Green Infrastructure and Water Management in Growing Metropolitan Areas

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Investment Grade Green and Sustainable Infrastructure (GSI)

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In his timeless thesis, *A Pattern Language, Towns, Buildings Construction*, the principal author Christopher Alexander related 253 patterns, one of which is especially useful when thinking about Green and Sustainable Infrastructure; “Each solution is stated in such a way that it gives the essential field of relationships needed to solve the problem, but in a very general and abstract way – so you can solve the problem for yourself, in your own way, by adapting it to your preferences, and the local conditions at the place where you are making it.” The problem of finding infrastructure solutions which appropriately balance our environmental, economic, and social needs has never been greater, and will continue to become even more challenging as the critical infrastructure of the United States continues to deteriorate as it approaches the end of its useful life faster than resources will allow it to be replaced. Accordingly, the opportunity for America’s planners and engineers to contribute with their ingenuity has never been greater and with this comes additional opportunity to tap into an emerging and very interested set of private investors who see the multiple outcomes of green and sustainable infrastructure as worthy of their investment resources.

To see forward, many times it is helpful to look backward and recognize similar patterns that guide change. The development of green and sustainable infrastructure (GSI) parallels the development of green and sustainable buildings in several ways. Similar to the advent of green and sustainable buildings, GSI has begun with technical innovation and a very unique demand from owners and investors seeking more tangible and intangible returns from their investments. Similar to the architects of green and sustainable buildings, the engineers of GSI are learning to adapt conventional materials and methods in new ways and creating a new Pattern Language for the planning and design of infrastructure solutions. Unlike green and sustainable buildings, the economics of GSI generally have lower initial costs, and almost universally lower lifecycle ownership costs. Similar to green and sustainable buildings, GSI will likely mature over a period of ten to fifteen years. Lastly, similar to green and sustainable buildings, GSI is attracting a set of early investors with exceptional market insight who are learning how to leverage initial investments into long-term returns and capture market share well ahead of the mainstream market shift.

Like other patterns it is also helpful to think of GSI in terms of systems. For practitioners of the natural and built environment, many recognize there is a direct link between economic systems and our natural assets; and that these systems seldom exist independently from one another. Economic systems are unable to function without benefit of the natural environmental systems - water, air, land and their embodiment as ecosystems all provide life that indirectly enables growth and development. Green infrastructure techniques are many times characterized by the use natural or semi-natural systems to maintain and support healthy and more sustainable
communities. This GSI can include any built environmental infrastructure solution that interacts with the natural environment to provide a community or city service. Land management, energy, power, transportation, water, wastewater, and stormwater systems are some of the more prevalent types of systems. The technical understanding and popular demand for green and sustainable infrastructure to support these natural systems is beginning to move from that of early evolution to rapid growth and the advancements are observable on an annual basis. The American Society of Civil Engineers (ASCE) reported in 2009 that the United States will need to spend $2.2 trillion over the coming five years to fund infrastructure needs, and approximately $286 billion annually through 2025. According the recent reports by the Congressional Budget Office, spending on transportation and water infrastructure as a share of the U.S. GDP has declined over the past fifty years, falling from 3.1% of the GDP in 1959 to 2.4% of the GDP in 2007. The juxtaposition between the need for infrastructure development and the lack of funding is resulting in new models to deliver infrastructure projects. Performance contracts with private entities that design, build, operate, and finance facilities can provide better value and less risk for the public.

### 5-Year Shortfall in Infrastructure Spending

![Diagram showing 5-Year Shortfall in Infrastructure Spending]

- **Total Estimated Spending**
- **Infrastructure Spending Shortfall**

#### 5-Year Shortfall: $1,176 billion

Source: American Society of Civil Engineers
Returning back to Alexander’s patterns, traditional (or grey) infrastructure involves the expansion or replacement of already existing and or non-functioning systems. Green infrastructure techniques add to this, the thinking that the solution should address multiple outcomes in a balanced way by taking a holistic systems approach to the solution often times including beautification of neighborhoods, reduction of energy use, cleaning of air systems, and increase in healthy living. These combined benefits can provide significant economic results. With an estimated $72 trillion\(^6\) worth of free goods and services provided by the natural living infrastructure, state and local governments, and forward thinking investors along with businesses are awakening to the idea of profiting and investing in the natural marketplace.

