THE ILLINOIS GREEN INFRASTRUCTURE STUDY

A REPORT
TO
THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
ON THE CRITERIA IN SECTON 15 OF PUBLIC ACT 96-0026,
THE ILLINOIS GREEN INFRASTRUCTURE
FOR CLEAN WATER ACT OF 2009

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ABSTRACT

Green infrastructure practices, for purposes of this study, are urban stormwater management techniques that rely on natural systems to retain more stormwater on-site through infiltration, evapotranspiration and harvesting for reuse. Implementing green infrastructure practices helps attenuate nutrients and other pollutants and reduce runoff volumes and peak flows. Based on our review of peer-reviewed scientific reports and articles, we found that, on average, many of these practices are as effective as conventional on-site detention basins in reducing total suspended solids and total nitrogen being discharged to waterways and that they can also reduce runoff volumes and peak flows discharged to urban streams, reducing erosion, sedimentation and flood risks. Using an economic model, we also found that using green infrastructure can result in substantial savings in both construction and life-cycle costs when compared to using conventional infrastructure to manage runoff in suburban, urban residential and commercial projects. Research addressing the valuation of ecosystem services also suggests that using green infrastructure can provide significant indirect economic benefits, as well, by increasing the amount of open space, vegetation, habitat and groundwater recharge occurring in developed areas. Since there is considerable experience in using green infrastructure in northeastern Illinois and in five other states we surveyed -- and since green infrastructure is already required under the state's General NPDES Permit No. ILR40 ("the MS4 permit") -- we conclude that promoting the greater use of these practices would be a cost-effective way for Illinois to improve urban stormwater management programs and the water quality of our lakes and streams. It would have the additional benefit of helping municipalities covered by the MS4 permit to meet their legal responsibilities.

Based on these findings, we recommend that Illinois EPA consider the following:

- Adopt a state-wide minimum volumetric standard for urban runoff, which could be adjusted to address site conditions;

- Phase-in green infrastructure practices over a number of years, such as by adopting a portfolio standard similar to the one already being used by Illinois for renewable energy;

- Implement these practices in new development, in redevelopment and major maintenance, repair and replacement activities undertaken by both public and private parties;

- Earmark funding for green infrastructure projects in state revolving loan funds, and develop a simple and transparent method for prioritizing these projects; and

- Encourage county and municipal stormwater management agencies to charge fees for managing and maintaining stormwater facilities, with the use of green infrastructure practices treated as a credit against such fees. Periodic performance monitoring and reporting should be required to retain any credit earned for using green infrastructure practices.

EXECUTIVE SUMMARY

I. INTRODUCTION

Stormwater discharges from urbanization remain a significant water quality issue in Illinois. Impervious surfaces, such as the roofs, alleys, roads, sidewalks and parking lots characteristic of urban development, change the hydrology of cities compared with undeveloped areas. Rain is unable to infiltrate on site, and the resulting stormwater becomes runoff. Runoff contributes to erosion, combined sewer overflows, sedimentation, and nonpoint-source pollution and threatens human and ecosystem health. At the same time, the lack of infiltration prevents our groundwater resources from being recharged, which in turn reduces the ability of the aquifers to contribute to and maintain the baseflow rates and water levels of our urban lakes and streams.

Our conventional stormwater systems – structures such as curbs and gutters, detention ponds and storm sewers – are inadequate to handle our future (and in some places, current) stormwater management needs. According to the Illinois EPA, 1,218 stream miles are already impaired by urban runoff and storm sewer discharges.[1] The National Research Council and the Center for Watershed Protection both found a direct relationship between urban land cover and the biological condition of downstream receiving streams, confirming that the alterations in hydrology caused by urbanization poses severe threats to the nation's waterways, and suggested that "a number of additional actions, such as conserving natural areas, reducing hard surface cover (e.g., roads and parking lots), and retrofitting urban areas with features that hold and treat stormwater are recommended."[2]

Green infrastructure practices use natural and engineered systems to manage urban stormwater discharge to waterways through preserving and mimicking natural pre-development hydrology.[3] Green infrastructure practices address the specific stormwater management goals of reducing runoff flow rates and minimizing the pollutant loads entering waterways, the same goals addressed by conventional stormwater infrastructure. But it also offers additional valuable community benefits not provided by conventional infrastructure, such as groundwater recharge, runoff volume reduction, improved air quality, temperature moderation and energy cost savings, increased open space for recreation and wildlife habitat and increased land values. Green infrastructure can be applied on the site, neighborhood, or regional scales. On a regional scale, green infrastructure can be an interconnected network of natural areas. On

[1] Illinois Environmental Protection Agency, Draft *2010 Illinois Integrated Water Quality Report and 303(d) List* (Table C-32).

[2] National Research Council, Committee on Reducing Stormwater Discharge Contributions to Water Pollution. 2008. Urban Stormwater Management in the United States. Washington DC; National Academy Press.

[3] Section 5 of PA 96-0026 defines "green infrastructure" in part as "any storm water management technique or practice employed with the primary goal of preserving, restoring, or mimicking natural hydrology. Green infrastructure includes, but is not limited to, methods of using soil and vegetation to promote soil percolation, evapotranspiration, and filtration." Green infrastructure practices have also been called "best management practices (BMPs)," "stormwater control measures (SCMs)," or "low-impact development (LID) practices" by various practitioners. We deem all these phrases to be functionally synonymous, and will employ the phrase "**green infrastructure practices**" in this report to describe any of the urban stormwater management techniques relying on natural systems to provide on-site stormwater infiltration, pollutant and nutrient attenuation, and volume and peak flow reductions.

the neighborhood scale, green infrastructure strategies include smart design -- such as encouraging cluster development that minimizes impervious surfaces -- which aim to preserve or restore the natural hydrology of a site to the greatest extent possible. Green infrastructure used at the site level includes the practices set forth in Table ES-1.

