WATER CENTER
UNIVERSITY OF MICHIGAN

NEW-GI
Neighborhood, Environment & Water Research Collaborations for Green Infrastructure

Joan Nassauer, Margaret Dewar, Shawn McElmurry, Natalie Sampson, Alicia Alvarez, Allen Burton, Catherine Riseng, Amy Schulz, Noah Webster, Nathaniel Lichten

ADVISORY BRIEF | APRIL 2016

EXECUTIVE SUMMARY

Executive Summary

We conducted an initial survey of 163 nearby neighborhood residents to understand residents' perceptions of the designs and of their neighborhood.

NEIGHBORHOOD, ENVIRONMENT AND WATER research collaborations for Green Infrastructure (NEW-GI) links Detroit's vacant property demolition process with new forms of green infrastructure (GI) designed for both ecological and social benefits. It uses a transdisciplinary design-in-science approach, bringing researchers and practitioners together to develop GI designed to manage stormwater and increase resident well-being where vacant property is changing neighborhoods. By assessing design performance, NEW-GI aims to contribute to future strategies for successful GI in Detroit.

PHASE ONE (2014-2015): In NEW-GI's first phase, project collaborators developed bioretention flower garden designs (Figure 1) and constructed four pilot sites on vacant lots in the Warrendale neighborhood of the Cody Rouge area on Detroit's west side. We conducted an initial survey of 163 nearby neighborhood residents to understand residents' perceptions of the designs and of their neighborhood. We also studied aspects of governance in Detroit and Cleveland that affect the implementation and maintenance of GI on vacant property.

PHASE TWO (2016-2018): In NEW-GI's second phase, we will provide guidance to inform GI development throughout Detroit. We will assess how residents perceive the pilot gardens, their impacts on residents' well-being, impacts on the quantity and quality of water entering the sewer system, and the ways in which existing governance systems shape GI installation and maintenance. Drawing on our analyses and on key findings in scholarly literature, we will produce guidance documents for local decision-makers and other GI stakeholders.

The following brief describes NEW-GI's goals and early outcomes, results from our initial neighborhood survey and governance analysis, and ongoing research.

FIGURE 1: Berm (top) and bollard (bottom) bioretention garden designs
IMAGES: NASSAUER LANDSCAPE ECOLOGY, PERCEPTION, AND DESIGN LAB

INTRODUCTION AND APPROACH

Within NEW-GI, collaboration between researchers and public sector practitioners and community members ensures that research is tuned to real needs and opportunities in Detroit.

NEW-GI (Neighborhood, Environment, and Water research collaborations for Green Infrastructure) is a transdisciplinary research project that integrates water quality, community well-being, governance, and design research in legacy cities. Through community, government, and academic collaboration, it produces evidence-based guidance for sustainably managing stormwater in ways that enhance Detroit landscapes and the lives of its residents.

NEW-GI links Detroit's vacant property demolition process with new forms of green infrastructure (GI) designed to manage stormwater and increase nearby residents' well-being. Green infrastructure is one use for vacant land with potential benefits for both the natural and social systems (Nassauer & Raskin, 2014). The US EPA defines green infrastructure as "systems and practices that use or mimic natural processes to infiltrate, evapotranspirate…or use stormwater on the site where it is generated," rather than removing runoff from the site through a municipal stormwater system"(US Environmental Protection Agency, 2016). By managing stormwater, GI may reduce flooding and combined sewer overflows, improve water quality, and address other environmental and human health hazards. A growing body of research also indicates that GI also has potential for health and well-being benefits such as enhanced neighborhood attractiveness, increased property values and increased opportunities for physical activity (Hufnagel & Rottle, 2014).

In NEW-GI, we apply and expand this research using a transdisciplinary de-sign-in-science approach, in which scientists and practitioners work together to draw on the science knowledge base to develop landscape designs that implement integrated strategies for achieving social and ecological objectives (Nassauer & Opdam, 2008). By evaluating the designs' performance relative to these objectives, collaborators can assess and refine them as strategies for future use while also building scientific knowledge.

Within NEW-GI, collaboration between researchers and public sector practi-tioners and community members ensures that research is tuned to real needs and opportunities in Detroit. The City of Detroit, with leading participation by the Detroit Water and Sewerage Department (DWSD) and the Detroit Land Bank Authority (DLBA), was essential to initiating and implementing the pilot phase of NEW-GI. The Cody Rouge Community Action Alliance and Warrendale Community Organization generously and creatively grounded the pilot project with community knowledge and perspectives. Enriched by new collaborations, these team members are essential to ongoing NEW-GI research.

OUR TRANSDISCIPLINARY TEAM

ADVISORY COMMITTEE OF COLLABORATORS IN PRACTICE:

Detroit Water and Sewerage Department

Detroit Land Bank Authority

Detroit Department of Planning and Development

Detroit Department of Housing and Revitalization

Cody Rouge Community Action Alliance

Warrendale Community Organization

RESEARCHERS:

Joan Nassauer (University of Michigan, Natural Resources and Environment)

Alicia Alvarez (University of Michigan, Law)

Allen Burton and **Catherine Riseng** (University of Michigan, Natural Resources and Environment)

Margaret Dewar (University of Michigan, Urban Planning)

Shawn McElmurry (Wayne State, Engineering)

Natalie Sampson (U-M Dearborn, Health and Human Services)

Amy Schulz (University of Michigan, Public Health)

