Community BioBlitz at the South Merrill Community Garden, September 2024. Photo by Delta Institute.

GREEN INFRASTRUCTURE MONITORING GUIDE

FALL 2024

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EXECUTIVE SUMMARY

Communities on the South and West sides of the City of Chicago are living with legacy systemic injustice and are disproportionally impacted by the effects of climate change, flooding, and degraded stormwater infrastructure – all threatening public health, water quality and economic opportunity. Vacant lots are common in these neighborhoods, further degrading community outcomes. Implementing Green Infrastructure (GI) on vacant lots is a community-level nature-based solution to capture stormwater runoff, improve water quality, expand urban canopies and address increasing climate concerns while using inclusive community engagement principles. However, a lack of local datasets to quantify GI's impacts and standardize implementation adds another barrier to the use of GI in these communities. To assist community groups, elected officials and neighborhood/municipal agencies implement GI, a robust roster of data and related knowledge/lessons must be available and distributed.

The City of Chicago owns approximately 10,000 vacant lots, the majority of which are located in neighborhoods on the South and West sides (Bloomberg, 2022). These same neighborhoods are disproportionately affected by stormwater flooding, which is exacerbated by climate change and aging stormwater infrastructure (Chicago-Kent Journal of Environmental and Energy Law, 2022). GI can be installed on vacant lots to mitigate local flooding. Prior research suggests transferring vacant lots to private ownership for greening and reuse may also positively affect neighborhoods by reducing violence and crime (Branas et al., 2018), improving health outcomes (South et al., 2018; Sivak et al., 2021), increasing home values (Lin et al., 2022), and, if properly managed and monitored, enhance local biodiversity (Anderson & Minor, 2017).

However, knowledge gaps have existed as to whether these benefits extend to vacant lots in Chicago's South and West sides given hyper-local context around urbanization, prior land use, regional climate patterns, and other nuances. Delta Institute investigated the aforementioned benefits of installing GI on vacant lots in the South and West side neighborhoods of Chicago. This GI Monitoring Guide provides recommended approaches to consistently and routinely investigate and monitor the effects of GI installation on vacant lot biodiversity, stormwater capture, and community co-benefits.

About Delta Institute

Delta Institute collaborates with communities to solve complex environmental challenges throughout the Midwest. Delta exists because environmental, economic, and climate issues hit communities—urban and rural—through disinvestment, systemic inequity, and policy decisions. We collaborate at the community level to solve our home region's new and legacy issues, by focusing on the self-defined goals and needs of our partners.

Delta Institute improves the living conditions of more than five million Midwesterners by transitioning one million acres to more resilient, conservation-focused practices, and by improving water quality and reducing flooding by capturing 100 million stormwater gallons. By 2025 we will achieve these goals through our agriculture, climate, water, and community development projects.

This is what a more resilient, equitable, and innovative Midwest looks like. Visit us online at www.delta-institute.org.

Acknowledgements

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We are grateful to partner with numerous community -based and -focused organizations:

- Blacks in Green (BIG) is a national network pioneering “the sustainable-square-mile” in a “city of villages,” where every household can walk-to-work, walk-to-shop, walk-to-learn, and walk-to-play – balancing environment, economics, and equity.
- Center for Neighborhood Technology (CNT) delivers innovative analysis and solutions that support community-based organizations and local governments to create neighborhoods that are equitable, sustainable, and resilient.
- Emerald South Economic Development Collaborative, Terra Firma is a 5-year, $25 million land care initiative launched in 2021 to beautify, maintain, and activate over 205 acres of vacant land on Chicago’s mid-South Side. Terra Firma uses vacant land as an engine of opportunity to create jobs, grow small businesses, improve the local environment, and enhance neighbors’ quality of life.
- Northwestern University, Civil & Environmental Engineering Department and Center for Water Research.
- South Merrill Community Garden educates and promotes a sacred space for the health and wellbeing of the intergenerational members of our community through gardening, engagement and accessibility to nature’s bounty.

This document and the tools provided aim to be action oriented and to provide the most current, correct, and clear information possible, but some information may have changed since publication. We encourage practitioners to reach out to us at delta@delta-institute.org with questions, corrections, or to discuss implementation challenges.

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STORMWATER MANAGEMENT MONITORING

Expanding GI at the community-level is a nature-based solution to capture stormwater runoff and improve water quality. By intercepting stormwater runoff before it enters sewar systems, GI has shown to prevent pollutants from entering waterways and reduce the severity of flooding events. However, knowledge gaps exist as to whether GI installations in vacant lots improve stormwater capture quantity and quality in Chicago's South and West side neighborhoods, notably in this case South Shore, Washington Park, and Woodlawn.

Delta Institute (Delta) recommends the following approaches to investigate the effects of GI implementation on stormwater runoff and water quality in Chicago's vacant lots. These recommendations are derived from collaborative efforts with Blacks in Green, Emerald South's Terra Firma initiative, the Metropolitan Planning Council, the Nature Conservancy, and Northwestern University's Civil & Environmental Engineering Department and Center for Water Research to install and monitor GI in several vacant lots in Chicago's South and West side neighborhoods.

Additional information on GI installation and monitoring may be found in Delta Institute's Design Guide for Green Stormwater Infrastructure Best Management Practices and a Delta staff co-authored journal article, *Community-centered instrumentation and monitoring of nature-based solutions for urban stormwater control* (O'Brien et al., 2024).

Stormwater Management Monitoring Glossary

A brief glossary of key terms related to the content in this section:

- **Soil CO2 Flux**: the movement or rate of carbon dioxide gas between the soil and the atmosphere (soil respiration), which is largely driven by soil temperature, moisture, and microbial activity.
- **Stormwater Retention**: quantified as flow and volume per land surface area.
- **Water Budget:** a calculation of the water that flows into, out of, and is stored within a stormwater treatment practice.
- **Project Team:** Any coalition or collaboration of stakeholders who are pursuing GI installation, monitoring, and assessment.

Data Collection

Through the lens of appropriate and consistent GI data collection, the below activities should be noted and undertaken in a linear fashion:

Site Existing Conditions

An inventory of site existing conditions (e.g., soil characteristics, vegetation, updated utility maps, hydrogeology and flooding information) are crucial prior to GI installation to measure site impact on stormwater and flooding mitigation. Environmental testing (e.g., soil contamination inspections) and utility inspections should be conducted on the site prior to site acquisition and GI installation to ensure the property meets health and safety standards. Soil cores taken during environmental testing should be analyzed for soil texture, water retention, carbon content, and hazardous metals by a certified laboratory. Drillers will map underground utilities, too. This process generally takes drillers one day per site.

