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Evaluation of Green Alternatives for Combined Sewer Overflow Mitigation:
A Proposed Economic Impact Framework and Illustration of its Application

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Evaluation of Green Alternatives for Combined Sewer Overflow Mitigation: A Proposed Economic Impact Framework and Illustration of its Application

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ABSTRACT

The mitigation of combined sewer overflows (CSOs) is a significant environmental and financial challenge, particularly for older urban communities where these overflows are most prevalent. Communities are increasingly examining more environmentally sustainable “green” alternatives for addressing these problems.

These green solutions are often endorsed because of the additional environmental, social, and economic benefits they produce. A growing body of reports and case studies – briefly reviewed here – describes and attempts to quantify these benefits as economic impacts.

Most estimates of economic impacts have focused on a comparison of the costs for construction and operation of green alternatives to traditional infrastructure approaches. Some of these have attempted to estimate the economic value of communitywide environmental and aesthetic gains, and other economic benefits are occasionally identified.

This report develops a broad framework, or taxonomy, for identifying and organizing the socio-economic impacts of sewer infrastructure projects. It focuses on a green project in Cincinnati, Ohio that has adopted broader economic goals. The report then uses this example to illustrate how the taxonomy can be used by community officials engaged in storm water management to obtain a fuller understanding of the economic benefits of green alternatives for CSO mitigation.

Specifically, this report provides three benefits for users:

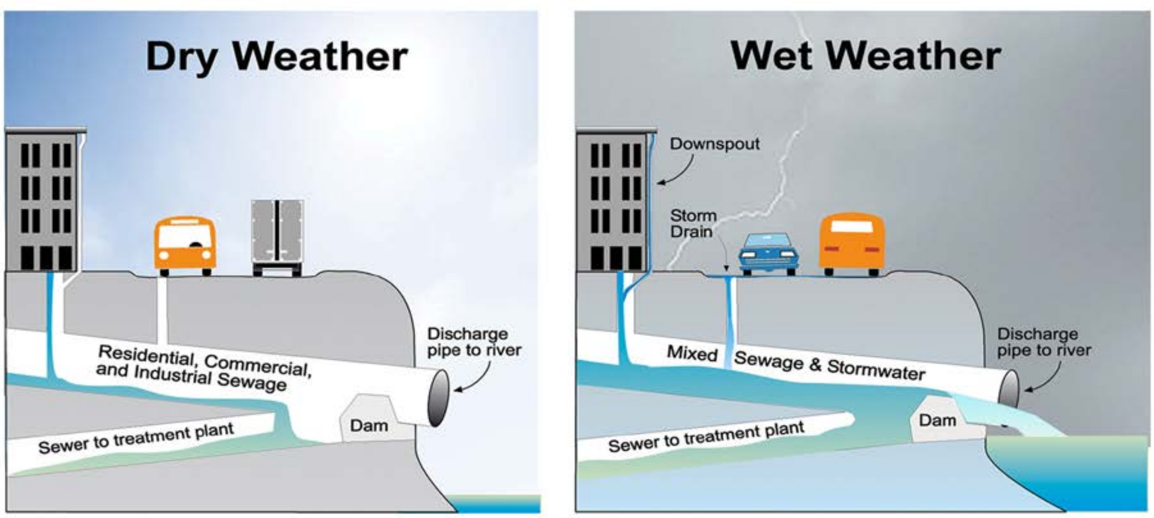
- **Guidance** to CSO and other communities that can inform their deliberations about gray versus green infrastructure approaches,
- An organizational **taxonomy** that is adaptable to any municipality, allowing for a particular community’s sewer or storm water management agency to modify the taxonomy to fit their needs, and
- A practical **tool** for pre- and post- green infrastructure implementation assessment of the socio-economic benefits of green infrastructure.

1. INTRODUCTION

1.A. SCOPE OF THE SEWER OVERFLOW PROBLEM

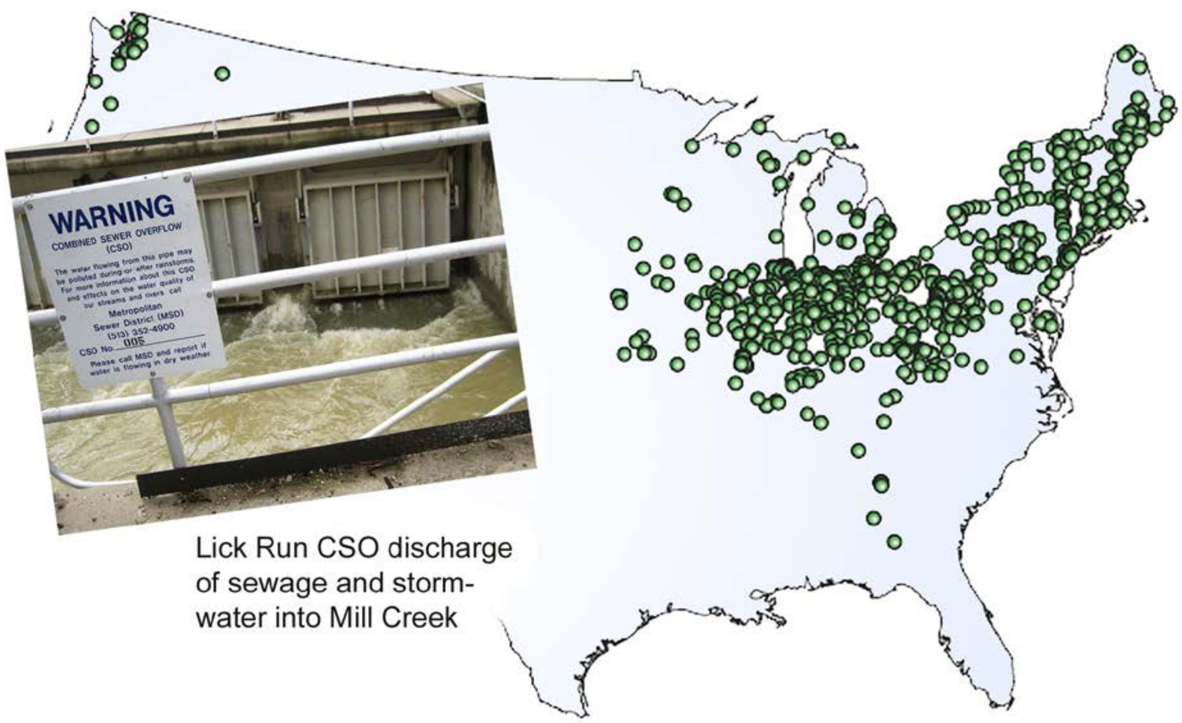
Sewer overflows are a major environmental and financial challenge across the country. Many communities, in particular urban areas with aging infrastructure, are combating neighborhood decay and contending with combined sewer overflow (CSO) mitigation for aging and insufficient sewer systems. Combined sewer systems, which are largely located in older and heavily-populated urban areas, are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. Most of the time, combined sewer systems transport all of their wastewater to a sewage treatment plant where it is treated and then discharged to a water body. During periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant and is then discharged directly into the environment (Figure 1).

Figure 1. Combined Sewer Overflow (CSO). During heavy rains, the combined flow of sewage and storm water is typically more than wastewater treatment plants can handle, and the Combined (sanitary & sewage) Sewer pipes discharge the excess sewage and storm water into streams. Such discharges create polluted waterways that expose humans and wildlife to pathogens and toxins.



These overflows, called CSOs, contain not only storm water but consist of mixtures of domestic sewage, industrial and commercial wastewater, and storm runoff. CSOs often contain high levels of suspended solids, pathogenic microorganisms, toxic pollutants, floatables, nutrients, oxygen-demanding compounds, oil and grease, and other pollutants. CSOs can cause violations of water quality standards. Such violations may pose a risk to human health, threaten aquatic life and its habitat, and impair the use and enjoyment of the Nation's waterways. In its 2004 Report to Congress on sewer overflows, the U.S. Environmental Protection Agency (U.S. EPA) identified 772 communities with CSOs. While the scope is national, communities in U.S. EPA's Great Lakes and New England Regions account for half of the identified consent decrees (30% and 20%, respectively)(Figure 2). The burden these consent decrees pose for communities is increasing, from an average of $31.9 million annually per community for consent decrees signed in 2002 through 2006, to an average of $52.6 million for decrees signed in 2007 or later.