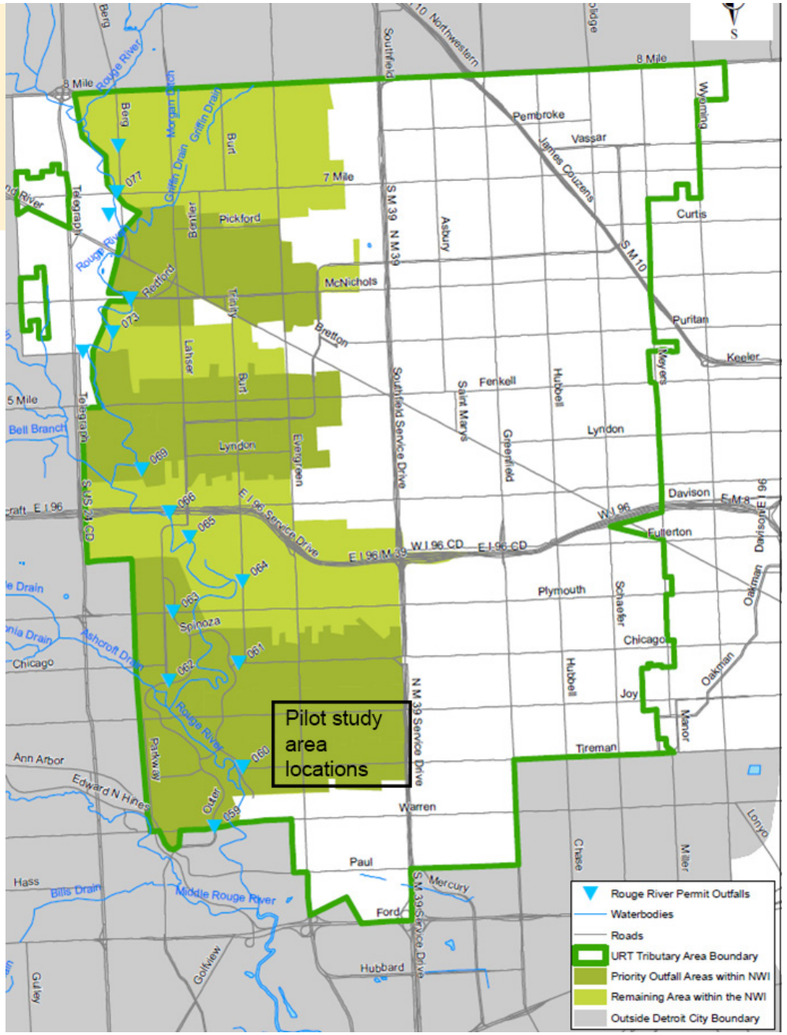
Noah Webster (Institute for Social Research)

The University of Michigan Water Center supports NEW-GI with a grant from the Erb Family Foundation.

Pilot Sites and Performance Assessment

In NEW-GI's first phase (2014-2015), we used design-in-science to develop bioretention flower garden designs and constructed four pilot sites on vacant lots as a strategy for managing stormwater and increasing the well-being of nearby residents. The four pilot sites are two replicates of each of two garden designs. We developed the designs and water quality sampling approach in detail with the Detroit Water and Sewerage Department and their contractors, who constructed the gardens. Each garden occupies two adjacent Detroit Land Bank Authority properties in the Warrendale neighborhood of the Cody Rouge area on Detroit's west side (Figure 2 and 3). Before construction, we conducted an initial survey of 163 nearby neighborhood residents to understand residents' per-ceptions of GI and their neighborhood. Throughout this process, we also studied aspects of governance in Detroit and Cleveland that affect the implementation of GI on vacant property. We now are evaluating the gardens' overall social and water quality performance to provide guidance to inform GI development throughout Detroit.

FIGURE 2: Pilot sites were constructed in the Warrendale neighborhood of the Cody Rouge area on Detroit's West Side.



USING SCIENCE AS THE BASIS FOR GREEN INFRASTRUCTURE DESIGN

White papers and briefs. In the second phase of the project (2016-2018), the research team will aid Detroit decision-makers in implementing cost-effective GI that produces environmental and social benefits. We will issue a series of white papers and briefs that draw on the pilot site performance assessments and on the scientific literature:

- *Brief Report on phase one findings (July 2016)*: will report the results of our 2015-16 neighborhood survey and comparative governance analysis.

- *White Paper on scholarly literature (December 2016)*: will synthesize GI-related scholarly literature from several disciplines to provide actionable guidance for Detroit GI decision makers.

FIGURE 3: Berm (green marker) and bollard (blue marker) pilot gardens are clustered in Study Areas 1 and 2. Residents within approximately 800 feet (grey boxes) were included in the initial survey. Each area includes a control site (yellow marker).

- *Integrated assessment of pilot gardens (March 2018)*: will include our water quality assessment of the pilot gardens integrated with results of a post-construction survey of nearby residents. It also will draw on our analysis of GI governance characteristics with an updated literature review to provide further guidance to Detroit GI decision-makers. Integrated assessments "bring together knowledge of ecosystems, people and policy to develop tools and information that policy makers can use" (Michigan Sea Grant & Graham Sustainability Institute, 2009).

- *White Paper (September 2018)* on the implications of the investigation with an updated look at the literature across our disciplines.

- *Concept Report (November 2018)* supplements the final White Paper with alternative watershed scale design concepts and governance approaches.

- *Short technical reports* will be issued in response to specific questions raised by Advisory Committee members and other Detroit decision-makers. These reports will address aspects of the gardens' performance related to NPDES permit compliance and identify opportunities for multi-functional community benefits.

The Advisory Committee will work with researchers to ensure that the integrated assessment and these publications address the concerns and priorities of GI practitioners.

Watershed scale design concepts and governance approaches. Throughout the second phase of the project, we will work with the Advisory Committee to develop more effective, cost-efficient GI design concepts and governance approaches for sub-watershed application in Detroit by drawing on the literature synthesis, results from performance assessments, and the 2017 integrated assessment.

GARDEN PERFORMANCE OBJECTIVES

From 2016-2018, NEW-GI's second phase will assess performance objectives related to five aspects of the pilot gardens:

- **DESIGN:** Assess the overall performance of two alternative GI designs based on an integration of human, water quality and the experience of governance characteristics. Our design researchers are working with our DWSD collaborators to analyze the costs of constructing and maintaining the pilot gardens. From this analysis, we will develop design concepts and identify governance opportunities to minimize maintenance and long-term costs of GI and provide alternative design concepts for a sub-watershed application in Detroit.

- **MAINTENANCE** is an overarching research objective for people, water and governance aspects of this assessment. As a part of NEW-GI's design-in-science approach, DWSD has committed to maintaining the pilot gardens while they are assessed over the next three years. We will examine the types of maintenance required to sustain the gardens' people and water performance during this period, and identify design concepts and governance opportunities for supporting long-term GI maintenance throughout Detroit. In addition, with support from the U of M Water Center, in February-March 2016 we designed and administered a survey among a random sample (N=2500) of Upper Rouge Tributary area residents specifically focused on residents' current practices, perceived likelihood and barriers to engaging in maintenance activities relevant to GI.