One might ask why? Today in the United States the challenge of addressing the nation’s aging infrastructure is compounded with significant municipal tax revenue instability resulting in capital improvement budgets shrinking, coupled with more and more deferred infrastructure needs. With diminished or in some cases the absence of the traditional methods of capital project finance, comes the opportunity for progressive thinking private and third party investors to become the key stakeholders who can see and profit from the long-term value of investing in these vital infrastructure needs, and more importantly the opportunity for providing the solution as a green and sustainable one. We have witnessed this model with a very direct revenue stream from the users in the delivery of roadways through Public Private Partnerships and financing models for over 15 years. Today this same basic model is extended to green and sustainable solutions with less tangible and immediate short-term revenue streams.
It is important as well to acknowledge the demand for green infrastructure in the United States. On March 9, 2012, The White House Council on Environmental Quality and Office of Public Engagement hosted a roundtable conversation entitled “Executing a Sustainable Infrastructure Vision.” The roundtable gathered together key stakeholders from the federal, private, association and academic sectors with the goal of having a conversation about the national vision for sustainable infrastructure. Key theme’s included:

1) Executive Order 13514 - Federal Leadership in Environmental, Energy and Economic Performance which directs agencies to meet a number of energy, water, and waste reduction targets.

2) In order to continue to meet the Federal government’s sustainability goals, we must ensure that our infrastructure projects also demonstrate the Federal Government’s commitment to environmental performance.

3) We must ensure that we build infrastructure that utilizes leading edge technologies and practices to ensure the most sustainable end product.

4) There is a false focus on first costs versus lifecycle costs.

5) Lack of standards and metrics to define sustainable infrastructure.

We believe this report and roundtable provide a primary understanding in the forward movement of green and sustainable infrastructure because it illustrates the large potential market in the United States for green and sustainable infrastructure and the only great limitation to capturing this market are metrics and standard technologies.\(^7\)

In the last four years, the practice of GSI is changing from a novel idea to that of an emerging technical practice as demand for GSI solutions are being called for in major urban centers. The demand can be seen in projects for the cities of New York, Charlotte, and Cincinnati, Ohio, where not only did the technical solution provide for multiple outcomes, but the projects were built utilizing innovative financing methods. New York City Energy Efficiency Corporation (NYCEEC) is a prime example of a public-private partnership working to effectively use green infrastructure to enhance energy retrofits throughout NYC. NYCEEC is a non-profit corporation with $37.5 million of federal stimulus money granted to New York under the Department of Energy’s “Energy Efficiency and Conservation Block Grant.” The goal of the NYCEEC is to leverage this stimulus money along with philanthropic and private capital. In addition to NYC, other cities are leveraging these public-private partnerships to finance an array of infrastructure investments. These partnerships are allowing cities to join forces with private investors to fund infrastructure projects in a different more cost-effective lifecycle cost manner. For example, in the city of Charlotte, North Carolina, CH2M HILL partnered with 11 other companies including Duke Energy and Verizon LLC, in order to form the non-profit group “Envision Charlotte.” Envision Charlotte is a unique public-private partnership that provides funding for sustainable and green infrastructure development within the city. The goal is to spur sustainable behaviors in uptown Charlotte’s business community and reduce defined environmental resource use and related costs by up to 20 percent in five years. In the city of Cincinnati, Ohio, the Metropolitan Sewer District of Greater Cincinnati entered into a federal consent decree with the U.S. Environmental Protection Agency in 2010 to reduce and control over 11.5 billion gallons of
combined sewer runoff discharging into local streams and rivers. Techniques being used for the remediation include bioswales, green roofs, reforestation, pervious pavement, and native vegetation. All techniques used will lead to enhanced water management, flood reduction, and city beautification. This green and sustainable infrastructure project will have lower capital costs and lower maintenance costs resulting in cost savings of $206 million over the lifecycle of the project. Through the program LENS™, designed and implemented by CH2M HILL, the Cincinnati project team was able to use a multi-objective decision making tool to place benchmarks to various green and sustainable infrastructure techniques. The following factors were assessed: 1) Environmental Stewardship 2) Economic Viability and 3) Social Values. LENS™ was able to identify individual projects based on return on investment and strength of green infrastructure techniques. The program was also able to identify techniques and solutions that would greatly improve on the projects. Based off this program, the Metropolitan Sewer District of Greater Cincinnati was able to identify the best projects with the greatest impact.