Figure 2. CSO Distribution in the United States. Dozens of major cities in the U.S. have been issued federal and/or state consent decrees for violating the Clean Water Act due to CSO discharges into rivers, lakes, and streams.



1.B. GREEN INFRASTRUCTURE SOLUTIONS TO SEWER OVERFLOWS

Given the high cost of these challenges, it is not surprising that communities are looking for solutions that offer cost savings or other benefits. Green infrastructure (GI) and low impact development (LID) are garnering more attention as communities find ways to manage their wastewater infrastructure issues, whether compelled by a consent decree to manage CSOs or not.

GI and LID are related, but distinct concepts. Much of the existing research, particularly case studies, focused on GI interventions. LID typically refers to land development and redevelopment that preserves or creates natural features to remove storm water from CSOs, treating it like a resource and not a waste product.[1] GI includes a broader range of interventions. The Center for Neighborhood Technology defines GI as "a network of decentralized storm water management practices, such as green roofs, trees, rain gardens and permeable pavement, that can capture and infiltrate rain where it falls, thus reducing storm water runoff and improving the health of surrounding waterways" (Figure 3).[2]

Figure 3. Green Infrastructure Technologies. Green infrastructure helps to: 1) reduce storm water runoff into aging combined sewer systems and thereby help to prevent overflows, 2) create additional green space for typical CSO areas, 3) provide additional economic and social benefits to these communities, and 4) comply with federal and state consent decrees.

[1] U.S. EPA (2012a)
[2] Center for Neighborhood Technology (2010)

One particular intervention is urban stream daylighting, which Buchholz and Younos describe as a process in which a portion of a waterway that was previously covered or engineered into storm water drainage is deliberately exposed.[3] It is motivated by ecology, economics, education, and/or aesthetics, with the goal being riparian habitat and water quality improvement. It can be a way of creating valuable open space in the middle of dense urban communities. In their review of 19 case studies of urban stream daylighting projects, Buchholz and Younos categorize projects into five groups based on the primary goal of the project:

- Creation of a park amenity,
- Economic development/flood reduction,
- Ecological restoration,
- Creation of an outdoor classroom/campus amenity, and
- Residential daylighting.

A common feature of all of the projects is they tend to alter the land use in the project area where the CSO mitigation occurs. Another example of this type of change is the daylighting of Little Sugar Creek in Charlotte, North Carolina, which has produced an urban greenway. As the physical landscape may be permanently altered in a manner that does not occur with traditional (gray) approaches, GI interventions are believed to generate benefits beyond the mandated water quality improvements, that gray approaches do not realize.[4]

U.S. EPA has published a number of documents over the years to guide communities and regulators in addressing CSO problems. Much of U.S. EPA's recent work has provided insights about green alternatives to traditional gray approaches and developing an integrated approach to developing more effective storm water and wastewater solutions.

1.C. EXISTING RESEARCH ON GREEN INFRASTRUCTURE BENEFITS

In this last decade, much research has surfaced examining the benefits resulting from green approaches to sewer utility and wastewater infrastructure issues. Green approaches to CSO mitigation are particularly attractive as a practice and object of research because they are seen as addressing each aspect of the Triple Bottom Line (TBL) – environmental, economic, and social priorities.[5]

Measures of the environmental prong of the TBL are relatively well defined and standardized, and other researchers have formalized a detailed taxonomy for evaluating environmental

[3] Buchholz and Younos (2007)
[4] See Stratus (2009); Wise et al. (2010)
[5] Stratus (2009)

impacts, such as are associated with CSO mitigation projects.[6] Regarding economic and social measures, there is considerably less consistency, particularly as they relate to GI. While projects vary from community to community, so too do the types of outcomes, analyses and uses of findings.[7] Often, the intended use of the findings influences the type of analysis employed. In performing complex economic analyses, it is extremely important to use the same methods for measuring both costs and benefits, lest the asymmetry produce incomplete or biased results.[8]

One challenge that exists in evaluating land use changes is the wide variety of land use changes that may occur.[9] To the extent, that consensus exists on economic and social impacts, the research, and case studies divide economic measures into two categories:

- Initial, or direct, economic outcomes: often savings on the hard costs of construction, and
- Subsequent, or indirect, economic outcomes, which may be defined as "costs and benefits that are not included in traditional engineering estimates of the expense to build and operate facilities."[10]

The initial, direct economic outcomes are generally well-defined and easily measured as a standard piece of engineering evaluation for CSO mitigation projects, both gray (traditional infrastructure) and green. There are construction costs for each alternative, and where green is less expensive than gray, the GI cost savings become a direct benefit.

In contrast to the clear comparisons in the first category of outcomes, the second category of subsequent or indirect outcomes is often less straightforward. Often, proxies must be used to define ancillary economic outcomes, which result from environmental or health impacts, in monetary terms. For example, monetary valuations of pollution reduction, carbon reduction, and heat stress reduction are common in the literature.[11] Commonly considered are changes to property values and valuations of public amenities such as green space.[12] These types of measures follow from potential sustainability goals that U.S. EPA notes in its 2012 Handbook.[13]

While it may often be the case that GI practices for CSO mitigation produce greater direct economic benefits through hard cost reductions compared to gray approaches, "there is a tendency…for green infrastructure proponents to wish to value the indirect benefits of these

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[6] Bare and Gloria (2008)
[7] Garmestani et al. (2011)
[8] Jaffe (2010)
[9] Bare (2010)
[10] Stratus (2009)
[11] See Center for Neighborhood Technology (2010); American Rivers et al. (2012); Wise et al. (2010); ECONorthwest (2007).
[12] See Center for Neighborhood Technology (2010); Wise et al. (2010); ECONorthwest (2007)
[13] U.S. EPA (2012b)

practices in terms of their abilities to support larger ecosystem services and functions."[14] Case studies and project evaluations focus considerably on valuing these non-market benefits; however, significant challenges exist. In the course of identifying and measuring the benefits accruing to a particular community for the particular practices implemented, the repeated caveats are the importance of local conditions and the difficulty of properly valuing outcomes for which there is no market for exchange where an observable price for the outcome is set.[15] In assessing these efforts, critics have noted, "Problems with using more indirect methods of valuation include unnecessary complexity, analytical asymmetry, and distributional distortions." [16]

Relying on a selection of case studies to guide project evaluation may result in a community omitting relevant measures, or focusing on outcomes that may not be applicable. Due to widely varying local conditions, many GI practices described in the literature vary widely in how they are implemented. When these differences are combined with the existence of multiple techniques that may be employed to estimate economic benefits, it is difficult to generalize from specific project evaluations. Consequently, even carefully constructed evaluations may not produce reliable results if they are based on case studies alone.

Aside from the substantial difficulties in obtaining generalizable estimates for the valuation of non-market benefits, another challenge is a lack of understanding, recognition or acceptance of the potential benefits that GI may generate.[17] Likely this lack of widespread recognition or consensus on these benefits is due to the fact they accrue to different groups in different magnitudes. Private individuals may experience some benefits, such as reduced energy costs, while other benefits are more diffuse like public goods such as parks and green space.

Most studies of GI's economic benefits have largely neglected important measures of economic vitality, focusing instead on measuring complex concepts that are inherently difficult to quantify, including the reduction in negative externalities such as pollution or the creation of public goods such as parks. As noted earlier in the categorization of urban stream daylighting projects, economic development may sometimes be a high priority for communities pursuing GI interventions.[18] The U.S. EPA notes that "improv[ing] the economic vitality of the existing community" is a potential sustainability goal.[19] Thus, measures pertaining to the economic vitality of the project area are consistent with economic and socio-economic impacts of GI, particularly for CSO mitigation projects that tend to occur within older, urban settings.

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[14] Jaffe (2010)
[15] See Center for Neighborhood Technology (2010); American Rivers et al. (2012); Wise et al. (2010)
[16] Jaffe (2010)
[17] Wise et al. (2010); ECONorthwest (2007)
[18] Buchholz and Younos (2007)
[19] U.S. EPA (2012b)

1.D. FOCUS OF THIS RESEARCH ON GREEN INFRASTRUCTURE BENEFITS

This research focuses on the redevelopment challenges associated with green alternatives for CSO mitigation, rather than new construction, which has received more attention from other researchers.[20] This report provides an initial characterization of "economic development" impacts, and proposes these measures as a more focused conception of the economic and social aspects of the TBL.

As illustrated in the review of case studies to follow, economic development impacts – such as changes in occupancy rates, employment, and income within the CSO project area – are largely absent from consideration. Beginning with a categorization of the impacts common in the existing research, this report attempts to fill this gap in the research on the economic benefits of green approaches to CSO mitigation in urban areas.