- **PEOPLE:** impacts on nearby residents' health, well-being and satisfaction with their neighborhood.

- **WATER**: effectiveness in reducing the quantity and improving the quality of water entering the sewer system during wet weather.

- **GOVERNANCE:** the ways in which governance systems affected the pilot garden installations, as compared with best-practice models for installing and maintaining green infrastructure.

These objectives were informed by scholarship on green infrastructure's environmental performance, the public health impacts of urban green space, and design research into what people value about the appearance of their neighborhoods. We also drew on our teams' long history of collaborative design and research in Detroit neighborhoods. Diverse collaborators have worked to ensure that the designs are multi-functional, providing long-term benefits beyond any single use (De Groot, 2006; De Groot, Alkemade, Braat, Hein & Willemen, 2010). Objectives that are specific to our investigations of people, water, and governance are detailed below.

PEOPLE: The following objectives are related to residents' perceptions of specific features in each design, as well as the gardens' overall impact on the neighborhood:

1. *Attractiveness:* The gardens are designed to appear to nearby residents as more attractive, neater, and better cared for than vacant lots with regular mowing or with only annual mowing maintenance. This is accomplished through features described in Figure 4, which give the appearance of a well-maintained garden.

2. *Safety:* The gardens are also designed to appear safer, because of features described in Figure 4.

Our design researchers are working with our DWSD collaborators to analyze the costs of constructing and maintaining the pilot gardens.

FIGURE 4: Attractiveness and safety features in bollard garden design.
Illustration by QIULING CHEN

Changes to codes, ordinances, and manuals may better support green infrastructure development on vacant lots.

3. *Preferences:* We anticipate that residents will prefer GI gardens over regular mowing or only annual mowing maintenance on vacant lots in their neighborhood because of the GIS designs' perceived care and neatness which enhance perceptions of safety and attractiveness.

4. *Health and well-being:* We anticipate that residents will report that having a GI garden in their neighborhood will reduce their stress and increase walking and other behaviors that have consequent health benefits. Residents also will report that they expect increased property values, feel safer in their neighborhood, and more frequently interact with neighbors.

5. *Familiarity and vacancy:* We anticipate that residents who are more familiar with garden sites because they live nearby, have a direct view, or pass by frequently will report larger expected health and well-being benefits than those who see the gardens less frequently. Residents in higher-vacancy areas will report greater impacts on their own and neighborhood well-being as compared to residents of lower-vacancy areas.

6. *Maintenance:* We anticipate that residents will prefer that government maintain GI sites, but that residents' knowledge about how to maintain landscapes, access to tools, and incentive for their participation that could affect their propensity to participate in maintaining GI.

WATER: The bioretention gardens are also designed to achieve stormwater management objectives:

7. *Stormwater quality improvement:* The gardens are designed to capture stormwater from the street and immediate site surface, reducing the quantity and improve the quality of water entering the municipal sewer system. This is accomplished using features described in Figure 5 and 10.

8. *Localized flooding:* Our DWSD collaborators will monitor shallow groundwater levels to ensure that gardens do not contribute to localized basement flooding (Figure 5 and 12).

9. *Maintenance:* We will track the types and frequency of maintenance performed by DWSD contractors and propose what is needed to sustain the gardens' performance.

GOVERNANCE: Implementing the GI designs allows us to assess policies and governance procedures that affect GI development on vacant lots:

10. *Codes and ordinances:* Changes to codes, ordinances, and manuals may better support green infrastructure development on vacant lots. This may include changes to land ownership transfer procedures, demolition procedures to directly prepare vacant property to implement GI, conditions under which installations on vacant land can compensate for lack of stormwater retention and remediation elsewhere in the city.

11. *Administrative systems:* Possibly administrative systems and guidelines could clarify city departments' responsibilities related to green infrastructure, including permitting and inspecting GI.

12. *Costs:* Improving the governance procedures in objectives 10 and 11 may reduce the capital costs and construction times of future GI installations.

13. *Maintenance:* Establishing maintenance plans, clarifying maintenance responsibilities and other strategies may ensure that the pilot gardens and other GI installations receive ongoing care.

We are employing social science, engineering, and aquatic science methods to assess the pilot garden's performance relative to these objectives. The following sections describe these methods in more detail and present initial findings from our pilot analyses.

