Green Infrastructure Design and Analysis

LimnoTech has provided our clients with sustainable water science and engineering solutions since long before green infrastructure gained currency as an environment-friendly approach to addressing wet weather challenges. That experience and expertise places us as leaders in applying green infrastructure techniques to municipal wet weather problems. For example, In 1999 the Bureau of Environmental Services in Portland, Oregon, one of the country's leading municipalities for green infrastructure, engaged LimnoTech to evaluate life-cycle costs of green roofs to better understand the feasibility of this technique. In 2006 LimnoTech was called upon to conduct a large-scale green infrastructure assessment for the nation's capitol. The Washington, DC green build-out model helped EPA see the potential and limitations of green infrastructure in managing wet weather flows, and the first phase of the project was awarded an Honor Award from the American Society of Landscape Architects.

The project descriptions presented in this document give a brief sample of our advancements in green infrastructure and sustainable water engineering and science. In addition to green infrastructure, we are also developing strategies and tools in other areas of water sustainability, including industrial water footprinting, urban river management and remediation using green technologies, water stewardship and conservation strategies for power providers, and innovative methods in sustainable agriculture.

Development of a Green Build-Out Model to Quantify Stormwater Benefits of Green Infrastructure

The City of Washington D.C. needed to better understand how green infrastructure practices could be implemented city-wide, and wanted to estimate the potential value of green infrastructure as part of their long-term water management plans. LimnoTech developed a Green Build-out Model applied to calculate potential reductions in stormwater runoff, wet weather discharge volumes and discharge frequencies associated with the application of different green stormwater infrastructure practices across the District of Columbia. Green infrastructure practices offered alternatives to traditional wet weather controls in the District where land is limited and traditional sewer infrastructure is unable to provide enough storage and treatment capacity. Green infrastructure facilitates infiltration and/or captures and stores rainfall and thus decreases the quantity of runoff, reduces peak flow rates, and improves water quality. In addition, green infrastructure cools its surroundings, cleans the water and air, creates urban habitat, adds aesthetic beauty to neighborhoods, and improves public health and safety. The Green Build-out Model is a modified version of the Mike Urban model developed for the DC Water's Long Term Control Plan for combined sewer systems.

The first phase of the Green Build-out Model project was performed as part of a grant from EPA to Casey Trees and LimnoTech. This phase worked to quantify the cumulative stormwater management benefits of trees and green roofs, and it received a 2007 Honor Award from the American Society of Landscape Architects. The second phase of the project was again funded by EPA and entailed performing similar modeling analyses for a suite of additional green infrastructure technologies and practices including permeable pavement, two types of streetside bioretention, rain barrels, and downspout disconnection to rain gardens. Both phases involved detailed analysis of GIS land cover data, development of model scenarios and assumptions, integration of green infrastructure practices and associated hydrologic processes into the model framework, running model scenarios, and post-processing the model results.

LimnoTech's Green Build-out Model demonstrated the efficacy of green infrastructure practices applied on a city-wide scale, and showed the value of including green infrastructure in the City's long-term water management plans.

Planning scenarios in the Green Build-out Model were run for the entire city and compared with baseline conditions over an average year, as well as for a 1-inch design storm. Results were summarized for over 450 MS4 outfalls and 60 CSO outfalls. Model findings are as follows:

- Reductions in average annual CSO volume discharges could be as much as 43%, or nearly 1 billion gallons city-wide under aggressive green build-out planning scenarios. This is significant, given the estimated $2.2 billion cost for CSO controls in Washington, D.C.
- Reductions in MS4 discharge volumes could be as much as 26% and could be important to TMDL implementation. Peak stormwater velocities would also be greatly reduced. This is important because of the high rates of streambank erosion observed in urban streams in Washington, D.C.

Green Infrastructure Opportunities Analysis as Part of CSO Long-Term Control Planning in Ottawa, IL

The City of Ottawa, IL (population 18,000), was required to update its long-term control plan to reduce combined sewer overflows (CSOs) in accordance with changes to Federal and State CSO policies. The City wanted to know whether green infrastructure could help reduce overflows. Such an approach could help the City's efforts to brand itself as "The Garden City."

LimnoTech was already assisting the City in characterizing the combined sewer system and the receiving waters to update the plan, and suggested that the City conduct a green infrastructure opportunities analysis. We gathered data regarding land cover, soil type, parcel ownership, and types of impervious land, and summarized them for each combined sewer area. We also performed a screening-level analysis with the collection system model to determine which areas had the largest reductions in overflow when impervious area was reduced. LimnoTech then met with City staff and other partners to develop an overall strategy for prioritizing controls and reducing discharges system-wide.

LimnoTech developed a suite of Best Management Practices (BMPs) to implement system-wide to ensure that Ottawa received overflow reduction credit for the green practices as it implemented its plan.