This report presents a broader taxonomy, which includes economic development impacts that do not rely on complex estimation of non-market benefits. These benefits occur first within the primary project area, but expansions to the larger metropolitan area, sewer service area, or community are possible. The taxonomy provides a framework that individual communities may use to measure changes in their project area following their GI investments.

Consistent with the analyses in previous studies, these economic impacts are ancillary in that they are not part of the standard metrics in an engineering evaluation. Similar to previous research, these impacts are expected to occur primarily because of the permanent land use changes necessary to implement the interventions, and thus assumed not to result from traditional gray approaches.

2. REVIEW OF CASE STUDIES

Case study analysis is common for planning and evaluation of storm water management programs and often has served as an effective means of evaluating specific outcomes for a particular community. However, there are drawbacks to relying on case studies for projecting potential outcomes. Most notably, even similar locations and projects will still have substantial variability in their outcomes due to differences in local conditions and the particular interventions pursued. While there is tremendous variation across locations, some consistencies have surfaced.

[20] ECONorthwest (2007)

One thorough review of nine case studies of GI storm water maintenance projects revealed that typical types of project analyses include: [21]

- Cost-effectiveness,
- Benefit valuation, and
- Cost-benefit analysis.

This review found the purpose of an analysis of GI economic impacts often guides the selection of techniques and outcomes. Broadly, the two most common motives for pursuing the analysis include:

- Gaining stakeholder support and/or funding and
- Supporting data-driven decision-making.

Employing economic principles and strategies in order to promote GI investments makes sense. It is these very principles that guide most investments, and economic outcomes, such as jobs created, business district redevelopment, increased property values, tax revenues, and substantial cost savings in efforts to meet environmental goals. However, in the case of GI investment decisions by public sewer agencies, these strategies are meant to serve both the preferences of consumers and the environmental objectives defined by federal and state laws and regulations.

As mentioned previously, there is another analysis of case studies that focused on urban stream daylighting projects.[22] This analysis included two projects that addressed urban sewer overflow and flooding problems and led to notable revitalization activities.

The first, Arcadia Creek in Kalamazoo, Michigan, was part of larger, 13-block redevelopment plan, which now provides a site for numerous city events and generates a positive economic impact for the city. The second, the daylighting of a section of the Grand River in Jackson, Michigan, which was undertaken for the purpose of removing a culvert that created a serious safety hazard, resulted in "unexpected business development and investment along the newly opened waterway."

In addition to these two sets of case studies, the Economics Center reviewed an additional selection of case studies that focused on CSO communities. These studies were produced by the American Society of Landscape Architects (ASLA). Two groups of case studies were selected for review. The first were GI projects that centered on CSO systems. The second group consisted of projects that explicitly evaluated the choice of green versus gray solutions to storm water management. The case studies are summarized in Tables 1 and 2.

[21] For more detail on these case studies, see Garmestani et al. (2011).
[22] Bucholz & Younos (2007)

They provide several examples wherein the green solution is less expensive than the gray solution, and this reduction in cost is true not only for (capital) cost assessments, but for several examples of life cycle costs. These lower costs contradict critics of GI who argue that GI is a high cost alternative. When GI is a lower cost alternative, it might be easier for water management officials to get buy-in from stakeholders.

Occasionally, economic considerations extend beyond project costs to an articulation of other benefits such as long-run economic impacts. The Lick Run project in Cincinnati, Ohio, the first project in Table 1, is an example of such an approach. Sewer district descriptions of the project stress the importance of the economic benefits of new green space amenities and anticipated urban redevelopment.[23]

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[23] U.S. EPA (2011)

Table 1. Summary of ASLA Case Studies featuring Combined Sewer Overflow Systems

Entity	GI Program Description & Objectives	Consent Decree	Role of Analysis	Type of Analysis	Key Metrics	Project Outcome
Lick Run, Cincinnati, Ohio	Daylighting and other GI features such as greater use of natural drainage systems, to reduce storm water volume and improve water quality.	Y	Overall cost assessment and performance analysis of storm water solutions	Capital cost assessment	Storm water reduction by gallons	Projected to reduce CSOs by approximately 630 million gallons annually
Speedway, Indiana	Combined sewer separation project utilizing bioswales, rain gardens, and native plant communities	N	Identify cost effective means to achieve water quality and ground water infiltration for 88% of annual rainfall	Cost Effectiveness	GI vs. gray analysis performed	Free draining soil utilization meant that GI was actually less expensive than gray infrastructure; 88% of all rainfall events can be fully captured/treated by new infrastructure
Indianapolis, Indiana	Combined sewer separation project with green infrastructure of two bioretention basins with overflow spillway	Y	Identify most cost effective means to achieve water quality and ground water infiltration for 88% of annual rainfall	Capital cost assessment	GI vs. gray solution comparison	Project captures, treats and filters all storm water up to 1", which for Central Indiana, covers ~88% of all rainfall.
Tabor to the River	Integrated hundreds of individual	N	Cost Effectiveness	Cost Benefit Analysis	Cost savings of $60 million over	Increased community engagement to improve

Program, Portland, Oregon	projects to improve sewer system reliability				the proposed gray solution	watershed health
East Ohio Street, Indianapolis, Indiana	Improve drainage, handicap accessibility, and replace deteriorating urban infrastructure in area. Project contains small rain garden grant	Y	Evaluate impact of redevelopment of area using GI	Cost Effectiveness	GI vs. gray solution comparison	Significantly reduced costs (10%) over gray infrastructure. Project removes an estimated 1.3 million gallons of storm water from the combined sewer system annually. This is ~90% of annual rainfall for area

Table 2. Other Relevant ASLA Case Studies featuring Green vs. Gray Analysis						
Entity	**GI Program Description & Objectives**	**Consent Decree**	**Role of Analysis**	**Type of Analysis**	**Key Metrics**	**Outcome of Analysis**
Rome, New York	Retrofit of downtown streetscape, tree planting in urban core, and inventory/analysis of existing public trees in Rome	N	Demonstrate costs of implementing aesthetic changes to the urban core	Capital cost assessment	GI vs. Gray solution comparison	90% of storm water infiltrates into new porous Flexi-Pave rubber pavement and dissipates naturally over time
West Milton, Ohio	Collection of rainwater incorporated into daylighting downspouts from green roof into decorative rain gardens as well as a large underground cistern	N	Cost Effectiveness	Cost Benefit Analysis	Reduction in costs (9% savings)	Significant reduction in the volume of runoff and a $13,000 savings for the school district in water bills annually
Mt. Tabor Middle School, Portland, Oregon	Implement storm water management through rain garden, porous concrete bioswales, storm water planters, and a	N	Assess potential of green solutions to meet objectives without damaging property aesthetics	Cost Effectiveness	GI vs. Gray solution comparison	GI storm water solutions had an overall savings of approximately $500,000 over the gray alternatives of added upsizing of sewer pipes

	green street					
Frick Chemistry Laboratory, Princeton, New Jersey	Construction of three Bioretention basins and a 12,000 gallon rainwater harvesting tank in order to manage storm water runoff	N	Cost Impact analysis & Performance Analysis	Life cycle cost analysis	Comparison of life cycle costs for GI vs. gray solution	Reduced the volume of storm water discharge by 583,270 gallons through the “greening” of site, with an additional 582,861 gallons reused annually for toilet services

Note: The Frick Chemistry Laboratory and Tabor Sewer Projects described in Table 1 included a Green vs. Gray cost analysis

3. CONVERSATIONS WITH COMMUNITY OFFICIALS

The Economics Center conducted structured conversations with storm water management officials in nine cities to understand how they apply economic principles for more effective GI investment and to ascertain if these officials saw a connection between GI investments and economic gains that may result from them. [24] From these conversations, we learned their experiences offer insights for other communities about the potential for using GI to address both environmental and economic objectives.

3.A. MARKETING GREEN SOLUTIONS

Among the various sets of case studies examined during this project, the overwhelming majority reported the "regulatory environment was favorable" to the GI project. Properly working out regulations can create a system of economic incentives that motivate property owners to manage storm water efficiently without an overarching development plan. Once this system is in place, officials still have to decide with whom to interact to get things done: developers or homeowners?