Once environmental testing is complete and site conditions have been shown to be acceptable, the Project Team should utilize EPA's National Stormwater Calculator (SWC) to review rainfall over a 15-year duration to provide a baseline measurement of stormwater runoff on the project site. The SWC estimates the annual amount of stormwater runoff based on local soil conditions, land cover and historic rainfall records. This data will be compared against actual conditions at the site – derived from visual inspection from community members and anecdotal evidence – and updated to model stormwater rate and volume for each site.

Site Acquisition

GI implementation and monitoring is dependent upon site acquisition, which can be a complex process. The site acquisition process may take several months to several years to complete. It is recommended that the site acquisition process begins in parallel with baseline measurement collection, as baseline measurements may be beneficial or required in the site acquisition process. Time should be allotted appropriately for both baseline measurements and the site acquisition process, as much as one can reasonably forecast.

If the site is within the City of Chicago, and is City-owned, the City of Chicago's Department of Planning and Development (DPD) requires aldermanic approval prior to sale and/or lease. A community outreach strategy may be required to engage community partners and secure aldermanic approval. Led by Chicago DPD, ChiBlockBuilder is the City of Chicago's application portal for the purchase and redevelopment of City-owned vacant land across the South and West sides in partnership with community stakeholders. The ChiBlockBuilder website features an interactive online map to provide potential buyers with important information about City-owned vacant land such as environmental clearances, zoning, square footage, and market value.

If the site is privately owned, steps may be taken to identify partners and roles such as community engagement lead, materials/implementation lead, site manager and long-term maintenance provider, as well as project design/construction management and oversight.

Monitoring Tools and Equipment

In coordination with community -based and -focused organizations and the surrounding community, the Project Team should develop a site instrumentation plan that details the location of GI monitoring equipment, such as groundwater wells and soil moisture sensors, prior to GI installation. It is assumed that Project Team members and/or community partners will collect baseline data gathered by the monitoring equipment.

The Project Team may begin developing a monitoring and instrumentation plan by first reviewing emerging and currently available monitoring technologies and equipment, including remote self-emptying rain and weather gauges equipped with water level sensors to quantify stormwater rate and volume on each site. Weather gauges should measure ambient site conditions such as temperature, humidity, barometric pressure, and wind-speed (*Figure 1*).

Figure 1: Weather monitoring station and groundwater well at the Garfield Park Eco-Orchard. Source: Northwestern University.

Monitoring equipment should be selected based on cost, ease of installation and maintenance, compatibility with site conditions, and overall performance. If stakeholder survey data suggests that air quality is a valuable measurement, then low-cost, durable air quality measurement tools should undergo the same review.

Types of Monitoring Equipment

The types of monitoring equipment included in the monitoring plan will depend on the site, but they may include:

Groundwater wells measure the site's water tables depth, amount of available water, and potential flow directions within the surrounding area (Figure 2). Groundwater wells may range in depth (10-30ft) depending on the site's water table. Each well should be surveyed with GPS and documented.

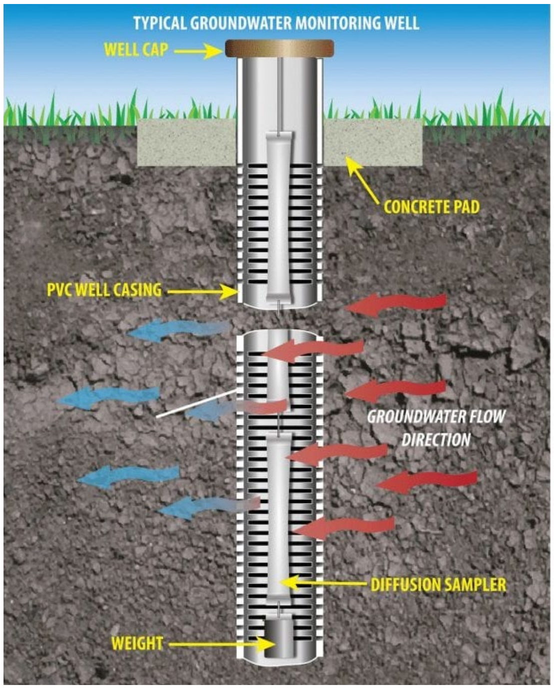


Figure 2: Typical groundwater monitoring well used to measure a site's water table depth, volume, and flow. Source: All American Environmental (https://allamericanenviro.com/service/monitoring-wells-installation/)

Placement of the wells can be left up to site owners. Wells may be flush to the ground. The Project Team will need occasional access to the sensor to download data/repair sensors. The wells will have data loggers, which will need to be secured to prevent vandalism/theft.

The drilling of groundwater wells is costly, so the Project Team may consider undergoing a Request for Quote process to solicit bids from several contractors. For example, the drilling of four groundwater wells in W. Woodlawn on four GI sites cost $25,700 in 2024. These costs included $16,600 for the subcontracted drilling services, $2,800 for private utility locating and $6,300 for field related services and reporting. Field oversight cost was largely based on the estimated drilling time as indicated by the subcontracted drilling service (two to three days) and equipment charges.

Upon completion of the field activities, the drilling personnel will compile and submit well construction forms to the Cook County Health Department. Boring logs and well completion forms will be provided to the Project Team.

Piezometers are utilized during groundwater well installation to measure the ground’s pore pressure or the compressibility of materials under hydrostatic pressure (*Figure 3*). The borings for the piezometers are continuously sampled utilizing a 3.25-inch outer diameter (OD) rod advanced by a direct push drilling rig with a 5-foot continuous sampler. A bentonite seal should be placed above the piezometer’s filter pack to grade. The well stickup may be about one foot above ground surface.