LENSTM outcomes example for Metropolitan Sewer District of Greater Cincinnati

SUSTAINABLE LENS™

The LENS tool provides detailed reports for key performance indicators of three project scenarios – Current, Stretch and Aspirational. Each project scenario provides strengths and weakness as well as a cost comparison. For more information, contact CH2M HILL, Dr. John Mogge and Tricia Shuler

In July of 2013, The Natural Conservancy, along with CH2M HILL and Davey Resource Group, released a report outlining the risks, infrastructure alternatives, and financing options for Howard Beach, Queens in response to Superstorm Sandy. The city of Howard Beach is located on an 18,000-acre wetland and is intersected by two major waterways, the Shellbank and Hawtree Basin, which hold numerous commercial and residential properties. These defining characteristics of Howard Beach provide significant flood risks due to coastal flooding and storm surges. The goal of the research was to investigate the current and future climate change risks facing Howard Beach and develop mitigation opportunities that use
green/sustainable and grey infrastructure alternatives, along with strategic financing options. The key findings included:

1) Howard Beach faces significant flood risks which could result in damages ranging from $30 million to $494 million. A rise in sea level of 32 inches will double the losses to $1 billion in a 100 year period.

2) Preliminary research showed an integrated green and grey infrastructure plan could cost-effectively reduce flood risks.

3) Opportunities exist to spread the cost among private and public entities that would greatly benefit from increased resilience.

The preliminary research outlined four alternatives for remediation including green infrastructure only and hybrid strategies (green and grey infrastructure). Using green infrastructure (wetlands, ribbed mussel reefs, beach nourishment, and berms) alone will not fully protect Howard Beach from major flood events. Hybrid strategies, however, can offer significant protection from severe flood events. These hybrid strategies included green strategies: dunes and berms, marshes, edges hardened with ribbed mussel toes, rock groins, artificial wetlands, and grey strategies: removable floodwalls and operable floodgates. By using a combination of infrastructure strategies, the city of Howard Beach would benefit from a reduction in capital and operating costs due to the use of green techniques. Financing interests from property developers, residents, industry, commerce, and a variety of underwriters and insurance companies, as well as the private sector are needed.

The Howard Beach study is an example of the growing complexity of the infrastructure challenge when further complicated with a changing climate. It demonstrates the importance of “systems thinking” (a fundamental principle of sustainability) and the need for a new “pattern language” for green and sustainable infrastructure. While climate change is an ever-growing risk, coastal communities in particular, as seen in the Howard Beach study, are at greater risk for storm surge and flooding. These communities are in need of techniques that will adapt to the emerging or irreversible impacts of climate change. And while green infrastructure techniques are in increasing demand, the role green infrastructure can play towards resiliency has not been fully realized. The Center for Clean Air Policy released a report titled “The Value of Green Infrastructure for Urban Climate Adaptation,” in which the authors call for climate extension specialists to customize and deliver adaptation information for coastal communities. These “climate extension specialists” would provide cities with timely and up to date forecasts on the climate change impacts to the local areas. In addition, extension specialists could help city managers make the case to elected officials about the value and benefits of green infrastructure in the local context of climate change and resiliency necessary for the area.8

The need for the private sector to respond to this traditional set of government services has never been greater and there are “early adopters” emerging such as Dow Chemical, Royal Dutch Shell, Swiss Re, and The Nature Conservancy. Currently, there are over 30 infrastructure funds ready to invest in the U.S. market with a levered purchasing power of approximately
$475 billion. The Green Path Partners and the West Coast Infrastructure Exchange Partnership are two of them. With the attraction of these types of private investors, CH2M HILL sees an avenue to begin to close the gap between infrastructure needs and the financial resources needed to address a small set of these needs. CH2M HILL’s current GSI partners are EKO Asset Managers in a joint venture called Green Path Partners for the east coast and the West Coast Infrastructure Exchange Partnership for the west coast. These organizations are third party financial institutions representing investors interested in the long-term returns of green and sustainable infrastructure.