Some officials suggested that targeted regulations can guide individual homeowners to implement new small-scale GI projects in established neighborhoods. However, most officials find it easier to work with developers because there are fewer of them than there are homeowners. While fewer resources are required to reach and educate one developer about GI options, such an approach must happen at an earlier stage than educating multiple homeowners. More resources are required for this kind of in-person relationship building, although there is at least one example of a small jurisdiction (Alachua County, Florida) that has a complete manual that can be distributed with guidelines for GI investment and incentives. One official noted that it was particularly beneficial to make contact with developers at this earlier stage, as it provided an opportunity to "do things right." Another approach—which does not require extensive interface with developers—can be used in conjunction with local regulations. This involves targeting large green spaces under public control for these projects, a tactic that has been pursued in Omaha, Nebraska.

According to several community officials, more public money is directed to *redevelopment* projects rather than new development projects, while the new development projects are seeing plenty of private, incentivized GI investment.

[24] Communities were identified by the Economics Center from a list of consent decree cities and existing case studies. They included Omaha, Nebraska; Kansas City, Missouri; Indianapolis, Indiana; Louisville, Kentucky; Covington and Newport, Kentucky; Lima, Ohio; Austin, Texas; Denver, Colorado; and Alachua County, Florida.

3.B. MANAGEMENT CHALLENGES OF GREEN INFRASTRUCTURE

In some of the case studies described above, economic development occurred because of GI investment. However, many of the case studies did not carry out a full cost analysis of green vs. gray infrastructure, so the aim of these conversations was to uncover evidence that communities see a connection between GI investments and economic gains that may result from it. For these officials, evaluating the additional benefits of GI is complicated by the absence of sufficient documentation of results. This is why most current and recent GI efforts are small-scale demonstration projects that focus largely on measuring impacts, with the objective of producing the necessary documentation being just as important as the environmental and socio-economic outcomes.

Another set of challenges associated with GI projects involves the operation and maintenance of GI. Projects that involve sewer agencies forming partnerships with property owners lead to uncertainties about who owns and is responsible for maintaining the infrastructure. In some cases, the burden of identifying and implementing accountability systems has led communities to cut back on partnership efforts. A second challenge concerns the need for more specialized workforce skill-sets associated with installing, operating, and maintaining these GI systems.

The conversations revealed a focus on engineering and environmental metrics because they are easiest to measure, with economic impact measures such as new business activity "harder to tell because of the economic times that we're in." When it is implemented, most officials indicate they treat the cost of the gray plan as a baseline, with relative savings from cheaper GI used to re-invest (for example, a rain garden means the size of a pipe being installed elsewhere can be smaller, therefore less costly). Building the necessary consensus among stakeholders therefore may not be difficult; often GI is desired by everyone involved because the smaller initial projects involve little financial risk while potentially offering substantial reward if successful projects can be "scaled up" to system wide implementation.

Community officials raised the issue of equity. Low income citizens may be disproportionately more likely to live in areas with CSOs and other environmental problems. While they would benefit from better-managed water flows, anecdotal reports from sewer managers indicate that, even when the GI represents a net financial gain via higher property values, the inability of renter households to extract equity from this capital gain means they do not receive the full benefit, even if they do receive some social/health benefits from achieving environmental goals; one official reported the property owners in such neighborhoods seem to be less interested in taking on the additional maintenance responsibilities associated with GI systems.

3.C. THE IMPORTANCE OF PROPERTY RIGHTS

Defining property rights is particularly relevant to the study of natural resource management because property rights to natural resources are often murky or subjected to a variety of government decrees. Decentralized development via management of private incentives requires clearly defined property rights, without which markets typically fail to reach the most socially desirable outcomes. However, when GI projects are undertaken in the context of responding to a consent decree or for the purpose of achieving a specific environmental outcome, the production of economic value may be a secondary objective, if it is a concern at all. If property rights are defined in a way that allows those with authority over water management and redirection to act, this type of value creation can take place.[25]

In light of these conversations, the development of a taxonomy of economic impacts is a step towards helping community officials identify significant impacts of their projects. Understanding these impacts will allow them to better plan how to address their storm water management goals.

4. ECONOMIC OUTCOME TAXONOMY

4.A. PREVIOUS MEASURES

As noted in the literature and case studies, some consistent themes arise as communities evaluate the impacts of their GI CSO mitigation projects. These commonalities allow for the creation of a preliminary taxonomy, or organizational structure, of economic benefits. All projects are concerned with construction, operation and maintenance costs. Sometimes they are addressed comprehensively in a life cycle cost analysis. These costs typically accrue to the entire service area or municipality, as they are generally funded by either sewer rates or bonds. These costs are private in that they are ultimately borne by individuals. Typically, researchers and community leaders would consider cost reductions associated with the adoption of GI practices, instead of gray, as economic benefits.

All projects, but particularly those that require changes to land use, entail disruption within the project area. Costs such as lost business activity may be considered private as they are incurred by the business owners; however, there is a convenience cost to consumers that is more diffuse. It is unclear whether GI practices lead to less disruption in the project area than traditional interventions.

The next theme that surfaces is the emphasis on the valuation of non-market outcomes as economic benefits. Generally, these are environmental and health benefits, such as impacts of

[25] This is illustrated by the situation in Colorado, where, as was described in one of these conversations, property rights are defined in an *a priori* manner, the relevant water is generally not owned by the person best able to redirect it or install decentralized GI. In fact—except in the wettest of rainfall seasons—many junior water rights holders may not have any right to redirect any of the water that flows across their properties, because the water that does fall is entirely absorbed by senior water rights holders. In situations in which the cost would be borne by one decision-maker, yet a different one has responsibility to mitigate the problem, market failure can often result even from attempts to properly manage water flow using purely economic incentives. Such a situation may benefit from a more centralized approach.

pollution reduction. Hedonic measures of amenity creation, such as parks and green space, are included. Just as the hard costs of construction accrue to the service area or community at large, so too do these particular economic benefits.

Among the several benefits identified in studies that accrue specifically to the GI project area, the most common ones are energy use/cost reductions (which may translate to utility bill savings), flood damage reduction, and changes to property values. These are the only benefits typically considered that accrue explicitly to individuals as a direct result of the CSO mitigation. While GI interventions produce these benefits and costs, many of them may be associated with gray interventions. Costs associated with disruption in the project area during construction occur with both alternatives. Similarly, if the mitigation strategy lowers treatment costs, there may be rate reductions for households and individuals and removal of the CSO may reduce flooding under either a gray or green approach. Finally, since the CSO mitigation is, at heart, an environmental concern, some of the non-market benefits that may result from reducing pollution may be realized with a gray approach.

Table 3 presents a framework, or taxonomy, for the most often considered economic impacts of CSO mitigation. The first organizational element of this preliminary framework is the division between initial and subsequent impacts, while the second addresses differences in geographic scale.

Table 3. Preliminary Framework of Economic Impacts
INITIAL ECONOMIC IMPACTS
▪ Project Area Specific • Disruption due to construction *Lost Sales to Businesses; time loss to motorists from traffic detours*
▪ Communitywide • Construction costs (savings) • Operations & Maintenance (O & M) costs (savings) • Life Cycle costs (savings)
SUBSEQUENT ECONOMIC IMPACTS
▪ Project Area Specific • Flood damage reduction • Reduced energy use • Changes in privately owned property values

- Communitywide
  - Monetized Environmental Benefits
    Reduction in pollutants (water and air)
  - Monetized Health Benefits
    Reduction in heat stress, pollution-related ailments
  - Monetized Public Amenities
    Newly created green space, parks and recreational space

4.B. ECONOMIC DEVELOPMENT OUTCOMES

As noted in the literature and case studies, motivations for pursuing GI interventions vary across communities, as do the interventions. As such, the outcomes measured tend to vary. Beyond the classification identified above, what is generally consistent across case studies and the literature is that benefits accruing to the project area, and its economic vitality, receive little attention as a priority or an outcome measure, with the exception of some references to local property values.[26]

The current work seeks to fill this gap in the research by identifying appropriate measures of economic and socio-economic vitality for CSO mitigation projects that utilize GI practices. First, we identify categories and candidate measures for economic and socio-economic impacts. Following this, the impacts will be explored in greater depth with real data for the Lick Run CSO Project in Cincinnati, Ohio. As described in the review of nine GI storm water case studies, most evaluations emphasize system-wide or community-wide benefits; however, the mitigation project is a local activity, often occurring within a specific neighborhood. Additionally, the existing research and case studies illustrate that GI practices are distinct from traditional "gray" approaches primarily because they often require permanent changes to land use, and they may change the ownership of land. Given the project is location-specific, it stands to reason that location-specific economic outcomes may occur. It is reasonable that such benefits can only occur in the project area with these significant changes to land use. GI interventions that consist more of green roofs or disconnecting downspouts, for example, are not likely to create these economic development impacts.