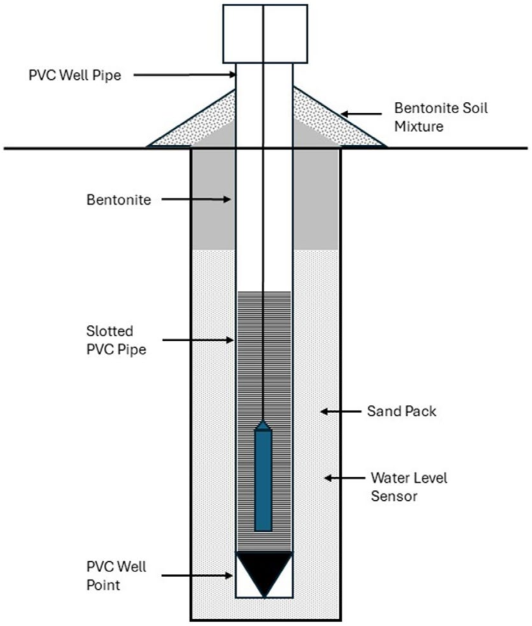


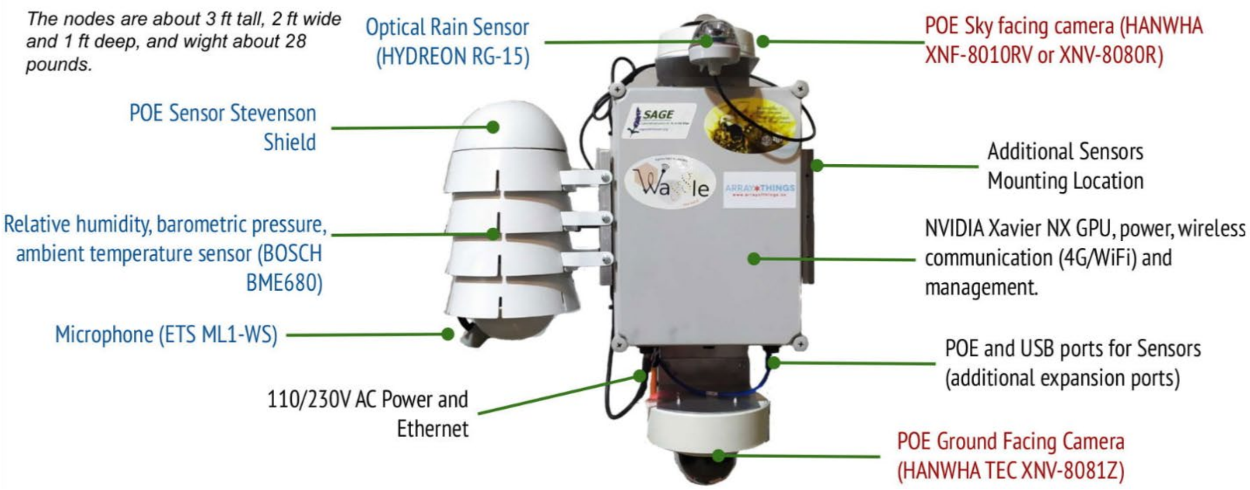
Figure 3: Cross section of typical piezometer with groundwater level sensor. Source: O’Brien et al., 2024.

Soil moisture sensors quantify volumetric water content of the surrounding soil, which can be used to estimate stormwater storage, GI response to rain events and monitor in situ conditions for plant growth (*Figures 3 and 4*). Soil moisture sensors range from $200-350 per sensor and are generally about 8-10 cm in length and width. These sensors can have integrated data storage or require an external data logger to record data from multiple individual sensors. Some manufacturers may also charge a one-time or annual fee for software required to download and view the collected data (O’Brien et al., 2023).

Figure 4: Soil moisture probe. Source: ICT International (https://ictinternational.com/product/mp406-soil-moisture-sensor/)

Self-emptying rain gauges measure precipitation and can be used for comparison against soil moisture and water level data to complete water budget calculations and evaluate GI performance (O’Brien et al., 2024). Self-emptying, or tipping-bucket rain gauges can be heated or unheated, depending on the desire to capture precipitation from rain and snow. Rain gauges can range in price from $50-$500.

Weather Monitoring Stations equipped with data loggers measure ambient atmospheric conditions such as temperature, humidity, wind speed, and solar radiation and may be employed to



The nodes are about 3 ft tall, 2 ft wide and 1 ft deep, and wight about 28 pounds.

Figure 5: Wild Sage Node environmental sensing system used to measure a site's weather conditions. Source: www.sagecontinuum.org

continuously monitor and collect data from sensors placed in the GI installation. Data loggers may be standalone, self-contained units that record data locally for later collection or wireless sensor networks that upload data in real-time to a central hub. Additional parameters for measurement are soil moisture, rainfall, water level, soil conductivity, CO2 flux, and air quality. These indicators may be collected in newer wireless sensors such as the Wild Sage Node (WSN) environmental sensing system (*Figure 5*). Weather monitoring stations typically vary in cost from $100 – over $1000 depending on the vendor and modality.

Water level sensors may be placed within a catch basin to measure the height or depth of water at a given location and can be used to measure downstream flow discharge or outflow within a stormwater drainage system to assess the efficacy of GI in reducing flooding (*Figure 6*).

Water level sensors are typically connected to a base station or computer in the field – either via optical USB or Bluetooth. Remote monitoring stations, like the Wild Sage Node or HOBO MicroRX Water Level Station and the HOBOnet Remote Water Level Monitoring System deliver water level data to cloud databases and can also collect soil moisture and environmental parameters like temperature, wind speed, and humidity. Prices vary between $300 – over $1000 depending on the vendor and modality.

Figure 6: Water level sensor being deployed into a catch basin to measure a site's water table height, depth, and flow direction. Source: Solinst (https://www.solinst.com/instruments/level-measurement-devices/)

Additional Considerations

Monitoring equipment should be installed at the site as part of GI installation but kept near the perimeter of the site to avoid interfering with future development and use of the sites (Figure 7). The equipment should be monitored by the Project Team and set up with alarms to identify potential technical issues to be resolved to maintain continuous data. Stations should be removed at the first frost and reinstalled the following Spring. Winter precipitation data may be provided by the closest weather station location to each site. The Project Team should also consider whether signage will be included as a teaching opportunity. This may answer questions from community members such as, "What data is being collected and where is it available?"

Figure 7: Example of planned monitoring equipment at the perimeter of a W. Woodlawn Sustainable Square Mile GI site. Source: Northwestern University.