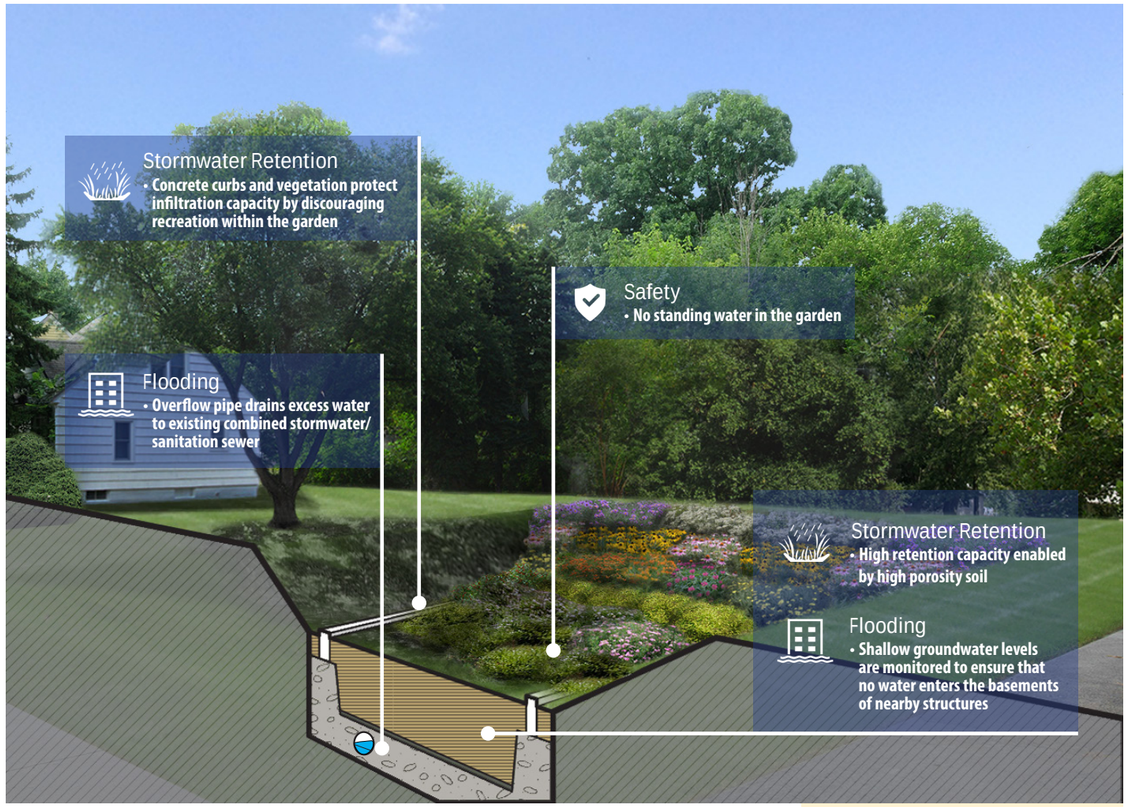


FIGURE 5: Stormwater performance features in bollard garden design.
Illustration by QIULING CHEN

ASSESSMENTS: INITIAL RESULTS AND NEXT STEPS

PEOPLE: PERCEPTIONS, PREFERENCES AND WELL-BEING

Before construction, we conducted a survey of neighborhood residents to gather baseline information about demographics and neighborhood characteristics. We also asked residents about their perceptions of attractiveness, safety, neatness and degree of care in the garden designs; and the safety, property value, and other health and well-being impacts that they anticipate the gardens having once installed; and their preferences among designs.

The neighborhood survey was conducted in two study areas (Study Areas 1 and 2, figure 2-3), each containing a control site and a pair of pilot garden sites. Residents were asked to respond to images of sites within the study area in which they resided. Images of control sites are shown in Figure 6; images of bollard pilot and berm pilot sites are shown in Figure 7 (Study Area 1) and Figure 8 (Study Area 2).

We will facilitate a short series of focus groups with residents in the summer of 2016, to gain preliminary insight into how neighbors have perceived and interacted with the gardens in the first year after installation. We will conduct a second, expanded survey in 2017, including the households from the initial survey as well as more than 300 additional households. The second survey will allow us to monitor effects of the pilot gardens as well as anticipate effects of other GI designs. We will also develop a simplified survey tool for post-construction assessment of GI installations in other locations in Detroit and other Great Lakes cities.

CONTROL SITES

a. Study Area 1

b. Study Area 2

FIGURE 6: CONTROL SITES
Images of vacant lots in Study Area 1(a) and Study Area 2(b) receiving the annual mowing maintenance typical of vacant properties in Detroit

BOLLARD PILOT SITE

a. Regular Mowing

b. Garden Installed

BERM PILOT SITE

c. Regular Mowing

d. Garden Installed

FIGURE 7. STUDY AREA 1 SITES
Computer-generated visualizations of bollard and berm design GI pilot sites in Study Area 1, as expected to look with frequent mowing but without a bioretention garden (a. and c.); and as expected to look with an established GI garden (b. and d.)

BOLLARD PILOT SITE

a. Regular Mowing

b. Garden Installed

BERM PILOT SITE

c. Regular Mowing

d. Garden Installed

FIGURE 8. STUDY AREA 2 SITES
Computer-generated visualizations of bollard and berm design GI pilot sites in Study Area 2, as expected to look with frequent mowing but without a bioretention garden (a. and c.); and as expected to look with an established GI garden (b. and d.)

METHODS: 2015-16 SURVEY

We constructed two replicates of each of two GI garden designs, with each set of two different garden designs in a different Warrendale study area (Figure 2-3). Before the installation, between November 2014 and April 2015 we conducted a full census survey of occupied households within 800 feet of the center of each study area, for a total sample of 164 residents. Residents were presented with five images (Figure 6-8), a control site: a nearby vacant lot with annual mowing; computer-generated visualizations of one nearby pilot site with frequent mowing and with a berm bioretention garden installed; and visualizations of the other nearby pilot site with frequent mowing and with a bollard bioretention garden installed.

Surveys were administered face-to-face by trained interviewers who are Detroit-area residents. Residents were asked about demographic characteristics, their experience in the neighborhood, their familiarity with each site, their perceptions of the garden designs, and the impacts they anticipate the gardens having when installed.

TABLE 1: Pre-Construction Survey—Participant Characteristics

Demographic and Household Characteristics (n=164)	
Average Age (19-82)	42 years old
Gender	Female 63%
Race	African American 93%
Income below $27,000/year	75%
Less than HS education	26%
Unemployment Rate	16%
Average Years in Neighborhood	9.8 years
Average Household Size	3.1 people(2 adults, 1.1 children)
Housing Occupancy	Renters 63%; Owners 33%
Experienced flooding in the past year	0 times: 36% 1-2 times: 52% 3+ times: 12%
Distance and Familiarity to sites (n=164)	
Familiar with Site	Control site : 65% GI sites: 53%
Average walking distance from home to site	Control site : 0.181 miles GI sites: 0.179 miles
Health Characteristics	
Are you limited in any way by your health?	Yes 27%
Avg. Depressive Symptoms Score	0.7 (scale: 0-3 symptoms reported)
Avg. Chronic Stress Score	2.2 (scale: 0-7 stressors reported)
Avg. Number of chronic health problem	1.7 (scale: 0-9 conditions reported)
Avg. self-reported health	3.8 (scale: 0 (poor) to 5 (excellent))

Residents rated bioretention garden designs as appearing safer than mowed lots and control sites.

RESULTS: 2015-16 SURVEY

Survey results are summarized in Table 1, Figure 9, and Appendix A-C. Key findings about garden performance objectives are described below. (All reported findings are statistically significant at a 5% p-value).

1-3. Garden attractiveness, safety and design preferences

- Residents rated bioretention garden designs as appearing more attractive than mowed lots and control sites. Residents also rated the garden designs as appearing neater and better cared for.

- Residents rated bioretention garden designs as appearing safer than mowed lots and control sites.