The framework that follows focuses specifically on the addition of market-based benefits within the project area to the taxonomy outlined above. It provides an outline for considering what types of impacts may result from the GI intervention and identifies appropriate measures for these impacts. As with many preceding evaluation efforts, appropriate measures may be influenced by local priorities and conditions. This framework provides a method for considering available measures that, while consistent with local priorities and conditions, may be easily interpreted and

[26] Because CSO project areas are often located in low or moderate income neighborhoods, localized economic benefits may warrant greater attention than communitywide benefits.

more easily compared across interventions, communities, or time. Thus, a "Comprehensive Taxonomy of Economic Impacts" is developed in stages to accomplish two goals:

- Identify and organize categories of impacts and
- Identify available measures of impacts, describing advantages and disadvantages

The innovative portion of this Comprehensive Taxonomy, which focuses on the Lick Run project area, begins with three major economic impact categories: Area Revitalization, Economic Activity, and Socio-economic Benefits. While measures have been organized under specific categories, there may be overlap. For example, property values, a well-established outcome measure, may be considered economic or socio-economic. We place it in the "economic activity" category primarily because it is easily monetized. Changes to property values impact the well-being of residents and business owners. Generally, increases in property values are believed to be a good thing to the extent that property is an asset; however, increases in property values may increase the cost to owners of maintaining the property through increased property taxes. These measures are concerned with observable changes to land, businesses, and people. Additionally, these measures are categorized by their assumed sequence of occurrence. In other words, the first category of outcomes is considered to be proximate to the GI intervention, and facilitates changes to the outcomes in the second category. This intuitive sequencing is appealing for evaluation purposes as it allows communities to define short- and long-term potential impacts.

4.B.1. Land Use and Property Conditions

This category is proximate to the GI intervention as it deals specifically with physical changes in land use and structures in the project area as a result of revitalization. While initial changes in these indicators are likely due to the intervention itself, subsequent changes may occur because of additional leveraged or stimulated investment. These measures allow for observing the mix of public-private involvement in the project area. Within this category, measures include:

- Land use mix of parcels (residential, industrial, commercial),
- Share of undeveloped property/parcels,
- Ownership mix of parcels (public/private), and
- Physical condition of property and of structures on developed parcels

4.B.2. Economic Activity

These measures are direct reflections of the economic activity, particularly as it pertains to businesses, occurring within the project area. The assumption is the changes to land use and zoning that occur as a result of the GI intervention will facilitate changes to both how the land is used and how intensively it is used. While the previous category measures changes to how the land is used, the measures that follow are considered illustrative of intensity or type of use:

- Occupancy rates on developed, commercially zoned parcels,
- Composition of businesses,

- Employment at local businesses, and
- Property values

The particular measures selected here may be reflective of the local priorities for redevelopment of the project area. Once the economic purpose of the project area has been identified, measures to observe changes should be identifiable. For example, a community may have a desire to stimulate a particular industry, employment, or type of development. The presence or concentration of the specific business or employment could be identified.

4.B.3. Socio-Economic Benefits

This category captures changes to the circumstances of people, primarily residents of the project area:

- Occupancy rates on residentially zoned property,
- Median income level of residents,
- Employment status of residents,
- Public assistance status of residents, and
- Wages paid to local employees

Table 4 presents a comprehensive taxonomy for evaluating GI interventions for CSO mitigation. In addition to the grouping of measures as described above, the final two columns address aspects of the advantages and disadvantages of these measures. “Sophistication Required” assesses the level of complexity in producing reliable economic estimates, and “Data Source” offers insight into the difficulty of compiling the necessary data.

Table 4. Comprehensive Taxonomy of Economic Impacts

Category	Geographic Area	Outcome/Impact	Measure	Sophistication Required	Data Source
Initial	Project Area	Disruption	Lost Sales to Businesses	Moderate	Business Survey
			Lost Time for Detours		Transportation Model
	Community	Hard Costs	Construction Costs	Low	Engineering Estimates
			O & M Costs	Moderate	
			Life Cycle Costs	High	
Subsequent	Project Area	Flood Damage	Flood Damage Costs	Low	Engineering Estimates, EIS
		Reduced Energy Use	Energy Costs		Public Utility
		Land Use and Property Conditions	Land Use Mix	Low	Local Government *
			Share of Undeveloped Property		
			Public/Private Ownership Mix		
			Physical Conditions		
		Economic Activity	Commercial Occupancy Rates	Low	Local Government *
			Business Composition		Federal, State Agencies
			Employment & Employee Wages		Federal, State Agencies
			Property Values		Local Government *
		Socio-Economic Benefits	Residential Occupancy Rates	Low	Federal, State Agencies
			Resident Median Income		Federal Agencies
			Resident Labor Force Participation		Federal Agencies
			Resident Public Assistance Receipt		State Agencies
	Community	Environmental,	Value of Pollution Reduction	High	Proprietary Estimates,

		Health, and Public Amenity Benefits	Value of Heat Stress Reductions, Pollution-Related Ailments		U.S. EPA/Industry Standards
			Value of Green Space, Parks, Recreational Space		

* Local Government includes County Auditor, Property Value Authority or similar agency, and City/County Planning Department

5. ILLUSTRATION OF THE TAXONOMY: AN APPLICATION TO LICK RUN

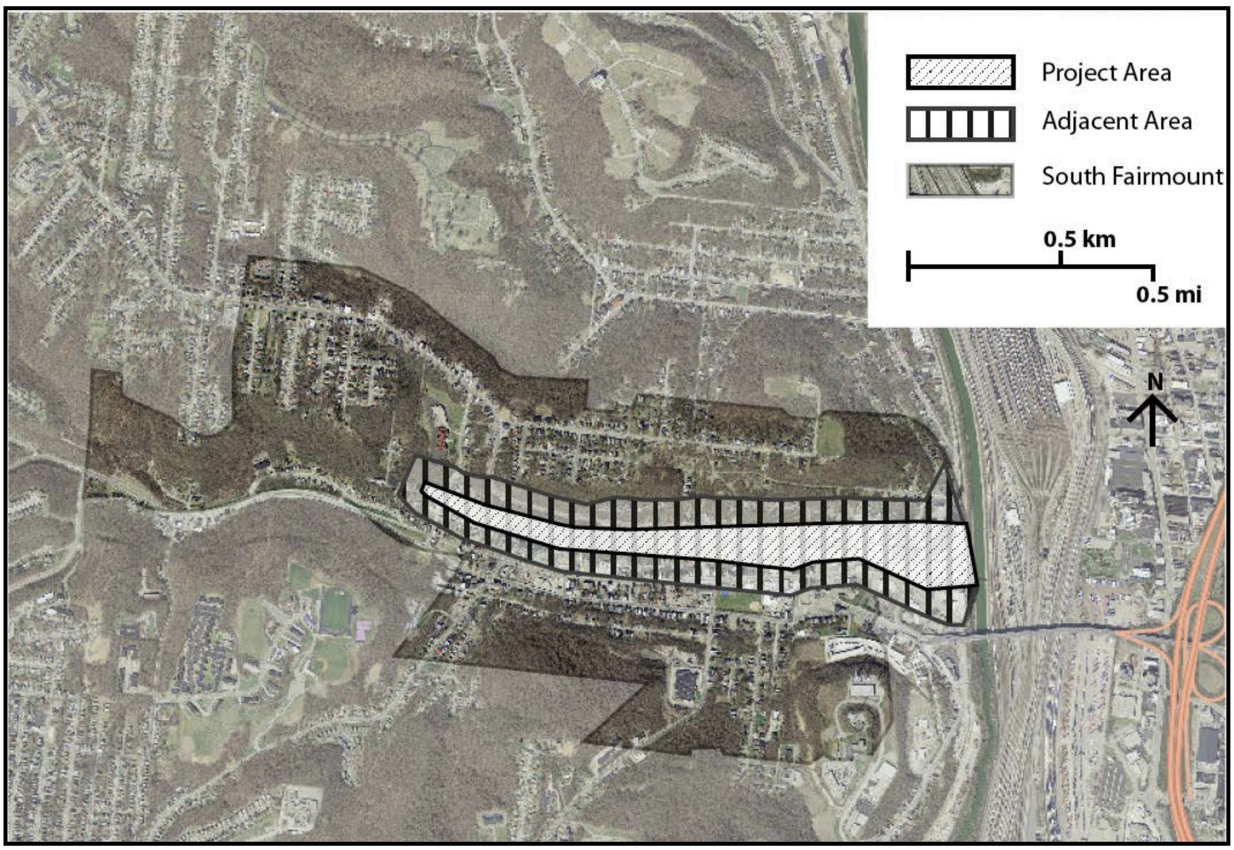
5.A. OVERVIEW OF THE LICK RUN PROJECT

Located in Cincinnati, Ohio, the Lick Run CSO is the largest in the area, producing an average of 1.7 billion gallons of overflow annually. The Lick Run Project Area is situated toward the eastern end of the 1,078-acre South Fairmount neighborhood, which makes up the lower elevations of the 2,700-acre Lick Run watershed (Figure 4).