Modelled Outcomes

The Project Team may use the Center for Neighborhood Technology's (CNT) Green Values Stormwater Management Calculator and EPA's GI Modeling Toolkit to identify the volume capacity capture goals of the site and model expected changes in stormwater retention. The Project Team should produce a summary report detailing expected changes and baseline data collection. CNT's calculator requires data inputs such as the site's square footage and the GI typologies to be installed to provide runoff potential estimated by the site's hydrologic soil group, annual precipitation, and the volume capture goal. The CNT calculator does not include evapotranspiration potential, which is typically much smaller than infiltration (capture) and runoff reduction, so the results may slightly understate the performance of the installed GI BMPs.The Project Team should then review the collected stormwater rate and volume data. This data will be compared to the modeled estimates created prior to GI installation. The Project Team should then create a summary report detailing site performance against modeled expectations.

Timeline

	Q1 Y1	Q2 Y2	Q3 Y3	Q4 Y1	Q1 Y2	Q2 Y2	Q3 Y2
Baseline stormwater assessment & monitoring	🟩						
Evaluate & purchase monitoring equipment		🟩					
Model expected site performance		🟩					
Equipment installation		🟩	🟩				
Ongoing data collection			🟩	🟩	🟩	🟩	🟩
Data review and analysis							🟩
Final monitoring template and findings							🟩

BIODIVERSITY MONITORING

As previously mentioned, GI installed on vacant lots may improve urban stormwater management by capturing and filtering excess runoff from high-volume rainfall events. GI installations that mimic natural assemblages of plants also provide habitat for insects, pollinators, and birds, thus improving local biodiversity. Enhanced biodiversity, in turn, may improve the functionality and resilience of GI installations. However, knowledge gaps exist as to whether GI installations demonstrably improve biodiversity in Chicago's neighborhoods and whether these improvements extend to the efficacy of GI. Therefore, Delta Institute recommends on-the-ground assessments of existing flora and fauna, such as a BioBlitz, to create a baseline of biodiversity on vacant lots in Chicago's south and westside neighborhoods prior to GI installation. Delta Institute's West Woodlawn BioBlitz Report is available here.

A BioBlitz (*Figure 8*) is an event in which participants identify as many living things as possible in an area in a short period of time to produce a snapshot of an area's baseline biodiversity. Civic scientists who participate in a BioBlitz not only collect valuable data about the species present in the study area prior to GI installation but may also learn about GI in their neighborhood and begin to envision what sustainable and inclusive stormwater management development in their neighborhood may look like.

Figure 8: Participants of the South Shore BioBlitz on September 28th, 2024, at the 71st and Crandon Organic Garden (2301 E. 71st St, Chicago, IL 60649). Image Source: Delta Institute.

Biodiversity Glossary

A brief glossary of key terms related to the content in this section:

- **Abundance**: the total number of organisms found in an area.
- **Biodiversity**: the variety of living things in an area. All living things interact with and influence one another as well as the environment in which they live.
- **Relative Abundance**: the evenness of distribution of individuals among species. An area may have a higher abundance of species, but less evenness of distribution of species.
- **Species Richness**: the number of different species found in an area.

In the Table below, the biodiversity of two parks is compared using the above measurements. We see that Park A has a greater Abundance of trees, but Park B has a greater Species Richness. Park A has a higher Relative Abundance of trees than Park B because the 100 individual trees in Park A are more evenly distributed among their species than Park B.

Table 1: Worked Example of Biodiversity Criterion Comparing Trees in Two Parks.

Assessment Metric	Park A	Park B
Abundance	100 Trees	20 Trees
Species Richness	50 White Oaks and 50 Elms	2 White Oaks, 4 Spruces, 1 Elm, 1 Bald Cyprus, 1 Pine, 1 Maple, and 3 Sycamores
Relative Abundance	Higher	Lower

Experimental Design

To determine the effects of GI on biodiversity, a comparison between sites with GI installations and control sites without them is recommended. Pre- and post- implementation assessments should be conducted to establish baseline conditions and measure changes. Comparisons among sites can only be made if variability is low among experimental and control sites. In doing so, changes to biodiversity, if any, may be assumed to be the result of GI implementation rather than other environmental factors. Control sites may be vacant lots and the experimental sites may be any parcel with a high observable degree of biodiversity such as a community garden, a nature sanctuary, or a forest preserve. If a BioBlitz is to be performed, it is recommended that the control sites and experimental sites are close enough together for BioBlitz participants to walk as a group.

It is also recommended that site history is collected for both control sites (vacant lots) and experimental sites. For example, without knowledge of a site's soil substrate (e.g., texture, water holding capacity) or management history (e.g., mowing, watering), it is difficult to suggest reasons for differences of plant community succession among the sites. While the plant communities observed in vacant lots are typically similar, there may be nuanced differences among sites below the surface, with possible ramifications to GI implementation.

Data Collection

A neighborhood-wide BioBlitz allows community members, civic scientists, and families to create a snapshot of the area's baseline biodiversity. BioBlitz participants use various tools and techniques to identify and document as many species as possible present across the control and experimental sites.

First, participants should perform walking surveys on each site and use the free mobile phone app, [iNaturalist](), to identify and inventory as many organisms at the species level as possible (*Figure 9*).

Figure 9: BioBlitz participants performing a walking survey and using iNaturalist to identify species. Image Source: Delta Institute.

While iNaturalist is a free and easy-to-use smartphone application, it sometimes requires substantial time for participants to download and install on their smartphones. Therefore, it is suggested that at least 30 minutes are reserved before the BioBlitz kickoff to address these technological realities. When future BioBlitz events, project teams would also do well to have several volunteers on hand that are familiar with iNaturalist to assist new users.

Additionally, iNaturalist provides recommendations for species identification based on crowdsourced data and user input. For this reason, and that many BioBlitz participants may not be trained ecologists, identification of species during the BioBlitz may not be completely accurate. To remedy this, it is recommended that local experts assist with species identification during future BioBlitz events. It is also recommended that the project team double-checks and amends, if need be, species identifications that were made during the BioBlitz after the event using the iNaturalist web platform.

Data collection itself is time intensive and requires careful coordination among BioBlitz participants. Therefore, when organizing a BioBlitz, it may be best to allocate at least 3 to 5 hours for data collection with scheduled breaks and a meal for participants.

Beyond species richness, abundance and percent cover, measurements of biomass, plant heights and floristic abundance may also be included in measurements during BioBlitz events. These measurements may help explain differences in insect, mammal and bird communities among sites.