Based on this strategy, LimnoTech developed a suite of Best Management Practices (BMPs) suited to meet Ottawa's goals. Some BMPs will be implemented system-wide, while others will be targeted for particular high-priority areas. LimnoTech quantified the expected benefits of these practices using EPA modeling guidance, to ensure that Ottawa gets proper overflow reduction credit for the green practices as it implements its plan.

RiverSmart DC - LID Demonstration Project

LimnoTech is working with a coalition of District government agencies, including the Department of the Environment, Department of Transportation, and DC Water, and several nonprofit organizations to assess the stormwater management benefits of green infrastructure or low impact development (LID) practices in Washington, D.C. This is a three-year project that involves retrofit installation and monitoring of LID practices in three demonstration neighborhoods across the District.

In the first year of the project, LimnoTech worked with project partners to evaluate potential demonstration locations where LID retrofits can be installed and monitored. This involved identifying and performing preliminary analyses of: 1) physical constraints and opportunities (e.g., proximity to other infrastructure, existing planned construction projects, etc.); 2) educational and political opportunities (e.g., landownership, jurisdictional boundaries, educational access, etc.); and 3) monitoring constraints (e.g., sewer access and network complexity). Based on these analyses, LimnoTech recommended three sewersheds that were chosen to serve as project demonstration sites. A fourth site was chosen as a control site.

LimnoTech also developed and implemented the monitoring program to collect flow data to evaluate the performance of the LID retrofits. We recently completed the baseline monitoring activities required in the pre-implementation phase. This monitoring effort collected precipitation and flow data for approximately six months from each project site. The data were analyzed to determine the baseline relationship between the amount of rainfall and the runoff generated at each demonstration site. At a later date, these data will then be compared to additional monitoring data that will be collected during the post-implementation phase to help quantify the stormwater management benefits of the LID retrofits.

LimnoTech is also on the design team that will be developing plans for the LID retrofits that will be constructed in public space. Our role will be to identify appropriate placement of practices in alleys and within the streetscape, and to develop the conceptual designs for each practice. As part of this effort, we have already worked to further characterize the study areas and have performed field verification and ground-truthing of sewershed boundaries and impervious features, as well as subsurface sewer alignment and structure locations.

Green Infrastructure Feasibility Assessment for Metropolitan St. Louis Sewer District

In a draft long-term CSO control plan update (August 2009), the Metropolitan St. Louis Sewer District (MSD) proposed a high level of control for CSOs along the tributaries and a green infrastructure program for CSOs directly discharging to the Mississippi River. The reason for this strategy was the expense of constructing tunnels along the downtown area and the lack of measurable improvements in the water quality in the Mississippi River. As part of our support to MSD, LimnoTech conducted a green infrastructure assessment for the 77-square-mile Bissell Point combined sewer system.

Spatial analysis in GIS was used to identify locations and the nature of green infrastructure opportunities. Computer modeling was used to compare relative benefits of green infrastructure between CSO sewersheds. LimnoTech then conducted a workshop with MSD to define the structure of the green infrastructure program. We subsequently wrote the green infrastructure chapter and are helping MSD obtain approval from U.S. EPA and Missouri DNR.

One of LimnoTech's key recommendations for MSD's green infrastructure strategy was to use vacant properties owned by the St. Louis Land Reutilization Authority (LRA). The approach included siting block-scale and neighborhood-scale green infrastructure projects to reduce storm flow into the combined system, and provide a range of ancillary community benefits. The intent of MSD's leading this approach is to not only reduce CSOs but also to facilitate redevelopment of these urban areas and provide community growth.

Spatial analysis in GIS was used to identify locations for green infrastructure opportunities. Computer modeling was used to compare relative benefits of green infrastructure between CSO sewersheds.

Evaluation of Green Infrastructure as a CSO Control Measure, Terre Haute, IN

The City of Terre Haute recently completed an update to their combined sewer overflow (CSO) Long Term Control Plan (LTCP), including a fresh analysis of CSO control options. The preferred control alternative eliminates four CSOs in Fairbanks Park through construction of a relief sewer and uses consolidation and storage for the two CSO basins north of the park. The City of Terre Haute identified green infrastructure as a potential means of reducing the volume or size of gray infrastructure in the collection system in the CSO basins upstream of Fairbanks Park (e.g. CSO-009 and CSO-010).

