

**American Water Resources Association**  
**2009 ANNUAL WATER RESOURCES CONFERENCE**  
**November 9-12, 2009**  
Seattle, WA

**Monday, Nov. 9**

**1:30 PM – 3:00 PM**

**SESSION 9: Funding, Planning and Modeling**

**Economic Aspects of Green Infrastructure: Results from the Pacific Northwest - Ed MacMullan,** ECONorthwest, Eugene, OR (co-authors: Sarah Reich, Bryce Ward, Mark Buckley)

Early proponents of low-impact development (LID) and other techniques that manage stormwater on site and promote more natural hydrological conditions, emphasized the many potential benefits of these practices. Demonstration projects and case studies that followed described the performance of LID or green infrastructure under local conditions. Today, municipalities and jurisdictions throughout the U.S. promote green infrastructure. Despite this success, however, questions, doubts and barriers persist that limit LID adoption. Stormwater managers, developers and property owners question the technical and economic performance of LID. Economic information that addresses these concerns can help inform decisionmakers and promote LID adoption. We present results from economic studies conducted in the Pacific Northwest, including an assessment of the costs and benefits of a greenroof vs. a conventional roof in Portland, OR; the impacts of greenstreets on residential property values in Seattle, WA; and survey results from property owners in Portland, OR, on their likely participation in a City-sponsored program of incentives that encourage the adoption of green-infrastructure practices. These studies provide information on 1) the range of economic costs and benefits for green infrastructure vs. grey or pipe infrastructure; 2) the ecosystem services and associated economic values that green infrastructure can provide; 3) the perceptions of property owners regarding green infrastructure; and 4) the economic considerations of including LID in large-scale restoration initiatives.

**Design Considerations for Retrofitting LID and Green Infrastructure into Existing Streets and Neighborhoods - Jennifer Belknap Williamson,** Brown and Caldwell, Portland, OR (co-author: Mike Prett)

Retrofitting existing urban areas with Low Impact Development (LID) practices provides an opportunity to improve stormwater quality and reduce stormwater volume, helping agencies meet water quality requirements for municipal stormwater NPDES permits and TMDLs while also reducing Combined Sewer Overflows (CSOs) and hydromodification impacts from stormwater runoff. There are unique challenges associated with planning, designing and constructing Green Infrastructure in existing urban environments, ranging from addressing parking and pedestrian access to protecting existing infrastructure and utilities. This paper summarizes key lessons learned during LID retrofit design focusing on case studies of two projects for the City of Portland, Oregon. As a part of the Oak B Basin Relief and Construction Project for the City of Portland, in 2008 Brown and Caldwell designed 15 LID vegetated stormwater facilities that will collect, filter, infiltrate and convey stormwater runoff from existing streets in a neighborhood built over 100 years ago. As a part of the Fanno Basin Multnomah Boulevard Green Streets project for the City of Portland, in 2009 Brown and Caldwell designed 12 LID vegetated stormwater facilities for a major collector, Multnomah Boulevard, and several adjacent parking areas. Working closely with both the Bureau of Environmental Services and the Office of Transportation, we addressed stakeholder concerns associated with retrofit of existing neighborhood streets through facility designs that meet parking and pedestrian needs while also supporting water quality and quantity goals as a part of Portland's "Green Streets" LID initiative. Issues addressed during the design of both projects included facility sizing, integration into street infrastructure, traffic safety, pedestrian and bicyclist safety and accessibility, protection of potable water lines and gas lines, relocation of utility meters and poles, tree protection, and response to adjacent property owner concerns about parking and access. The City of Portland is now planning a large scale application of LID retrofits to reduce CSOs and meet Phase 1 NPDES permit requirements through the Brooklyn Basin: Tabor to River project, which includes plans for over 600 retrofit

LID facilities in a 1,500 acre area of the City. The lessons learned during these projects will be valuable during this extensive new effort.