Species Richness of each site may be estimated by the number of unique species identified by iNaturalist. Abundance may be estimated by visual surveys with large organisms readily counted. However, smaller

Figure 10: Use of 1m2 quadrat to estimate abundance of common plant species. Image Source: Delta Institute

and more abundant organisms – such as Red Clover or Common Dandelion – may be estimated by counting the number observed in a 1m^2 quadrat and multiplying that number by 10 for the whole site (*Figure 10*). For example, five Red Clovers observed in one quadrat were recorded as n = 50 for the entire site. It should be noted, while this method was useful to standardize estimations of Abundance across all sites for comparison, the resulting counts of species may be misleading.

The 1m^2 quadrat (*Figure 10*) may also be used to measure the percent cover – an indicator of the Relative Abundance – of vegetation at the sites using 1m^2 quadrats positioned along a random 10m line transect. Percent cover provides observers with an idea of how much space a certain plant species occupies in a site.

Finally, it is recommended to deploy insect traps along a random 10m line transect at each site 24 hours prior to the BioBlitz. On the day of the Bioblitz, participants collect, identify, and document the trapped insects using iNaturalist (*Figure 11*). Insect counts were included in Species Richness and Abundance.

Figure 11: BioBlitz participants identifying insects from traps with iNaturalist. Image Source: Delta Institute.

Data Analysis

It is recommended that the two following indices be used to calculate and compare biodiversity among the control and experimental sites:

First, **Simpson's Diversity Index** (SDI) may be used to quantify and compare the biodiversity among all sites. SDI provides a value between 0 and 1, where high scores (close to 1) indicate high biodiversity, and low scores (close to 0) indicate low biodiversity (Simpson, 1949). To calculate SDI, both *Species Richness* and *Abundance* of a site must be measured. The formula for calculating SDI is as follows - where n is the number of individuals of one species and N = the total number of all individuals:

$$\frac{D = 1 - \Sigma n(n-1)}{N(N-1)}$$

Worked example:

Species	**Site 1**			**Site 2**		
	***n* (number of individuals)**	***n* - 1**	***n* (*n* - 1)**	***n* (number of individuals)**	***n* - 1**	***n* (*n* - 1)**
American Crow	12	11	132	6	5	30
Blue Jay	3	2	6	5	4	20

Northern Cardinal	4	3	12	2	1	2
American Goldfinch	10	9	90	15	14	210
House Sparrow	15	14	210	11	10	110
***N* (total number of individuals)**	**44**			**39**		
		Σ	**450**		**Σ**	**372**

For “Site 1”: $D = 1 - \frac{450}{44*43}$ ➡ $D = 1 - \frac{450}{1892}$ ➡ $D = 1 – 0.237$ ➡ **$D = 0.763$**

For “Site 2”: $D = 1 - \frac{372}{39*38}$ ➡ $D = 1 - \frac{372}{1482}$ ➡ $D = 1 – 0.251$ ➡ **$D = 0.749$**

One value of *D* does not tell us much about biodiversity at a site. However, when compared among sites, two *D* values help tell a larger story. Here, we see that “Site 1” has a higher *D* value than “Site 2”. Therefore, we can infer that “Site 1” is more biodiverse than “Site 2”.

The **Shannon-Weiner Species Diversity Index** (SWSDI) should also be employed to calculate and compare biodiversity among the sites. The SWSDI calculates biodiversity by taking the total number of each species in the area, the proportion of each species to the total number of individuals, and sums the proportion multiplied by the natural log of the proportion for each species. The higher the number, the higher the diversity of species. Ideally, one should compare populations that are the same size in numbers of individuals (Nolan & Callahan, 2006). The formula to calculate SWSDI is as follows where (i) represents species, Σ is to “sum”, *ln* is the ‘natural log’, and p_i is the proportion of the entire community made up of species (i).

$$H = -\Sigma p_i * ln(p_i)$$

Worked Example:

	Site 1				**Site 2**			
Species	Number (*i*)	p_i	$\ln(p_i)$	$p_i * \ln(p_i)$	Number (*i*)	p_i	$\ln(p_i)$	$p_i * \ln(p_i)$
American Crow	3	0.14286	-1.94591	-0.278	8	0.28571	-1.2528	-0.3579
Blue Jay	6	0.28571	-1.25276	-0.3579	4	0.14286	-1.9459	-0.278
Northern Cardinal	7	0.33333	-1.09861	-0.3662	5	0.17857	-1.7228	-0.3076
American Goldfinch	3	0.14286	-1.94591	-0.278	2	0.07143	-2.6391	-0.1885

House Sparrow	2	0.09524	-2.35138	-0.2239	9	0.32143	-1.135	-0.3648
Total	**21**			**-1.5041**	**28**			**-1.4969**
			H	**1.5041**			***H***	**1.4969**

In the above worked example, Site 1 is shown to have a higher SWSDI score than Site 2, which suggests it has greater biodiversity.

Percent cover – or Relative Abundance – of plant cover at all sites may then be determined by first visually estimating the percentage of space that each plant species occupied within a 1m^2 quadrat along a randomly placed 10m transect across all sites. The estimated percentage is then converted to cm (1% = 1cm). Next, the sum of each plant species' coverage per transect is combined to provide each plant species' total coverage (cm) across the 10m transect. The total coverage (cm) is then divided by 10m and multiplied by 100 to provide a percentage. Plant species may then be categorized into functional groups – trees, shrubs, forbs and grasses. The percentage cover of each functional group per site may then be calculated. The Table below demonstrates an example of the Relative Abundance of plant cover compared among several sites from a 2024 BioBlitz in Chicago's South Shore neighborhood.

Table 2: Comparison of percent cover of plant functional groups among three sites in South Shore on September 28, 2024.

Site	Plant Functional Group	Floristic Cover (%)
S. Merrill Community Garden	Grass	37.10%
S. Merrill Community Garden	Forb	26.50%
South Shore Nature Sanctuary	Grass	52.00%
South Shore Nature Sanctuary	Forb	5.00%
South Shore Nature Sanctuary	Tree	16.00%
Vacant Lot	Forb	22.00%
Vacant Lot	Grass	78.00%

ECONOMIC AND COMMUNITY CO-BENEFITS

Beyond their environmental impacts, GI has the potential to generate both economic and community benefits. These benefits may include impacts on insurance rates, housing prices, and other economic indicators. In addition to economic outcomes, GI can enhance community well-being by improving community health, increasing perceptions of safety, and a stronger sense of place. It is important to assess baseline economic and community conditions during the site selection process and monitor changes in key indicators after implementing GI best management practices (BMPs).