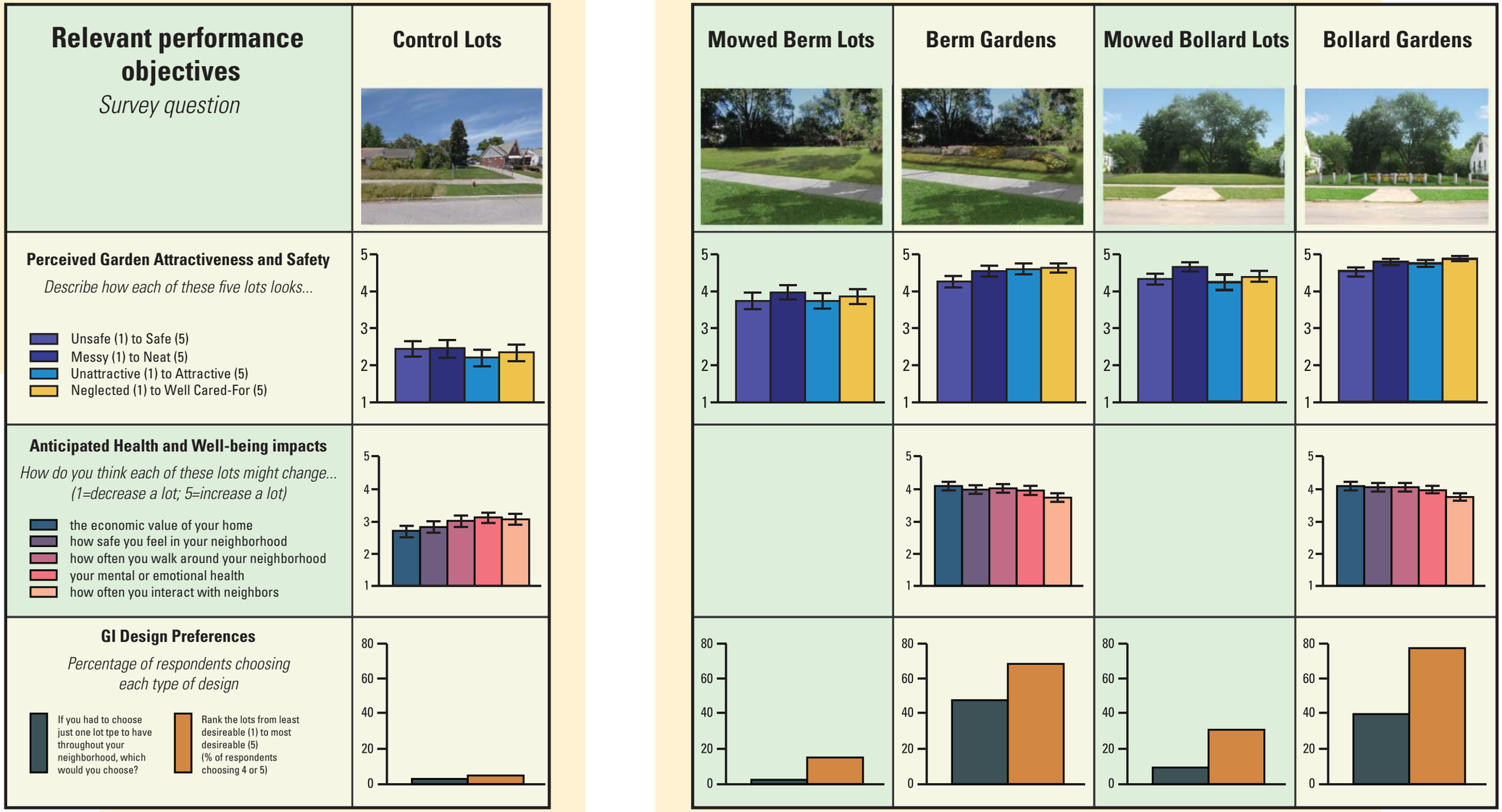
- Residents strongly preferred to have bioretention gardens in their neighbor hood, as compared to regularly mowed lots or control sites. Residents also preferred regularly mowed lots over control lots, indicating that a neat, maintained appearance is important for positive perceptions of sites regardless of GI design.

4. Health and well-being

- Residents anticipate that GI installations will positively impact their mental and physical well-being. A higher percentage of respondents anticipated improvement in their mental health, walkability, economic value of their home, safety, and frequency of interaction with neighbors as a result of the bioretention gardens as compared to control sites.

- Bioretention gardens may bring additional benefit to residents experiencing higher levels of chronic stress. Higher levels of chronic stress and depressive symptoms were associated with greater anticipated impact of the gardens on residents' own mental health and on neighborhood safety, controlling for related health and demographic factors.

FIGURE 9: Responses by 163 nearby residents to lot visualizations, averaged across Study Areas 1 and 2. Visualizations from one study area are shown for illustrative purposes. See Figure 6-8 for the full set of visualizations, and Appendix B and C for responses from within each study area.



5. Familiarity and vacancy

- Familiarity with garden sites was associated with greater perceived impact of the gardens on anticipated walking frequency and mental health, controlling for demographic factors. Shorter walking distance to the sites was associated only with greater anticipated impact on mental health. Further research is needed to understand if other factors—such as lines of sight and most frequently traveled routes—shape the ways in which residents interact with and perceive future benefits of neighborhood GI installations.

- Block vacancy rates are related to resident perceptions of anticipated GI impacts. Those familiar with sites expect GI gardens to have a greater impact on the economic value of their home when they live on a block with a proportion of vacant homes that is higher than the median rate for all blocks in our sample area (Figure 10). Residents of high-vacancy blocks also expect GI gardens to have a greater impact on the frequency with which they interact with their neighbors.