Figure 4. Future "Gateway to the West." The Lick Run watershed covers about 2,700 acres on Cincinnati, Ohio's west side. It includes the South Fairmount community and is home to CSO 5, the largest CSO in the area. The decaying neighborhood is now part of one of the largest public works projects in Cincinnati's history and one of the nation's largest proposed experiments in green infrastructure.

The Metropolitan Sewer District (MSD) of Greater Cincinnati has developed a GI alternative for mitigating this CSO, which includes the Lick Run Project Area, an approximately 50-acre site bounded primarily by Queen City Avenue on the north and Westwood Avenue on the south (Figure 5). It includes a variety of land uses and a varied building stock. The map shows the Lick Run Adjacent Area, consisting of approximately 50 acres, which includes the parcels that are adjacent to the Project Area along these two primary streets and will be significantly affected by the project.

Figure 5. Lick Run Area Map. Map of the Lick Run Project Area, an approximately 50-acre site, which shows the Lick Run Adjacent Area, also consisting of approximately 50 acres, which includes the parcels that are adjacent to the Project Area along these two primary streets and will be significantly affected by the project.



Planning and implementing a GI project to address its largest CSO has involved a much greater level of non-traditional activities for MSD than would have been required for a gray project. MSD’s plans to reduce storm water flow and re-create green space within an older urban neighborhood through the daylighting of the lower portion of Lick Run will require the acquisition by MSD of the majority of the defined Project Area. Most of this is occurring through negotiation, although eminent domain remains a last option.

MSD's plans have necessitated higher levels of community engagement. Community engagement consists of presenting plans and soliciting comments at open neighborhood meetings, considering how the incorporation of community suggestions might improve the project, and seeking ways to get stakeholders, especially residents, to participate in broader efforts at urban revitalization in the area. At these community meetings, it was found that 78% of respondents supported the Lick Run Alternative (Green) Plan, compared with 16% who supported the deep tunnel and 6% who were unsure. In the course of these community engagement efforts, residents raised a number of questions about the economic impacts of MSD's proposed GI project. It is instructive that several of these questions mirror elements of the Comprehensive Taxonomy that focus on project area impacts. Among the concerns raised were: a lack of information about anticipated impacts on local jobs and businesses, the potential for redevelopment and revitalization through urban infill on vacant properties, and the need to look more closely at impacts on neighborhood socioeconomic conditions.

To illustrate the usefulness of the more comprehensive taxonomy presented in this report (Table 5), the final section of this report applies its novel elements to the Lick Run CSO project, focusing on both the Lick Run Project Area and the Lick Run Adjacent Area. The following discussion demonstrates the availability of data for applying the Comprehensive Taxonomy's project area measures (See Appendix for discussion about data sources).

Table 5. Guide for Applying the Taxonomy to the Lick Run Project

Outcome/Impact	Measure	Project Area	Adjacent Area
Land Use and Property Conditions	Land Use Mix		
	Share of Undeveloped Property		
	Public/Private Ownership Mix		
	Physical Conditions		
Economic Activity	Commercial Occupancy Rates		
	Business Composition		
	Employment & Employee Wages		
	Property Values		
Socio-Economic Benefits	Residential Occupancy Rates		
	Resident Median Income		
	Resident Labor Force Participation		
	Resident Public Assistance Receipt		

5.B. IDENTIFICATION OF DATA FOR APPLYING THE TAXONOMY

5.B.1. Land Use and Property Conditions

The Lick Run Project Area is comprised primarily of commercial and public land uses, along with vacant land (Table 6). The largest of these three categories is commercial, which comprises 26.6 percent of the total acreage within the Project Area. Public land uses (including parks, schools, and institutional) account for 26.1 percent of the total land area. Commercial and public land uses are more prevalent in the Project Area than in the Adjacent Area or the South Fairmount neighborhood as a whole. On the other hand, the Project Area has little residential area (11.1%), which is markedly less residential than the Adjacent Area and the neighborhood (37.8% and 28.0%, respectively).

Table 6. Land Use Distribution, Sorted by Share of Project Area

	Project Area	Adjacent Area	South Fairmount
Commercial	26.6%	13.3%	7.2%
Public	26.1%	9.0%	24.2%
Vacant	21.7%	21.8%	31.8%
Industrial	14.5%	18.2%	8.9%
Residential	11.1%	37.8%	28.0%

All three areas have high levels of vacant land (21.7%, 21.8%, and 31.8%, respectively). Vacant land or vacant parcels consist primarily of undeveloped plots of land that are free from structures or other additions. These lots, however, are not necessarily blighted or have a negative impact on the area; instead, they may just be underutilized currently, which ultimately may allow for more development in the future. Residential land use in the Project Area and the Adjacent Area is dominated by multi-family housing, (70.7% and 77.0%, respectively). South Fairmount as a whole consists largely of single-family land use, which accounts for two-thirds of all residential area. Table 7 details the various types of residential uses within the three areas.

Table 7. Residential Land Use Distribution						
	Project Area		**Adjacent Area**		**South Fairmount**	
	Land Area	Parcels	Land Area	Parcels	Land Area	Parcels
Other Housing	70.7%	41	77.0%	98	33.1%	447
Single Family	29.3%	21	23.0%	64	66.9%	1,201

A more detailed examination of non-residential development within and surrounding the Project Area shows a rather diverse mix (Table 8). Within the Project Area, 41 percent of non-residential total land is commercial property; this consists of general and automotive commercial (retail, auto repair, service, and restaurants and accommodations), offices, and mixed-use development. Mixed-use properties are generally defined as properties that serve multiple purposes such as having space for residential as well as offices. In the Project Area, Adjacent Area, and neighborhood, mixed-use parcels primarily consist of either commercial storefronts with residential above or commercial storefronts with office units in the floors above. Public land use accounts for 37.9 percent of the Project Area, with the most prevalent specific use being public service (20.0%) and parks and recreation (14.3%). Lastly, industrial land – which includes light industrial, heavy industrial, and manufacturing – accounts for 21 percent of the Project Area.

Table 8. Non-Residential Land Use Distribution			
	Project Area	**Adjacent Area**	**South Fairmount**
Commercial	**41.0%**	**35.7%**	**18.6%**
General and Automotive	32.7%	29.1%	14.8%
Office	5.9%	2.2%	2.9%
Mixed-Use	2.4%	4.4%	0.9%
Public	**37.9%**	**25.0%**	**59.6%**
Public Service	20.0%	13.1%	27.1%
Parks and Recreation	14.3%	0.0%	0.3%
Public Utility and Other	3.6%	11.9%	12.3%
Institutional			16.2%
Educational			3.7%
Industrial	**21.1%**	**39.3%**	**21.8%**

The Adjacent Area and the South Fairmount neighborhood as a whole have much different proportions of occupied non-residential land uses. The Adjacent Area's largest land use is industrial, with 39.3 percent of all land area being used for this purpose, while industrial use accounts for only 21.8 percent of land use in the South Fairmount neighborhood. Commercial land use in the Adjacent Area is prevalent, comprising 36 percent of the total non-residential land area, but only 18.6 percent of South Fairmount's non-residential land area is commercial, and nearly 60 percent is dedicated to public use.

An analysis of property conditions can be conducted in a number of ways. Data about building permits provide a standard measure of property investment, while citations for building code violations are indicators of disinvestment and other problems. The most serious measure of disinvestment in an area is vacant, condemned buildings that must be demolished, or will require major rehabilitation (Table 9).