Economic Indicators

Median Sold Price can be utilized as an indicator of a study area's local real estate market. Tracking home prices over time provides insight into the economic effects of green infrastructure and other community investments. Research shows that properties near GI, such as rain gardens and pervious pavements, experience higher sale prices. According to the Center for Neighborhood Technology, doubling the square footage of GI near a home can result in a 0.28% to 0.78% increase in home sale value.

Vacant Housing Units are often a sign of economic challenges but also present opportunities for revitalization. Community gardens with green infrastructure designs have shown an increase in property values and influenced neighborhood redevelopment. Therefore, if there is a decrease in vacant housing units, it could indicate a revitalization of a community. For example, properties within 1,000 feet of a community garden saw a 9.4% increase in value over five years, particularly in low-income neighborhoods (Wise et al., 2010).

Property Values can significantly be impacted by green infrastructure and green spaces; tree planting near homes has been shown to increase property values by 2-10%, with hedges and landscaped curbs contributing an additional 3.6-4.4% to home prices (Conway et al., 2008). However, the economic impact of GSI can vary. For example, Hoover et al. (2020) found that while proximity to open spaces typically increases housing prices, some cities, such as Omaha, do not show statistically significant effects. These mixed results highlight the importance of local context in assessing GSI’s economic impacts.

Unemployment Rates also provide an important measure of a neighborhood’s economic health and act as an indicator for assessing the indirect impacts of community investments. Green infrastructure projects not only create immediate job opportunities in areas such as planning, construction, and maintenance but also have the potential to drive long-term economic growth. By evaluating changes in unemployment rates, it is easier to understand the indirect benefits of GI projects. These projects can act as catalysts for more community investments, fostering economic activity and creating a ripple effect that generates jobs across various sectors. Monitoring these changes provides information on how GI contributes to immediate workforce development and sustained economic vitality in the community.

The **number of active businesses** in a neighborhood indicates its economic vibrancy, similar to unemployment rates, which reflect the area’s overall economic health. Monitoring changes in the number of active businesses following the implementation of green infrastructure projects can provide more information on the indirect economic benefits.

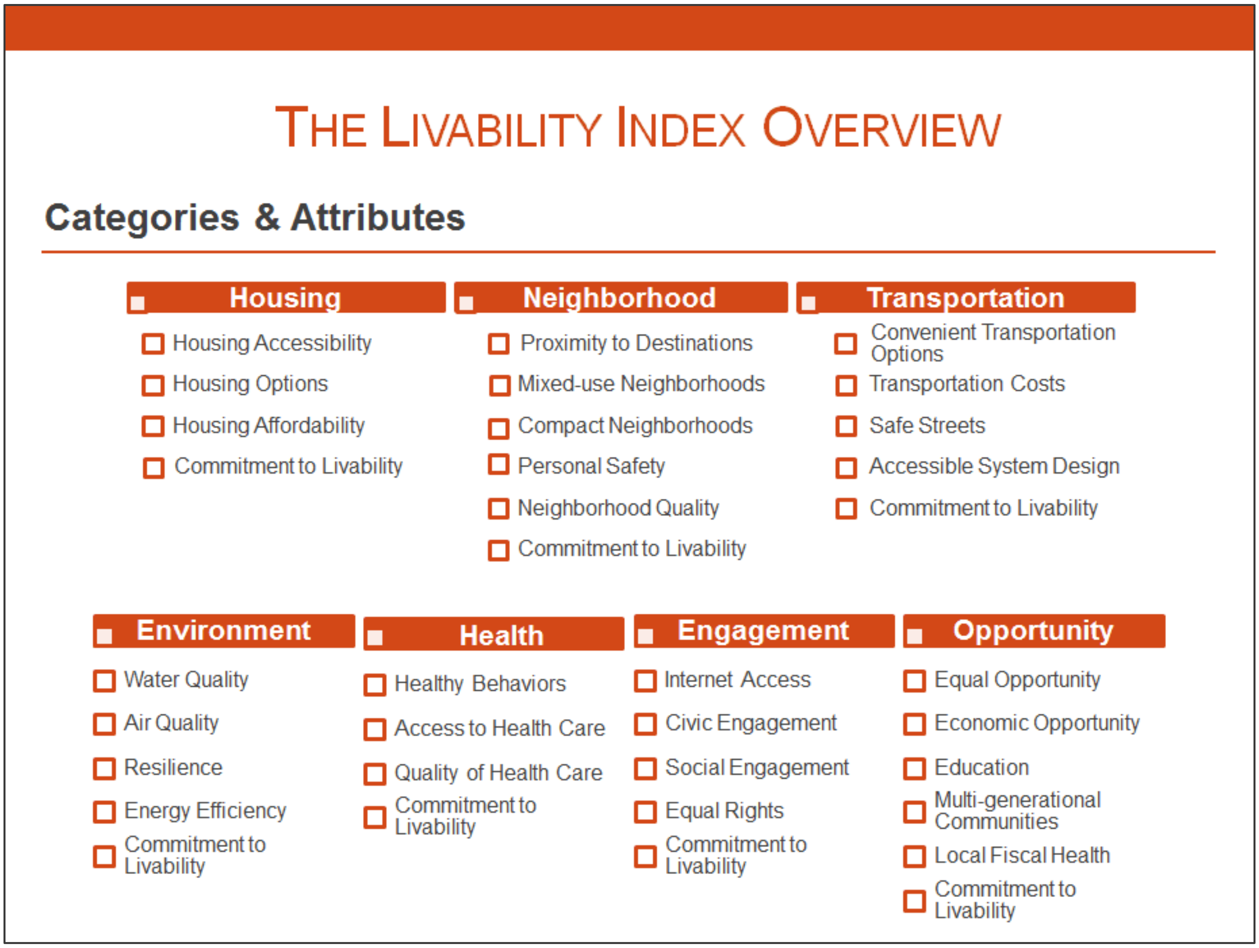
Similarly, **the percentage of owner-occupied housing units** should be monitored to assess residential stability and community investment. Higher homeownership rates often indicate stronger community ties, economic resilience, and a deeper sense of belonging among residents. Tracking these changes provides a clearer understanding of how green infrastructure fosters more economically resilient and connected communities. These metrics highlight the ripple effects of GI, showcasing its ability to enhance economic stability, strengthen social ties, and promote long-term neighborhood growth.