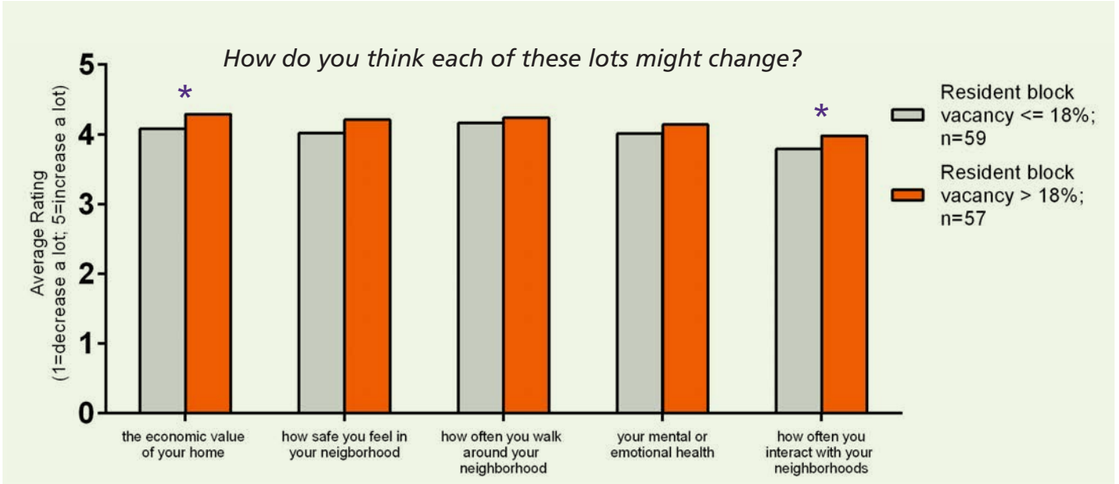


FIGURE 10. Average ratings of perceived health and well-being impacts of GI sites by resident block vacancy rate among resident familiar with the site. * = significant association with residential block vacancy rate.

Prior to garden installations, all the water entering the curb cuts flowed directly into the municipal sewer.

6. Maintenance: With the support of the UM Water Center, we designed an additional survey and administered it via mail and online to a random sample of Upper Rouge Tributary area residents in February-March 2016. Resident response to the survey exceeded expectations with 377 (over 15%) of the sample of residents completing the survey. Our ongoing analysis of results of this additional survey may provide insights into residents' current yard maintenance practices, their degree of interest in helping maintain biorretention gardens on nearby lots, and the ways in which garden condition, distance from their home, incentives, and other factors may shape this interest.

WATER: QUALITY, QUANTITY AND FLOODING

We will assess the garden's stormwater management performance by working with our DWSD collaborators to monitor the quality and quantity of water entering sites from the street, overflowing into the existing sewer, and infiltrating to property boundaries. Monitoring will begin in spring 2016 and continue for two years.

7. Stormwater quality improvement: Stormwater enters the pilot gardens through a curb cut on the adjacent street, and exits through infiltration and through the demolished house's sewer lead (Figure 11). Prior to garden installations, all the water entering the curb cuts flowed directly into the municipal sewer. As a result, comparing the quality and quantity of water entering the garden through the curb cut with that of the water exiting the garden into the sewer will allow us to assess the gardens' water quality and retention performance.

Water quality sampling and flow monitoring locations are indicated in Figure 12. We will test samples for alkalinity, pH, hardness, anions, dissolved oxygen, solids, conductivity and temperature; and for contaminants including metals, nutrients, and polycyclic aromatic hydrocarbons. We will use bioassays to measure the overall toxicity of water entering and exiting the garden, by monitoring the mortality rates of aquatic invertebrates (D. magna and H. azteca) immersed in water at each end of the system.

On behalf of DWSD, Tetra Tech will use flowmeters to monitor the volume of water flowing into the garden and out into the sewer. They will also drill shallow groundwater monitoring wells at one or more of the pilot gardens, allowing us to track infiltration from the garden into the soil.

FIGURE 11: Completed garden showing retention features

8. *Localized flooding:* Tetra Tech will also use the monitoring wells to track groundwater levels at the perimeters of the site, to ensure that groundwater levels do not rise to the level of nearby basements.

9. *Maintenance:* We will observe the gardens to identify areas that require maintenance during regular visits to conduct monitoring, with a focus on catch basins that may accumulate debris from the street.

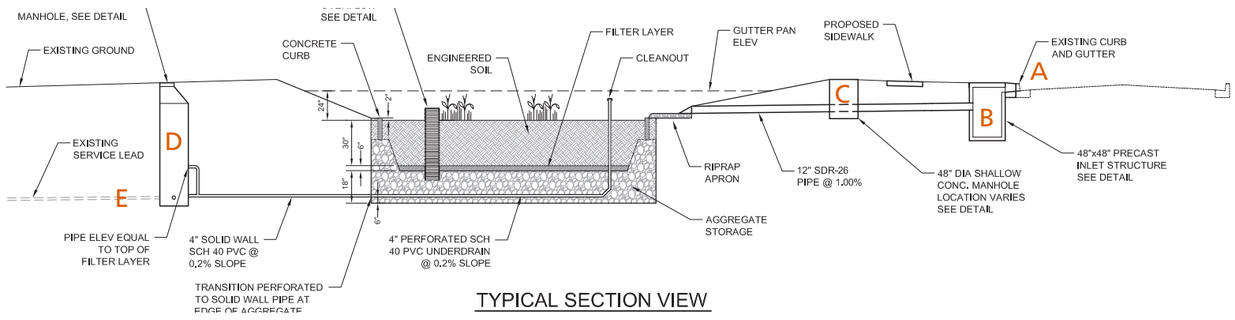


Figure 12: Pilot garden cross-section. Water enters the garden from the street at A and exits into the sewer at E. Inflows will be sampled for water quality at the street catchment (B) and outflows through a manhole behind the garden (D). Flow volumes will be measured entering at C and exiting at D. Image source: Tetra Tech

Governance: Supporting and expanding GI development

Most cities' codes and ordinances were written to manage development where demand for property drives transitions from less to more intensive forms of development. However, in many Detroit neighborhoods, minimal demand exists to drive this transition. A central challenge is to learn how to govern and promote changes to less intensive but beneficial land uses, including GI.

During NEW-GI's first phase, we conducted a comparative assessment exploring the transition from abandoned structure to GI in Detroit and Cleveland, based on extensive interviews and review of regulations, laws, ordinances and codes, in each city. We drew on this assessment to identify key governance issues (objectives 10-13) to explore in more depth in the project's second phase.

NEW-GI's second phase will analyze ways that Detroit's governance characteristics affected pilot bioretention garden installation and maintenance; and compare these to best practice governance and community models for installing and maintaining effective GI. Drawing on this analysis, we will identify changes to laws, ordinances and regulations as well as new administrative routines that could facilitate GI development in Detroit. Initial findings from the comparative assessment, anticipated analyses in the project's second phase, and the types of guidance that may result include:

10. *Codes and ordinances:* NEW-GI will complement the City's work already underway to establish and update stormwater-related codes and ordinances.

- *Initial Findings:* existing codes and ordinances focus on situations where development is occurring. Ordinances focus on land uses with substantial impermeable surfaces.