LimnoTech conducted a detailed analysis of green infrastructure retrofit potential in the CSO 009 drainage area on behalf of the City of Terre Haute. The goal of this evaluation was to identify potential green infrastructure retrofits in the City's CSO-009 drainage area, estimate the cost of those retrofits and assess their benefit in terms of stormwater volume capture. Based on this evaluation, it was found that there are widespread opportunities for green infrastructure implementation in the CSO 009 basin, which contains large impervious areas created by large buildings, surface parking lots, and streets

The detailed analysis indicated that significant stormwater storage potential exists, even for partial implementation of green infrastructure. Based on LimnoTech's analysis, it appears possible that green infrastructure implementation can provide equivalent storage to offset the need for millions of gallons in storage tank volume to control overflows from CSO basins 009 and 010 at a lower cost per gallon. The City intends to explore the feasibility of utilizing green infrastructure controls in these basins during the implementation of the preferred alternative.

Cleveland Green Infrastructure Feasibility Study

Cities face growing regulatory and technical challenges associated with wet weather management, including stormwater runoff control and combined sewer overflow (CSO) reduction. Traditional gray solutions are reliable but costly. Cities are seeking more sustainable alternatives. Green infrastructure (GI) has emerged as a potential approach that also offers the possibility of ancillary benefits, such as an improved quality of life for urban residents. To receive full support from stakeholders, however, municipal utilities must first identify opportunities for constructing green infrastructure projects that provide maximum effectiveness at controlling wet weather flows.

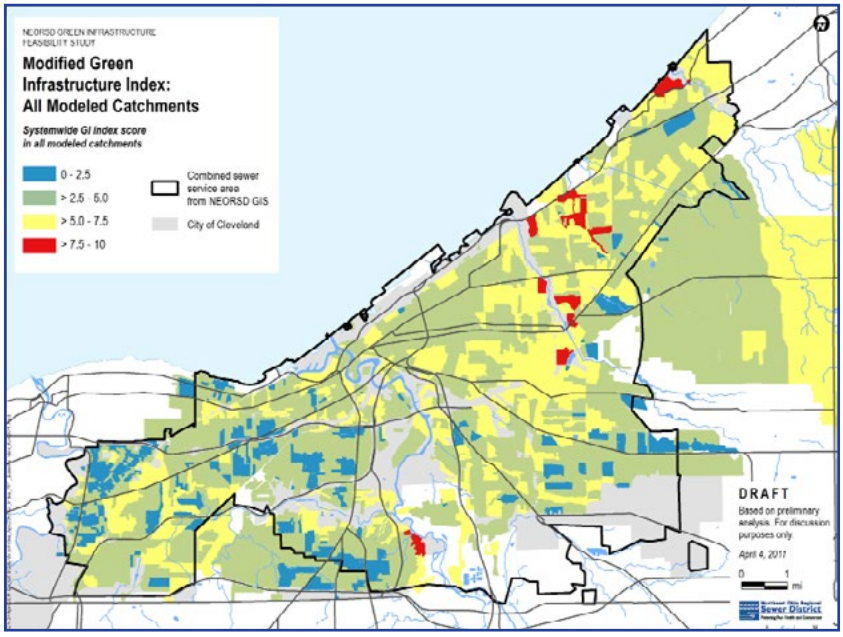
As part of a consent decree with U.S. EPA to reduce wet weather overflows, the Northeast Ohio Regional Sewer District (NEORSD) is exploring green infrastructure options in Cleveland. The District has begun a green infrastructure program that will reduce annual combined sewer overflows

by 44 million gallons at an estimated cost of $42 million. Part of NEORSD's challenge is that its service area covers approximately 81 square miles. The opportunity for green infrastructure to contribute to urban redevelopment is well-recognized in Cleveland, but the District also wants larger-scale green infrastructure projects that they can own and maintain to ensure continued effectiveness into the future. Key questions need to be answered so that NEORSD can target their efforts at places where their investments will most likely succeed:

- Where do local conditions create opportunity spaces that will facilitate GI implementation?
- Where do local conditions indicate that GI is more likely to be effective?
- Where do sewer-system modeling results indicate responsiveness to changes to surface stormwater management?

To help NEORSD answer these questions, LimnoTech developed and applied a "green infrastructure index" designed to identify project opportunities based on technical and socio-economic factors, using spatial data and output from collection system models. Available spatial data were rigorously processed and screened to identify useful metrics for factors such as stormwater offload opportunities, land availability, and partnering and redevelopment opportunities. Model output was used to add information on overflow quantity and sensitivity of overflow reduction to changes in surface hydrology, such as would be manifested by green infrastructure. NEORSD worked with key stakeholders to screen metrics and develop weightings factors. The resulting numerical index was used to score and rank subsections of the entire combined sewer service area.

The green infrastructure index developed for this study, which is believed to be the first of its kind applied in the United States, represents an approach that can be readily adapted for application to other large urban areas.



LimnoTech's green infrastructure index will identify project opportunities using metrics for factors such as stormwater offload opportunities, land availability, and partnering and redevelopment opportunities.