Community Indicators

Neighborhood Safety is a critical indicator for evaluating how green infrastructure (GI) projects influence perceptions of safety within a community. Studies have shown that GI, such as planting more trees, can reduce crime rates and enhance feelings of security in neighborhoods (Burley, 2018). These spaces provide opportunities for social interactions and foster stronger community bonds, which can help deter crime and improve residents' comfort in their surroundings. Additionally, aesthetically enhanced environments often encourage greater foot traffic, further contributing to a sense of safety. Neighborhood safety can be assessed by conducting community surveys before implementing GI projects and periodically afterward to track changes in perceived safety over time. For example, the Chicago Department of Public Health conducts an annual survey of adults aged 18 and older in Chicago to gain insights into their health and experiences. This survey includes a measure of neighborhood safety, asking respondents whether they feel safe “all of the time” or “most of the time” in their communities. This type of data can be utilized to monitor changes in perceived safety following the introduction of green infrastructure projects.

A **sense of belonging** is critical in creating thriving communities. High community belonging often correlates with improved mental health, reduced crime rates, and stronger civic engagement, making it a crucial metric for sustainable community development (Heinze et al., 2019). Monitoring this indicator helps identify how GI projects foster a sense of place and community pride. For example, implementing GI in new parks or green corridors can provide shared spaces for residents to gather, increasing feelings of connection and engagement. The annual survey by the Chicago Department of Public Health also examines the number of adults who strongly agree or agree that they feel part of their neighborhood. Surveys like this are valuable tools for monitoring changes in community impacts following GI implementation, providing a way to assess how these projects influence a neighborhood's overall well-being over time.

AARP Livability Score is another tool that evaluates neighborhoods on a scale from 0 to 100 across seven categories by looking at the intersection of housing, neighborhood, transportation, environment, health, engagement, and opportunity. The seven categories are supported by 61 indicators, comprising 40 metrics and 21 policies (Figure 12). The metrics assess a community's current livability, drawing on data collected and analyzed from local, state, federal, and private sources. The policies evaluate how livability may improve over time based on present actions. Policy data is sourced from publicly available information and spans the entire United States. Monitoring a community's baseline livability score before green infrastructure (GI) implementation and tracking changes afterward can highlight the impact of these projects. Improvements in the score following GI investments can demonstrate how such initiatives enhance a community's overall quality of life.



THE LIVABILITY INDEX OVERVIEW

Categories & Attributes

Housing
- ☐ Housing Accessibility
- ☐ Housing Options
- ☐ Housing Affordability
- ☐ Commitment to Livability

Neighborhood
- ☐ Proximity to Destinations
- ☐ Mixed-use Neighborhoods
- ☐ Compact Neighborhoods
- ☐ Personal Safety
- ☐ Neighborhood Quality
- ☐ Commitment to Livability

Transportation
- ☐ Convenient Transportation Options
- ☐ Transportation Costs
- ☐ Safe Streets
- ☐ Accessible System Design
- ☐ Commitment to Livability

Environment
- ☐ Water Quality
- ☐ Air Quality
- ☐ Resilience
- ☐ Energy Efficiency
- ☐ Commitment to Livability

Health
- ☐ Healthy Behaviors
- ☐ Access to Health Care
- ☐ Quality of Health Care
- ☐ Commitment to Livability

Engagement
- ☐ Internet Access
- ☐ Civic Engagement
- ☐ Social Engagement
- ☐ Equal Rights
- ☐ Commitment to Livability

Opportunity
- ☐ Equal Opportunity
- ☐ Economic Opportunity
- ☐ Education
- ☐ Multi-generational Communities
- ☐ Local Fiscal Health
- ☐ Commitment to Livability

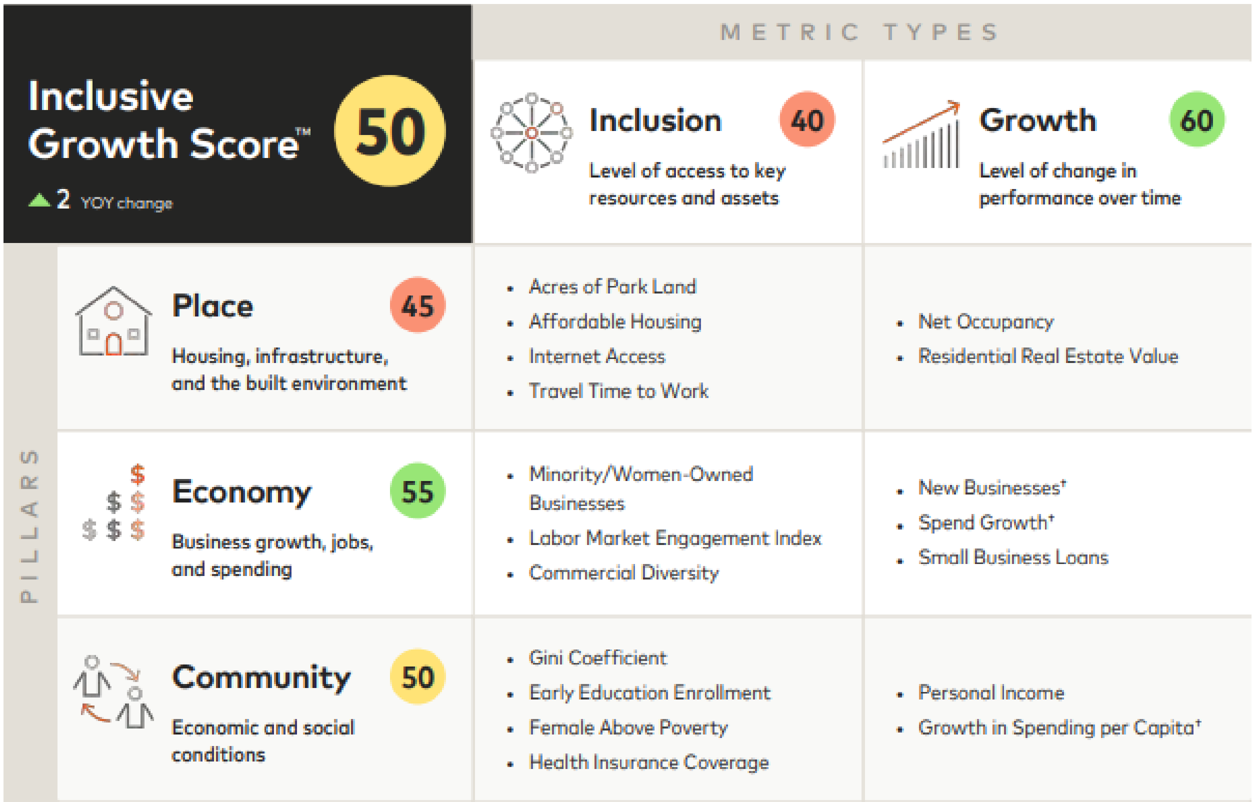
Figure 12: Indicators within the seven categories of the AARP Livability Index (Source: AARP)

