triple bottom-line benefits?*

To address this research question, four tasks associated with the IA research process were undertaken:

- Task 1: Define and refine the policy-relevant research question of the barriers to the use of GI
- Task 2: Clarify the history, causes, and consequences surrounding the issue
- Task 3: Identify and evaluate potential options to address the issue through community engagement
- Task 4: Develop and disseminate information that can guide decisions and aid in wide-spread implementation of GI

7.1 Task 1: Define and refine the policy-relevant question

This task was an initial summary of existing information to clarify the policy-relevant research question (posed above). The project team used previously published datasets and reports to describe the use of green infrastructure in the region to inform an advisory board that was convened to direct future tasks. The advisory board validated the research question, but did suggest a simpler version to guide conversations:

> *If green infrastructure is actually superior to grey infrastructure, why is it not utilized more?*

However, it should be noted that as the project evolved, stakeholders challenged this alternative simplified version of the research question. Discussions during Task 2 and Task 3 activities suggested the topic should not be framed as "green vs. grey" but rather "how can green infrastructure complement or enhance grey infrastructure" since they fundamentally serve different purposes. This sentiment is shared by the principal investigators on this project.

The advisory board had other valuable suggestions for implementing the research plan including:

- They believed the value of GI is "greater than the sum of individual parts" and that co-benefits should be articulated to improve the value proposition. They also believed the cost-benefit ratio improves with time but can be hard to demonstrate.
- They thought it was important to differentiate between green infrastructure and green stormwater infrastructure. Consensus was that the term "green infrastructure" was appropriate to use (instead of low impact design or green stormwater infrastructure) because of general understanding and common use of the term green infrastructure as long as the design team was clear during future tasks that the primary focus is stormwater management.
- They thought it was important for each community to address the following questions: How are local decisions made? Who can

influence those decisions? What are the institutionalized barriers to GI in that community? How can those specific barriers be addressed?
- They thought it was important to connect GI to local water issues (lakes, streams, streams, etc.). In other works, it is better to focus on what it can do for "my community" instead of the entire Great Lakes.
- Finally, they had specific recommendations (discussed in subsequent sections) on who to engage during focus groups, community visioning sessions, and for survey distribution.

7.2 Task 2: Clarify the history, causes, and consequences of the issue

This task had two overarching subtasks: 1) synthesize existing information on green infrastructure planning and implementation and 2) convene focus groups of policy makers and stakeholders to further clarify the issue.

The broad synthesize of information is covered in Chapter 3 of this report, and the implementation of GI in Michigan is articulated in Chapter 4. Overall, research indicated there were significant barriers to widespread implementation of GI including financing, policy, knowledge, risk aversion, and public acceptance. However, several Michigan communities have successfully implemented GI as a strategy for dealing with various stormwater quantity and quality concerns. The most successful situations are where the decisions to invest in GI was locally driven with regional governmental consortiums and/or non-profit organizations assisting in the process.

The project team hosted focus groups at the following state-wide or regional meetings of stakeholders that broadly represent groups interested in GI:

- Michigan Municipal League
- Michigan Association of Planners
- Michigan Water Environment Association
- Michigan Association of County Drain Commissioners, and
- Macatawa Area Coordinating Council.

By hosting focus groups at diverse venues, the research team had discussions with planners, engineers, elected officials, staff, and citizens to explore the causes and consequences of barriers to GI implementation. Topics that were discussed extensively included: financing, life-cycle cost analysis (there was consensus that the true cost associated with GI is unknown); uncertainty associated with long-term performance and required maintenance; hydrologic performance in various weather and site conditions; barriers based on codes and ordinances (there was consensus that if a community wants to have widespread implementation of GI, there needs to be regulatory drivers); aesthetics and public acceptance; and design and construction of GI. Finally, some focus groups discussed in depth the co-benefits of GI. Traditional stormwater management techniques have one purpose while successfully implemented GI can serve multiple purposes including improving quality of life for residents. Some focus group participants view articulating co-benefits as essential to GI implementation.

7.3 Task 3: Identify and evaluate potential options through community engagement

This task had two overarching subtasks: 1) community visioning sessions and 2) development and implementation of an online survey.

Public engagement sessions were held in Zeeland/Holland, Elk Rapids, Royal Oak, and Arcadia. Each of these communities were engaged based on the needs of the community and details are in Chapter 5. With regards to public engagement, the most important aspects are determining local values; developing a common language/framework for discussions; developing and communicating a GI vision based on those values; and evaluating community capacity and leadership for implementing the GI vision.

Finally, the aim of the survey was to better understand the barriers that exist to the adoption of GI. The details of survey methodology and findings are in Chapter 6. The survey results determined that inertia, risk aversion, and uncertainty must be overcome to implement green stormwater infrastructure. The status quo for stormwater management is grey infrastructure. Because these systems have been functional for decades, there is a great deal of acceptance around traditional approaches and, accordingly, this impedes the adoption of GI. The survey also determined there may be a divide between implementers of GI and advocates of GI. The survey showed that stormwater implementers in government and the construction industry had higher levels of experience with building and maintaining traditional infrastructure while advocates for GI in academia and nonprofits had more experience with GI education, politics, and financing. This disconnect in experience and language is a distinctive barrier. Finally, the survey demonstrated GI education and policies must be locally relevant and focused on enabling the transition from traditional infrastructure to GI.

7.4 Task 4: Develop and disseminate information

During the duration of the IA research project, over one thousand community leaders, professionals, and engaged citizens across the state were engaged. Tangible products of the project were this final report; an executive summary of the survey results (Basu, Sinha, and Carpenter, 2020); community engagement reports for Elk Rapids, Royal Oak, Zeeland, and Arcadia; funding and policy recommendations; and a series of workshops/presentations on the findings. The information compiled provides direction for decision makers to implement green infrastructure on a wider scale.

7.5 Key barriers and opportunities

In summary, key barriers to GI implementation identified during the project included conflicting codes/ordinances, cost, lack of financing options, maintenance difficulties, municipal and public acceptance, lack of regional planning, and uncertainty in performance. Opportunities for removing those barriers included:

- Revising local codes and ordinances to allow for and/or promote GI, which can be initiated by a code audit process.
- Establishing funding mechanisms for both implementation and maintenance (while funding is necessary, but not sufficient for widespread implementation).
- Identifying and cultivating local leaders (both elected and civic) who can advocate for GI implementation.
- Articulating the co-benefits of GI to improve the value proposition and long-term cost/benefit ratio.
- Determining local community values (such as recreation, wildlife habitat, aesthetics, climate resiliency, etc.) and develop GI implementation strategies that align the benefits of GI with those values. However, those implementation strategies need to align with community capacity.
- Establishing programs for simplified long-term monitoring and maintenance of GI.
- Developing a framework to integrate local and regional planning and policies to encourage coordination across agencies and jurisdictions.
- Conducting public education and outreach projects to assist public works professionals and citizens with understanding the role of GI in their communities (while education is necessary, it is not sufficient for widespread implementation).

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