Green Path Partners is a joint venture between CH2M HILL and EKO Asset Managers to match financial investments to projects which support natural systems and creative designs to deliver adaptive and resilient (green and sustainable) infrastructure. As the green infrastructure evolution continues, the partnership of Green Path Partners seeks to harness and drive this new “pattern language” for infrastructure solutions forward. Green Path Partners works to link up investors from foundations, family offices, pensions, and endowments to support natural infrastructure as a way to deliver public-private partnerships. Green Path Partners targets projects that:

1) Offer an opportunity to integrate natural infrastructure into a traditional infrastructure approach;
2) Provide a positive ecological impact with significant and demonstrable social and economic outcomes; and
3) Afford an opportunity to use innovative financial structures, non-traditional impact investment capital, or both.

The City of Philadelphia, PA, in conjunction with EKO Asset Managers, recently established the Green City, Clean Waters program, which requires the city to retrofit 10,000 impervious acres of public and private property to manage stormwater runoff onsite within the next 25 years. The market for these retrofits is estimated to be in the realm of $400 million. Given the lack of municipal funding available from local, state and federal funds, and by leveraging the incentives from the city of Philadelphia for green infrastructure retrofits, the demand for private investors is increasing. By utilizing green infrastructure technologies and investments, Philadelphia expects to see additional tangible and intangible benefits such as additional use of the city’s waterways; reduction of health problems caused by air pollution and excess heat; increased property value; increased ecosystem benefits; poverty reduction due to creation of local, green jobs and energy savings.

The West Coast Infrastructure Exchange Partnership (WCX) was formed to help promote job creation and long-term economic competitiveness by closing the gap between demand for public infrastructure and the supply of funding. The WCX aims to encourage innovation in infrastructure finance through performance-based partnerships. The WCX seeks to link investors to high value long-term public domain needs by:
1) Identifying public project development and delivery methods that yield more measureable value for dollar,
2) Creating and advancing new mechanisms for project finance, including those that would attractive private investors,
3) Connecting the investors to opportunities,
4) Helping investors and project sponsors understand and mitigate risk,
5) Advance new technology and best practices as well as strengthening public sector capacity,
6) Ensuring climate risk factors are considerations.

Because of the high demand for infrastructure projects, and lack of local and state funding, the WCX is able to provide real opportunities to address the challenges facing the delivery of infrastructure projects. The WCX has the ability to work directly with state and local governments to enhance their capacity in risk management, project vetting, and project finance. (CH2M HILL serves as a technical consultant to the WCX) The West Coast Infrastructure Exchange will provide the following services to the public and private sectors:

1) Arm project designers and sponsors with a Business Case evaluation tools to assess risk – social, environmental, and economic costs and benefits – and a balance risk/rewards returns from structured deals,
2) Investment prioritization,
3) Streamline project evaluation,
4) Accelerate the movement of pre-vetted projects,
5) Support project planning and transactions,
6) New level of transparency and objectivity to the market space.

Utilizing these services, the WCX hopes to change the approach to infrastructure financing from state and local government reflexive commitment to status quo financing mechanisms, project types, and sources of repayment.9