Table 9. Vacant Condemned Buildings

	Project Area	Adjacent Area
Total Structures	105	176
Condemned Buildings	23	24
Percent Condemned	21.9%	13.6%

Additional property analyses can be conducted by means of a visual inspection of properties or parcels within an area. Properties can be rated based on their street front aesthetics, building quality, maintenance, and overall conditions. To ensure quality and consistency, field workers follow a thorough rating guide and conduct the analysis of the area on foot or take extensive photographs by car to be able to take more detailed notes.

5.B.2. Economic Activity

Economic activity occurs largely within the commercial and industrial land use categories, with certain public uses contributing to an area's economic base. By collecting information on the business mix and intensity of use, it is possible to obtain a greater appreciation of the extent of economic activity occurring within an area. Some information can be collected from secondary sources, including business directories and government databases, and this can be supplemented with data compiled through business surveys conducted by local government staff or local business associations, chambers of commerce, or colleges. Combining data from these sources produces the following summary of businesses (Table 10).

Table 10. Lick Run Project Area Businesses by Type	
Commercial	
Restaurant/Retail/Household Services	10
Non-Household Services/Miscellaneous Other	7
Industrial	
Construction	5
Manufacturing	4
Transportation	4
Total Businesses	30

Commercial land uses include retail stores and household service businesses, offices, and restaurants and accommodations. Industrial land uses consist mostly of extraction, construction, manufacturing, transportation, and distribution activities. In general, businesses in industrial areas do not primarily serve residents in the immediate area. Rather, their primary benefits to the surrounding area come from providing a daytime population for the area, which may generate demand for other businesses, and from being a potential source of jobs for area residents.

Combining information from various data sources, there are approximately 30 businesses in the Lick Run Project Area, employing about 330 people. In analyzing the economic activity within the Project Area, commercial and industrial businesses are considered separately. About 10 of these businesses are restaurant/retail/household services that serve neighborhood residents. Almost all of these commercial businesses are quite small. On the other hand, the majority of larger businesses are engaged in either manufacturing or some type of activity (e.g., bus company, construction firms) that involves them working throughout the City and beyond. Employment in the Lick Run Project Area comprises nearly half of all employment in South Fairmount (46%). Further, that means that almost half of all jobs within the neighborhood are concentrated within less than 5 percent of the total land area. Table 11 details the total number of jobs, total wages, and yearly average wage of each job.

Table 11. Employment and Wages

	Jobs	Total Wages	Average Wage
Project Area	330	$10,230,000	$31,000
Adjacent Area	230	$6,095,000	$26,500
South Fairmount*	150	$3,840,000	$25,600

Total	710	$20,165,000	$28,400

*Less Lick Run Project Area and Adjacent Area

Yearly wages were calculated based on second quarter earnings for all jobs within the Project Area, Adjacent Area, and total neighborhood. Unlike the previous tables, the Project Area and Adjacent Area are excluded from the South Fairmount neighborhood figures to better illustrate the importance of the Lick Run Project Area. The Lick Run Project Area has the highest wage per job, with a $4,500 per year difference between it and wage levels for the Adjacent Area and the remainder of the neighborhood. However, wage levels for jobs in all three areas are well below the 2011 averages for the nation ($48,000), the metropolitan area ($46,400), and the county ($52,000). Property value is highly dependent on the type and intensity of use. In the Project Area, residential and commercial property values are the highest, with total values of about $500,000 per acre for land plus improvements, and land values of about $120,000 and $170,000 per acre, respectively. Industrial property has a much lower average land value, about $55,000 per acre, which largely accounts for the difference between commercial and industrial property in total value per acre. Vacant land is valued at only $6,800 per acre, which suggests these properties may have negative characteristics that would likely contribute to a lack of market demand (Table 12).

Table 12. Property Values in Project Area

Land Use	Total Property Value per Acre	Land Value per Acre
Residential	$516,300	$118,200
Commercial	$477,000	$168,200
Industrial	$349,100	$54,500
Vacant	$6,800	$6,800

Trends in economic activity may be an important consideration. This includes any trends in the types and level of business activity, property value, and the amount of unused business space. In Lick Run, the number of businesses and the employment level has been decreasing in recent years.

5.B.3. Socio-Economic Characteristics

Socio-economic data from the Census Bureau's American Community Survey (at the ZIP or Census Tract level) and data from state and local sources allow us to estimate the characteristics that are shown in Table 13.

Table 13. 2010 Socio-Economic Characteristics

	Project Area		Adjacent Area	
Population	319		788	
Households	179		476	
Average household size	1.78		1.66	
families below poverty level		37%		40%
Housing units				
vacant	75	42%	155	33%
occupied	104		321	
owner-occupied	29	28%	72	22%
renter-occupied	75	72%	249	78%
Median household income	$25,031		$22,435	
unemployment rate	23.2%		23.8%	

Two other potential measures of socio-economic characteristics are a street activity analysis and an analysis of the social effects of the built environment. Many different university researchers train and employ students to undertake such analyses, which are usually customized to particular projects. As illustrated in Table 14, different types of street activities and land use activities can be given positive, neutral, or negative ratings to reflect their assumed contribution to or detraction from healthy neighborhood social conditions.

Table 14. Examples of Activities Affecting Social Conditions

	Street Activities	Land Use Activities
Positive	Normal Conversation, Cooking, Demonstrating a Message, Eating/Drinking, Entering/Exiting Home, Expressing Affection, Playing/Performing, Shopping, Walking Pets, Working	Neighborhood Parks, Retail, Residential
Neutral	Getting In/Out of Car, Passing Through, Reading,	Offices not serving

	Smoking, Standing, Sitting, Talking on the Phone, Waiting for Bus	households
Negative	Appears Drunk, Being Harassed, Fighting/Yelling in Anger, Harassing Someone, Lying/Sleeping, Panhandling, Urinating	Industrial, Large Parking Areas, Vacant Lots, Abandoned Buildings

The street activities analysis is comprised of observations of how individuals are interacting with their physical space as well as other individuals in the area. Pedestrian activities are scored based on a series of criteria; if the activity is perceived as beneficial, it is given a positive score and if the activity is perceived as detrimental, it is given a negative score. Activities such as smoking, waiting for a bus, getting in or out of a car, or talking on the phone are tallied as neutral activities.

The land use activities analysis assesses how the type of land use in an area affects the overall urban fabric. In general, neighborhood parks, multi-family residential, and high-traffic retail uses contribute more to neighborhood vitality than churches, single-family housing, and other retail uses. At the other end of the spectrum, industrial uses and vacant storefronts are less detrimental than surface parking, vacant lots, and abandoned buildings. To a large degree, the economic value of these social activities ends up being captured in property values, but quantifying the activities helps stakeholders understand the benefits better.

5.B.4. Future Changes in Land Use and Property Values

The Lick Run Project will likely have a direct effect on the way in which land is used in the Project Area and Adjacent Area and in the neighborhood as a whole. The daylighting of the stream may increase parks and recreation, public service uses, and residential housing in the area. What follows is a brief discussion of how land uses may change in the Project Area and Adjacent Area as a result of MSD's Lick Run project. While this list is not exhaustive, it does offer an overview of the types of land use change that are possible. The most likely change in land use would be that daylighting the stream will result in increased public uses as green space and increased land uses as parks and recreation. These changes in land use may not directly result in increased tax revenues or an increased tax base, but they have an effect on local property values and quality of life. Further, a portion of the Project Area will be likely classified as public use land, therefore the land use change is almost guaranteed.

Another type of change in land use expected is the mix of residential land uses. Although the Project Area is already dominated by multi-family housing land area (about 70% of all residential land area in the project area is multi-family), there is the potential that additional multi-family and mixed-use units will be developed in response to increases in green space. The main reason that single-family housing is not expected to increase in the Project Area or Adjacent Area is because of the limited amount of space available for residential development. However, development within the rest of the South Fairmount neighborhood surrounding the Adjacent and Project Areas may increase in terms of single-family homes. This could occur if the expected increase in community and resident amenities – such as additional retail and commercial space as well as increased quality of life area such as parks and green space – attracts new residents.

As mentioned above, changes in residential land use around the Project Area and Adjacent Area are a possible result of, and impetus for, economic development through changes in commercial and other non-residential land uses. Retail establishments, food and accommodation, and service industry land uses may increase their shares of total land use as traffic in the area and population density increases. Further, office and commercial land uses may increase if redevelopment leads to increased access to larger populations and employment growth. Although the relationship between residential and non-residential changes in land use is speculative and almost recursive in nature, it is clear that increased residential land use will lead to increased commercial services and amenities as well, and in turn increased commercial development due to perceived profitability stimulates residential development.