- *Phase two analysis:* we will assess codes and ordinances that shaped pilot garden installation, track stormwater ordinances and other regulations under development in Detroit, and compile examples of codes and ordinances from other cities.

- *Anticipated guidance:* models and guidance for managing and promoting GI development through changes to existing laws, ordinances and codes, or the creation of new regulations.

11. *Administrative systems:*

- *Initial findings:* a lack of administrative routines or systems forms a barrier to GI projects. City employees are uncertain about acceptable practices and permitting and inspection responsibilities. As a result, permitting requests may be met with no action, or with excessive inspections

- *Phase two analysis:* we will assess permitting and inspection process for pilot garden installations, and existing permitting and inspection responsibilities as applied to GI installations.

- *Anticipated guidance:* suggestions for modifying, establishing or formalizing systems related to GI permitting, inspection and maintenance.

12. Costs:

- *Initial findings:* GI projects on vacant lots may face lengthy administrative hurdles and high permitting costs as a result of the issues identified above.

- *Phase two analysis:* we will assess ways in which permitting and inspection shaped the pilot garden's costs and construction timelines.

- *Anticipated guidance:* reductions in GI capital costs that could result from new or modified codes, ordinances and administrative systems.

13. Maintenance:

- *Initial findings:* planning and resources for long-term GI maintenance are limited. Projects may rely on nearby residents to conduct informal maintenance.

- *Phase two analysis:* we will assess ways in which the pilot gardens are maintained and existing systems for GI maintenance in Detroit.

- *Anticipated guidance:* models for integrating long-term maintenance planning into the GI development process.

CONCLUSION

NEW-GI's first phase proposed alternative designs for GI as part of the demolition process of vacant property and provided evidence of GI's potential as an attractive use that may increase the well-being of residents. In an initial survey, residents rated pilot GI garden designs as more attractive, safer, neater and better cared for than vacant lots without GI, and they indicated that they preferred GI gardens on vacant lots in their own neighborhood. They also anticipated that GI gardens would enhance their mental and physical well-being. Further, our data suggest that those experiencing high levels of chronic stress may enjoy additional benefits. The first phase of research also identified several ways in which laws, ordinances, regulations or administrative routines could be improved to support GI implementation and long-term function.

In an initial survey, residents rated pilot GI garden designs as more attractive, safer, neater and better cared for than vacant lots without GI.

In its second phase, NEW-GI will thoroughly assess the pilot gardens' social, water quality/quantity and governance functions, and address additional questions including GI maintenance. Drawing on these assessments and on a broad-ranging review of the GI-related scholarly literature, we will produce a series of briefs, white papers and technical reports providing actionable guidance for GI decision makers, with specific relevance to Detroit, as shown in Table 2.:

- *Report on phase one findings (July 2016)* reporting the results of our 2015-16 neighborhood survey and comparative governance analysis.

- *White Paper on scholarly literature (December 2016)* synthesizing GI-related scholarly literature from several disciplines to provide actionable guidance for Detroit GI decision makers.

- *Integrated assessment of pilot gardens (March 2018)* including our water quality assessment of the pilot gardens integrated with results of a post-construction survey of nearby residents. It also will draw on our analysis of GI governance characteristics with an updated literature review to provide further guidance to Detroit GI decision-makers.

- *White Paper (September 2018)* on the implications of the investigation with an updated look at the literature across our disciplines.

- *Short technical reports (ongoing)* will be issued in response to specific questions raised by Advisory Committee members and other Detroit decision-makers.

- *Watershed scale design concepts and governance approaches (ongoing):* Throughout the second phase of the project, we will work with the Advisory Committee to apply our project findings to ongoing GI development in Detroit by developing new design concepts, governance strategies, or other guidance. This work will contribute to technical reports and the September 2018 White Paper, and will be the subject of a November 2018 Concept Report that will supplement the final White Paper.

As practitioners directly involved in GI planning and implementation, the Advisory Committee's guidance and feedback will be essential to ensuring that these research products are highly relevant to green infrastructure decisions in Detroit. Collaboration among members of the NEW-GI team, including researchers, City of Detroit practitioners, and community stakeholders, can inform decisions to support and enhance GI in Detroit and also deepen scientific understanding of GI's social and environmental potential and performance.

	2016				2017				2018			
Tasks and ***Deliverables***	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Actionable Synthesis of GI Design, Water Quality, Governance and Socio-economic Issues												
Review and analyze scholarly literature	■	■	■	■	■				■			
White papers				■							■	
Technical reports					■	■	■	■	■	■	■	
Performance Evaluation of Pilot Gardens												
Water quality monitoring and analysis	■	■	■	■	■	■	■	■				
Community survey and analysis	■	■			■	■	■	■	■	■		
Governance assessment	■	■			■	■	■	■				
Integrated assessment of implications								■	■			
Pilot Garden Performance Assessment Reports			■						■			
Watershed Scale Design Concepts and Governance Approaches												
Ongoing concepts, strategies and guidance	■	■	■	■	■	■	■	■	■	■	■	■
Identify site(s) for sub-watershed GI treatments								■	■			
Plan and design treatments			■	■	■	■	■	■	■	■	■	■
Sub-watershed design and governance concept report												■

Table 2: Timeline of major tasks and deliverables in NEW-GI's second phase (2016-2018).

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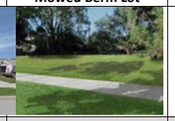
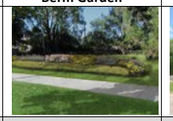
APPENDICES: RESULTS BY STUDY AREA