The Mastercard Inclusive Growth Score is another tool that can be used to assess how a community fosters inclusion and growth. It evaluates neighborhoods, cities, and regions through a percentile rank ranging from 0 to 100, with 50 representing the average score.

The score is based on three key pillars:

- Place: Reflecting physical and environmental factors that contribute to quality of life.
- Economy: Highlighting economic opportunities, workforce development, and economic mobility.
- Community: Focusing on social equity, civic engagement, and overall community well-being.

These pillars are measured using 18 key metrics, offering insights into how communities can balance growth with inclusivity. Tracking changes in the Inclusive Growth Score before and after green infrastructure (GI) projects can help identify how GI investments enhance local equity, economic vitality, and quality of life. This score can serve as a valuable tool for assessing the broad impacts of GI projects, ensuring they contribute to sustainable and inclusive development.



Inclusive Growth Score™ 50 ▲ 2 YOY change	**METRIC TYPES** **Inclusion** 40 Level of access to key resources and assets	 **Growth** 60 Level of change in performance over time
PILLARS **Place** 45 Housing, infrastructure, and the built environment	• Acres of Park Land • Affordable Housing • Internet Access • Travel Time to Work	• Net Occupancy • Residential Real Estate Value
Economy 55 Business growth, jobs, and spending	• Minority/Women-Owned Businesses • Labor Market Engagement Index • Commercial Diversity	• New Businesses⁺ • Spend Growth⁺ • Small Business Loans
Community 50 Economic and social conditions	• Gini Coefficient • Early Education Enrollment • Female Above Poverty • Health Insurance Coverage	• Personal Income • Growth in Spending per Capita⁺

Figure 13: Example of the Inclusive Growth Score with performance indicators contributing to a score of 50 (Source: Mastercard Center for Inclusive Growth)

Data Collection Methods

Monitoring the impact of GI on community benefits involves a combination of methods, including surveys, data analysis, and the use of existing datasets. Leveraging established data from reputable sources, such as local health departments, metropolitan planning agencies, and other government or research organizations, is essential. These datasets often provide valuable insights into community indicators, saving both time and resources by eliminating the need for redundant data collection. Relying on pre-existing datasets also ensures consistency and accuracy in monitoring.

For assessing neighborhood-level economic data, tools like ArcGIS Business Analyst can be highly effective. This mapping software allows for the visualization of key demographic, business, lifestyle, and census data within the project area, enabling a better understanding of the economic and community co-benefits of GI. Additionally, the software helps produce maps and visual aids that can be shared with stakeholders to communicate the project's impact.

Data should be collected at multiple geographic levels, both before and after GI installation, to capture trends and assess the broader effects:

- City level
- Community level
- Within a half-mile radius of the site

Tools like Excel macros can automate periodic assessment analysis to streamline the reporting of economic and community impacts. This process saves time, ensures consistency, and simplifies the generation of reports highlighting changes and trends over time. This approach helps track the ongoing impact of GI on the local economy and community well-being.

When comparing data, it's important to contrast the economic performance of areas within a half mile of the GI installation with broader city and community-level data. This comparison helps account for any regional or community-wide economic trends unrelated to the GI project itself.

The tools and methods used for monitoring the economic and community co-benefits of GI will depend on the specific project. Common tools include ArcGIS Business Analyst, Geographic Information Systems (GIS), and community surveys. The Project Team should develop surveys and can be most effectively distributed through trusted community members to ensure high engagement and reliable responses.

FINAL THOUGHTS

Flooding disproportionately affects Chicago's South and West side neighborhoods with cascading negative impacts to community health and economic opportunities. In the first stages of this work, Delta's community engagement efforts identified vacant lots as an additional blight felt by South and West side Chicagoans. Green Infrastructure (GI) installations, such as rain gardens, bioswales, and permeable pavement are proven strategies to capture and filter stormwater, thereby mitigating flooding in urban areas. If GI can be installed on community-prioritized vacant lots, Chicagoans in the surrounding area may enjoy reduced flooding and additional benefits such as improved biodiversity and sustainable economic redevelopment.

Here, Delta Institute provided a guide to monitor the efficacy and effects of GI installations on vacant lots in Chicago's South and West side neighborhoods before and after installation. Baseline data is crucial to collect before GI is installed to measure against the resulting stormwater retention, biodiversity, and economic benefits so that outcomes may be tied to the implementation of GI on vacant lots. After installation, measurements from monitoring equipment, biodiversity canvassing, and community and economic indicators will help tell the story of GI's benefits to stakeholders.

The information in this guide not only comes from Delta's GI design and monitoring expertise, but also from current, on-the-ground efforts in West Woodlawn and South Shore to transform vacant lots into multi-functional GI installations. Delta is working with South Merrill Community Garden to acquire a large vacant lot on S. Paxton Ave. by performing community outreach, engaging with local decision makers, and collecting crucial baseline data. In 2024, Delta also helped Blacks in Green install GI at 6444 S. Langley Ave. by collecting baseline data, helping to design an implementation and monitoring plan, and financially supporting the costs of GI installation and monitoring equipment. The Project Team will continue to utilize the information provided in this guide to monitor the effects of GI on these two sites. Ultimately, these efforts will help to refine this guide and contribute to a replicable, transferable roadmap for other community groups to transform prioritized vacant lots with GI and measure the stormwater retention, biodiversity, and economic outcomes.

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