The fundamental hurdle investors face when analyzing the value of green and sustainable infrastructure is how to put a dollar value on natural assets which are deemed “free” goods and services. Paul Hawken, Amory and L. Hunter Lovins first addressed this challenge in their landmark work “Natural Capitalism” in 1999.10 Building from their early work and now from well over a decade’s work by the Rocky Mountain Institute, the economics of sustainability are far better understood. Returning back to the report from the White House Council on Environmental Quality and Office of Public Engagement Roundtable,11 one major request from industry leaders and investors was the adoption of a sustainable infrastructure rating system to create this assessment of sustainable attributes of a project. Similar to the foundation of LEED in 1998, a new rating system, Envision™, has emerged that provides the missing link to economically, environmentally, and socially assess natural capital. Envision™ is unique in the sense that it is the first rating system which accurately provides a holistic, cost effective framework for evaluating and rating the community, environmental, and economic benefits of infrastructure projects. The rating system can be used across an array of projects to meet or
exceed sustainability goals, evaluate environmental benefits, guide decisions about scarce resources and assess costs and benefits over a project’s lifecycle. Similar to the LEED rating system structure, Envision™ assesses the following topics 1) cost benefits over the lifecycle of the project, 2) environmental benefits, 3) use outcome-based objectives, and 4) reach higher levels of sustainability achievement. Similar to the LEED rating system, Envision™ enables projects to be eligible for an Envision™ award. Similar to the LEED rating system, the Envision™ rating system has 60 sustainability criteria “credits,” divided into 5 sections: Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Risk. Similar to the LEED rating system, Envision™ utilizes a checklist tool, which also acts as an educational tool that helps users become familiar with the sustainability aspects of infrastructure design. Similar to the LEED rating system, Envision™ will provide investors with a more in-depth guidance and rating system to accurately assess green infrastructure projects. As a charter member and co-developer for Envision™, CH2M HILL has found the rating system allows planners and engineers to more completely account for the tangible and intangible outcome of promoting green and sustainable infrastructure. We also find the rating system is a great benefit to owners and clients who need to assess the long-term financial outcomes of a project.

Developed initially as a collaboration of the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure, the rating system is now endorsed by the American Society of Civil Engineers (ASCE), the American Council of Engineering Companies (ACEC), and the American Public Works Association (APWA). Until 2012, there had been no broadly endorsed infrastructure rating system to properly assess the sustainability of a technical solution and accordingly help value it. Now with the Envision™ tool investors no longer wonder about the suitability of the projects that they are interested in underwriting or the risks involved in delivering green and sustainable infrastructure. As with Patterns before, Envision™ is emerging as the “LEED” for green and sustainable infrastructure projects.

Just like Mr. Alexander stated in Patterns “…. you can solve the problem for yourself, in your own way, by adapting it to your preferences, and the local conditions at the place where you are making it.” Green infrastructure allows for just this - a holistic, multi-functional approach to problem solving for the specific problem and specific area. It allows for the solution to not just solve the problem area, but also provides a solution that affects the greater scale. GSI technologies enable GSI solutions which provide benefits in the following all-encompassing areas:

1) Environmental: minimize environmental impacts, reduce waste, reduce energy and resource consumption
2) Social: enhance community and livability, enhance public safety, health and security, and support public services and land use
3) Economical: project cost savings and return on investment, economic development and support job growth
So how does this apply to resiliency and climate change now and in the future? There are a few things we know for certain – population growth and development are stressing overused resources and global climate variations are resulting in unprecedented floods and droughts. Our natural capital that we depend on for life is depleting. The World Bank estimates that natural capital makes up a significant share, up to 36%, of a country’s wealth. By utilizing green and sustainable infrastructure technologies, flooding could be reduced, stormwater runoff could be limited, water quality could be improved, greater land conservation, and livability could improve. Overall we would see a significant decrease in the depletion of our natural capital. Our nation’s and municipal goals moving forward should be threefold: 1) Understand the value of our natural capital and by extension begin to protect and enhance it, 2) Utilize green and sustainable infrastructure technologies to begin protecting our natural capital, and 3) Educate government officials on the local issues of resiliency and financing opportunities available for restoration and problem solving. By utilizing the tools mentioned above, Green Path Partners, West Coast Infrastructure Exchange, LENS™, and the Envision™ rating system, we believe the gap between the old ways of building infrastructure (and its financing) and the new ways of building infrastructure (and alternative financing) will start to close. Unfortunately, we can no longer afford to build with the same Patterns of the past; we must continue to move forward with a new Pattern for infrastructure development.

References


2 See CH2M HILL’s Statement of Qualifications to Dow Chemical Corporation and The Nature Conservancy for example of this popular demand and technical examples.

3 American Society for Civil Engineers, State Report Card, 2009

4 Congressional Budget Office


10 Hawken, Paul; Lovins, Amory B.; Lovins, L. Hunter (1999) “Natural Capitalism: Creating the Next Industrial Revolution” Little Brown and Company New York City, USA

Rocky Mountain Institute <http://www.rmi.org/>


12 Institute for Sustainable Infrastructure <http://www.sustainableinfrastructure.org/>