Characteristic (Range)		Total Sample (n=164)	Study Area 1 (n=82)	Study Area 2 (n=82)	*Significant difference between study areas?*
		Mean (SD) or %			
Demographic and Household Characteristics					
Age (19-82)		42.2 (14.8)	41.4 (15.1)	43.1 (14.5)	-
Gender (% female)		63.0%	68.3%	56.8%	-
Race (% African American)		93.0%	95.1%	91.5%	-
Income below $27,000/year (%)		75.0%	78.6%	72.7%	-
Less than HS education (%)		26.5%	23.5%	29.6%	-
Unemployment Rate (%)		12.0%	11.0%	12.2%	-
Years in Neighborhood		9.8 (10.2)	10.1 (9.5)	9.5 (10.8)	-
Household Size		3.1 people (1.9) / 1.1 children (1.5)	3.2 people (1.7) / 1.2 children (1.5)	2.9 people (2.1) / 1.0 children (1.5)	-
Housing Occupancy (% owners)		34.4%	30.8%	38.2%	-
Experienced flooding in the past year (%)	0 times	28.0%	28.0%	43.9%	-
	1-2 times	58.5%	58.5%	45.1%	
	3+ times	13.0%	13.0%	11.0%	
Distance to and Familiarity With Sites					
Familiar with Control site (% Yes)		65.0%	62.2%	67.9%	-
Familiar with GI sites (%)	None	29.3%	31.7%	26.8%	-
	One site	35.0%	30.5%	41.5%	
	Both sites	34.8%	37.8%	31.7%	
Walking distance from home to site (miles)		Control site : 0.2 (0.1) GI sites: 0.2 (0.1)	Control site : 0.2 (0.1) GI sites:0.2 (0.7)	Control site : 0.2 (0.1) GI sites: 0.2 (0.1)	-
Health Characteristics					
Limited in any way by health? (% Yes)		27.0%	29.3%	24.4%	-
Depressive Symptoms Score (0-3)		0.7 (0.5)	0.7 (0.5)	0.6 (0.6)	-
Chronic Stress Score (0-7)		2.2 (1.9)	2.2 (1.9)	2.2 (1.9)	-
Number of chronic health problems (0-7)		1.7 (1.8)	1.9 (1.9)	1.5 (1.6)	-
Self-reported health (0-5)		3.8 (1.0)	3.7 (1.0)	3.8 (1.0)	-
Neighborhood Characteristics					
Proportion of vacant houses on block (0-0.6)		0.2 (0.1)	0.3 (0.1)	0.2 (0.1)	***
Condition of yards on block (1-4)		2.6 (0.9)	2.5 (0.7)	2.8 (0.9)	*

APPENDIX A Pre-Construction Survey—Participant Characteristics by Study Area
*Statistical significance of difference between study areas: - = not significant; * = p-value<0.05; *** = p-value<0.001*

		Control Lot	Mowed Berm Lot	Berm Garden	Mowed Bollard Lot	Bollard Garden
Relevant performance objective *Survey question*						
	Number of Responses	82	82	82	82	82
Perceived Garden Attractiveness and Safety *Describe how each of these five lots looks…*	Unsafe (1) to Safe (5)	*1* **1.8**	*5* 4.5	*5* 4.7	*5* 4.3	*5* 4.6
	Messy (1) to Neat (5)	*1* **1.6**	*5* **4.8**	*5* **4.9**	*5* **4.5**	*5* **4.8**
	Unattractive (1) to Attractive(5)	*1* **1.4**	*5* **4.5**	*5* **4.9**	*5* **4.2**	*5* **4.8**
	Neglected (1) to Well-Cared For (5)	*1* **1.5**	*5* **4.7**	*5* **4.9**	*5* **4.2**	*5* **4.8**
Anticipated Health and Well-being Impacts *How do you think each of these lots might change… (1=decrease a lot; 5=increase a lot)*	The economic value of your home?	*2* **2.2**		*4.5* **4.3**		*4* **4.2**
	How safe you feel in your neighborhood?	*2* **2.3**		*4* **4.1**		*4* **4.0**
	How often you walk around your neighborhood?	*3* **2.5**		*4* **4.2**		*4* **4.1**
	How often you interact with your neighbors?	*3* **2.8**		*4* **3.9**		*4* **3.8**
	Your mental or emotional health?	*3* **2.8**		*4* **4.0**		*4* **3.9**
GI Design Preferences *Percentage selecting each design, from the designs within their cluster*	If you had to choose just one lot type to have throughout your neighborhood, which would you choose?	**1.2%**	**2.4%**	**68.3%**	**6.1%**	**22.0%**
	Rank the lots from least desireable (1) to most desireable (5) (respondents selecting 4 or 5)	**4.9%**	**23.2%**	**90.2%**	**12.2%**	**69.5%**

APPENDIX B Selected responses to lot visualizations from 2015-16 survey-Study Area 1.
Formatting key: *median score in italics;* **mean score in bold**

		Control Lots	Mowed Berm Lots	Berm Gardens	Mowed Bollard Lots	Bollard Gardens
Relevant performance objective *Survey question*						
	Number of Responses	82	82	82	82	82
Perceived Garden Attractiveness and Safety *Describe how each of these five lots looks…*	Unsafe (1) to Safe (5)	*3* 3.2	*3* 3.1	*4* 3.9	*5* 4.4	*5* 4.6
	Messy (1) to Neat (5)	*4* **3.4**	*3* **3.3**	*5* **4.3**	*5* **4.8**	*5* **4.9**
	Unattractive (1) to Attractive(5)	*3* **3.1**	*3* **3.0**	*5* **4.3**	*5* **4.5**	*5* **4.8**
	Neglected (1) to Well-Cared For (5)	*4* **3.3**	*3* **3.1**	*5* **4.4**	*5* **4.6**	*5* **4.9**
Anticipated Health and Well-being Impacts *How do you think each of these lots might change… (1=decrease a lot; 5=increase a lot)*	The economic value of your home?	*3* **3.3**		*4* **3.9**		*4* **4.0**
	How safe you feel in your neighborhood?	*3* **3.4**		*4* **3.9**		*4* **4.1**
	How often you walk around your neighborhood?	*3* **3.5**		*4* **3.9**		*4* **4.0**
	How often you interact with your neighbors?	*3* **3.3**		*3* **3.6**		*3* **3.7**
	Your mental or emotional health?	*3* **3.5**		*4* **3.9**		*4* **4.0**
GI Design Preferences *Percentage selecting each design, from the designs within their cluster*	If you had to choose just one lot type to have throughout your neighborhood, which would you choose?	**2.4%**	**1.2%**	**26.8%**	**12.2%**	**57.3%**
	Rank the lots from least desireable (1) to most desireable (5) (respondents selecting 4 or 5)	**6.1%**	**6.2%**	**46.3%**	**49.4%**	**86.3%**

APPENDIX C Selected responses to lot visualizations from 2015-16 survey-Study Area 2.
Formatting key: *median score in italics;* **mean score in bold**