### **Developing and Calibrating Hydrologic Models for Evaluation of Green Infrastructure Options in Seattle's CSO Control Program - Dustin Atchison, CH2M Hill, Bellevue, WA**

Model development and calibration for combined sewer overflow (CSO) projects is commonly focused on generating volumes that can be used in sizing improvements to the capacity of the combined sewer system itself. Such management and improvements include providing storage, capacity improvements and wet weather treatment options to handle the flows predicted by the models, commonly referred to as "grey" infrastructure. Alternatively, green infrastructure largely focuses on managing the flows themselves to either reduce the need for or the size of CSO control facilities. This approach places a greater emphasis on not only adequately simulating the flows in the systems but also more precisely defining how those flows are generated. For example, a common green infrastructure strategy is to disconnect impervious surfaces from the system; inaccurate modeling of the contributing impervious area to the system could lead to skewed evaluation of the potential benefits of green infrastructure. This paper will present the methods incorporated in developing and calibrating combined sewer models for two basins in Seattle Public Utilities system, Genesee and Henderson Street Basins, as part of the CSO program and alternatives evaluation. The development of the model involved careful consideration in how the runoff generating surfaces within the basins were delineated and entered into the model to maximize the flexibility in modeling green infrastructure alternatives later in the project. Due to the size of the basins, an automated calibration routine developed using concepts from the Generalized Likelihood Uncertainty Estimation (GLUE) theorem, is also used to generate hydrologic parameters to match monitoring data collected over an eighteen month period. This automated calibration process is essentially a Monte Carlo process, that, while powerful, can lead to hydrologic parameter sets that closely match the monitoring data but may not necessarily represent the physical hydrology of the basin. The paper will summarize the screening processes that were used to assure that selected best-fit parameters more appropriately represent the system allowing for proper evaluation of the green infrastructure options considered in the alternatives, including rooftop disconnection, cisterns, rain gardens, green streets and permeable pavements.

### **A Technically Rigorous and Easy to Apply Method for Sizing Stormwater Low-Impact Design for Stream Bank Erosion Control - Tony Dubin, Brown and Caldwell, Seattle, WA (co-author: Eric Mosolgo)**

Stormwater NPDES permits are commonly requiring specific measures to protect creeks from accelerated stream bank erosion. These measures typically include some combination of project site runoff controls that match post-project flow durations to either pre-development or pre-project flow durations across a range of flow rates that are capable of moving substantial quantities of bed material (i.e., geomorphically significant flows). Stormwater managers are often encouraged and in some cases required to emphasize integrated, low-impact design (LID) stormwater controls to supplement or replace traditional stormwater detention ponds. The shift in regulatory requirements and the increasing emphasis on LID have presented challenges to the engineering community, municipal plan reviewers, and regulators. Clear design standards and analysis tools for the application of LID to protect against stream bank erosion are often lacking. Brown and Caldwell has been working with the Contra Costa Clean Water Program and San Diego County to simplify the application of LID devices (e.g., bioretention, infiltration swales) for stormwater flow duration control, which is commonly referred to as hydromodification in California. Prior to these efforts, LID stormwater controls were designed to provide water quality treatment by routing runoff through vegetation and soil mixtures, but not to meet hydromodification goals. These designs have been modified to include a flow restrictor at the outlet that allow LID devices to function as underground detention systems with controlled outflows. The critical elements our approach include a) technically rigorous HSPF modeling of LID devices, b) pre-sizing common LID devices across a variety of different soil and land cover types, and c) synthesizing the results into an easy to apply software tool that simplifies the process of sizing stormwater controls and provides transparency to both project proponents and municipal plan reviewers. The easy to apply software ensures better compliance with development standards and a consistent application of LID. Contra Costa's Hydromodification Program has been

approved by state regulators and is currently being applied by more than 20 municipalities across the County. This presentation will review of the technical approach to sizing LID, introduce the software-based sizing methodology, and discuss specific LID case studies.