Lastly, changes in the third most prominent land use, vacant parcels, are expected. As additional green space, park and recreation land uses are developed, the share of residential and non-residential land uses will affect the current stock of residential and non-residential land area as well as potentially detract from the share of vacant land area. These land use changes will, in turn, produce other economic impacts that can be estimated with the economic activity measures in the taxonomy. These economic metrics are likely to be the most useful ones for decision makers. Table 15, which summarizes most of the metrics presented in this section, demonstrates these various measures of conditions in the Lick Run area can readily be incorporated into the Comprehensive Taxonomy. When comparable data are compiled after the GI project and consequent redevelopment occurs, community leaders will be able to present an assessment of the project’s economic impact.

Table 15. Taxonomy of Lick Run Project Area Economic Impacts			
Outcome/Impact	**Measure**	**Project Area**	**Adjacent Area**
Land Use and Property Conditions	Land Use Mix		
	Commercial	26.6%	13.3%
	Industrial	14.5%	18.2%
	Residential	11.1%	37.8%
	Share of Undeveloped/Vacant Property	21.7%	21.8%
	Public Ownership Share	26.1%	8.9%
	Physical Conditions: Condemned	22%	14%
Economic Activity	Commercial Occupancy Rates		
	Business Composition		
	Commercial	41.0%	35.8%
	Industrial	37.9%	25.0%
	Public	21.1%	39.3%
	Employment & Employee Wages		
	Total Employment	330	230
	Average Employee Wage	$31,000	$26,500
	Property Values (per acre)		
	Residential	$516,300	
	Commercial	$477,000	
	Industrial	$349,100	
Socio-Economic Benefits	Residential Occupancy Rates	58.0%	67.0%
	Resident Median Income	$25,031	$22,435
	Resident Labor Force Participation	23.2%	23.8%
	Resident Public Assistance Receipt	37.0%	40.0%

6. CONCLUSION

Communities have to make very expensive decisions when confronted with a consent decree: the average community must spend over $50 million annually to comply with consent decrees signed in 2007 or later. This motivates explorations of alternative methods that can achieve the same or enhanced environmental goals while allowing for progress economically, socially, and aesthetically. This study proposes a framework for analyzing whether a particular environmental need can be better met through the use of green infrastructure investment rather than the traditional “gray” approach. The nature of this framework must be complete to enable a benefit-cost analysis to occur, something which is rare among these communities because they lack the understanding, interest, or skills to do so comprehensively.

This report presents a comprehensive taxonomy, which includes economic development impacts that do not rely on complex estimation of non-market benefits. These benefits occur first within the primary project area, but expansions to the larger metropolitan area, sewer service area, or community are possible and likely. The taxonomy provides a framework that individual communities may use to measure changes in their project area following their GI investments. The need for this taxonomy is supported by a set of informal interviews with community officials, as well as by a careful review of dozens of case studies from multiple sources. The taxonomy’s primary value is that it provides a systematic way of sorting the economic impacts of GI by timing, scope and scale, complexity, and proximate relationship to project investment.

In the application of the taxonomy to the Lick Run project, this report demonstrates that data about physical, economic, and social conditions are either publicly or readily obtainable, and these data can be leveraged to illustrate the potential impacts of GI on economic activity, including wages and property values. As communities think through strategic deployment of GI, considering these dimensions will be critical. With a tool such as this, communities can conduct a pre- and post- implementation assessment of the socio-economic benefits of GI.

REFERENCES

American Rivers, the Water Environment Federation, The American Society of Landscape Architects and ECONorthwest. (2012). "Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-Wide."

Bare, J. (2010). "Recommendation for land use impact assessment: first steps into framework, theory and implementation." *Clean Technology and Environmental Policy*. 13: 7-18.

Bare, J. & Gloria, T. P. (2008). "Environmental Impact Assessment Taxonomy Providing Comprehensive Coverage of Midpoints, Endpoints, Damages and Areas of Protection." *Journal of Cleaner Production*. 16:1021-1035.

Buchholz, T. & Younos, T. (2007). "Urban Stream Daylighting: Case Study Evaluations" *Virginia Water Resources Research Center Special Report.* Virginia Polytechnic Institute and State University.

Center for Neighborhood Technology. (2010). *The Value of Green Infrastructure: A Guide to Recognizing its Economic, Environmental and Social Benefits.*

ECONorthwest. (2007) *The Economics of Low-Impact Development: A Literature Review*. ECONorthwest, Eugene, OR.

Garmestani, A.S., et al. (2011) "The Economics of Green Infrastructure and Low-Impact Development Practices." In Hale W. Thurston (ed). *Economic Incentives for Stormwater Control.* CRC Press.

Jaffe, M. (2010). "Reflections on Green Infrastructure Economics." *Environmental Practice.* 12 (4): 357-365.

Stratus Consulting. (2009). "A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds." Stratus Consulting, Washington, DC.

United States Environmental Protection Agency. (2011). *Lick Run Watershed Strategic Integration Plan.* (EPA 905-R-11-006).

United States Environmental Protection Agency. (2012a). "Low Impact Development." Retrieved September 2012 from http://water.epa.gov/polwaste/green/

United States Environmental Protection Agency. (2012b). *Planning for Sustainability: A Handbook for Water and Wastewater Utilities.*

Wise, S., et al. (2010). *Integrating Valuation Methods to Recognize Green Infrastructure's Multiple Benefits.* Center for Neighborhood Technology.

Case Studies

American Society of Landscape Architects: Green Infrastructure and Stormwater Management

Evans, R., et al., "Upper 40/Foster's Run Stream Restoration"

Mercurio, C., Plumley Engineering, "Rome Canopy Restoration Project"

Pumphrey, A., Williams Creek Consulting, "Ohio Street Pilot Project"

Remenschneider, K. "Combined Sewer Separation Project: CSO 143"

Rock, R., et al. "Frick Chemistry"

Sauer, E., Ruetschle Architects, "Milton Union Exempted School"

Stevens, H., City of Portland, "Mt. Tabor Middle School Rain Garden"

Wolnitzek, G., et al. "Lick Run"

APPENDIX: METHODOLOGY/DATA FOR LICK RUN ILLUSTRATION

A number of data sources were used in applying the taxonomy to the Lick Run Project Area. Of these data sources, the Cincinnati Area Geographic Information Systems (CAGIS) was used extensively in addition to U.S. Census Bureau and Bureau of Labor Statistics data. These data sources provided information on land use, market price, parcels, employment, and socio-demographic information. In particular, CAGIS was used to provide information on the sub-census tract level whereas the U.S. Census Bureau information was applied primarily to census tract and neighborhood level analysis.

CAGIS aggregates data from multiple local and national sources. Of these, CAGIS uses the Hamilton County auditor's office data, an office that is primarily responsible for municipal and county property valuation and recording. The data provided by the auditor is important for evaluating change over time of an area as the scale of the data is by property parcel or building. The level of specificity and acuteness of analysis that is granted by having parcel data allows the researchers to look at specific changes in property use. For example, the auditor's site provides data about the historical sale price of various properties in a study area. From this, the researcher can look at a number of things: has sales price increased linearly, or is it apparent that some sort of development affected the price of properties; have properties gone unsold or maintained the same ownership for extended periods of time (which may indicate assumed market changes or established land-uses); or has the velocity of property sales increased over time. Other uses of the CAGIS and auditor's data deal with property and building permits and citations. Building permits are a common indicator of investment within an area whereas property and building citations are symptomatic of local disinvestment.

The other data sources are geared towards econometric analysis and measuring employment within the study area. The Bureau of Labor Statistics provided information about employment and wages (ES202). This data can be used to track local changes in employment within various businesses, business by business. Additionally, ES202 data provides information on new business start-ups as well as wages paid.

Although these data sources are aggregated from other publicly available sources, ES202 and data similar to CAGIS data may not be available for all municipalities. Due to ES202 containing business identity variables, the information is not strictly publicly available. The Economics Center was able to receive a full variable list including businesses, addresses, employment, and wages accrued in order to perform geographically sensitive analysis. CAGIS, being partly funded by the city and county government, is another example of an information consortium that may not be in all municipalities. The information provided by CAGIS is local, and helpful when doing geographic analysis. Other cities or municipalities may have an office or section of an office that deals with local mapping and data management tasks.

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