Table ES-1. Description of Stormwater infrastructure Practices Assessed in this Study

Infrastructure	Description
Bioinfiltration	Vegetated systems designed to facilitate the infiltration of stormwater and remove pollutants through infiltration media and/ or vegetation uptake. Examples: bioretention areas, swales, infiltration basins
Permeable Pavement	Pavement which allows stormwater to infiltrate into underlying soil. Filters some pollutants.
Filtration	A variety of devices which actively or passively filter pollutants out of stormwater. Many are proprietary designs. Often used in conjunction with other green infrastructure or as retrofits to existing storm drains.
Green Roof	Roofs with a vegetated surface and substrate designed to reduce runoff through transpiration and evaporation and filter rainwater through media, vegetation, and geotextiles
Constructed Wetland	Manmade wetland intended to intercept runoff, reduce peak flows, decrease runoff volume and mitigate pollution

The use of natural areas, or green infrastructure practices, to replace or supplement conventionally-engineered urban stormwater management systems has gained considerable interest both within the United States and internationally.[4] Our report explores the science of green infrastructure practices and evaluates existing and potential policies, regulations and administrative tactics that could be adopted in the State of Illinois to promote the widespread, appropriate use of green infrastructure stormwater management strategies and techniques. Our research is intended to assist the Illinois Environmental Protection Agency (IEPA) in evaluating and documenting the seven specific criteria mandated by section 15 of P.A. 96-0026, the "Illinois Green Infrastructure for Clean Water Act," adopted by the Illinois General Assembly and signed into law on June 30, 2009.

II. THE EFFECTIVENESS OF GREEN INFRASTRUCTURE

Does green infrastructure work effectively to reduce the impacts of stormwater? This is probably the most important question which must be addressed in a systematic manner prior to implementation of a

[4] Reductions in stormwater runoff using green infrastructure principles have also been mandated for all federal facilities with footprints exceeding 5,000 square feet by section 438 of the Energy Independence and Security Act of 2007. Further, congressional recognition of the benefits of promoting green infrastructure practices is reflected in the American Recover and Reinvestment Act of 2009 (ARRA), where state Clean Water State Revolving Loan funding was expressly earmarked for green infrastructure, energy conservation and other innovative projects.

statewide green infrastructure policy. And, if it does work as intended, is it still affordable when compared to the costs of the conventional technologies used to manage urban stormwater?

To answer the first question, we examined data in published, peer-reviewed studies to evaluate the effectiveness of green infrastructure. Such studies have all undergone a critical evaluation by several experts in the field, and only studies that are able to stand up to this scrutiny are published. We also looked at some data that were not rigorously peer-reviewed, including the U.S. Environmental Protection Agency's International Stormwater Best Management Practices Database.[5] To assess the cost-effectiveness of green infrastructure, we used a literature review, data from past research and a green infrastructure economic model called the Green Values® Calculator, developed by the Center for Neighborhood Technology (CNT) to compare different urban stormwater management technologies – both green and conventional -- over their useful lives.

To evaluate the effectiveness of green infrastructure, we used four indicators that reflect pressing stormwater issues and are commonly (and relatively inexpensively) monitored. Since sedimentation, nutrient enrichment and flooding are among the three biggest stormwater problems threatening ecosystem and human health, mitigation of total suspended solids (TSS), total nitrogen (TN), runoff volume, and peak flow were selected for comparison between types of green infrastructure. It is important to note that this analysis looked at green infrastructure practices separately, and not as potential supplements to conventional stormwater management structures.

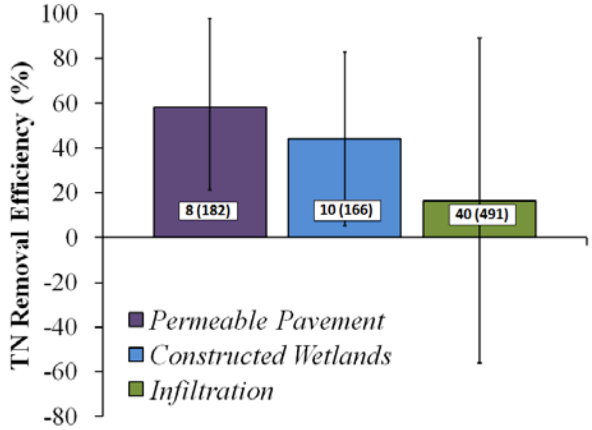
Green infrastructure categories analyzed include on-site stormwater filtration systems, bioinfiltration infrastructure (including rain gardens, bioretention, biofiltration, bioswales, and grass swales), permeable pavement, green roofs, and constructed wetlands. After examining 57 peer-reviewed journal articles, some of which monitored more than one site (for a total of 173 sites), we found that green infrastructures generally reduced total suspended solids and total nitrogen, and decreased runoff volume and peak flow.

In general, we found that green infrastructure works on average as well as conventionally-engineered detention and retention basins in reducing water pollution risks (see Figs. ES-1A and 1B, below). We found that green infrastructure practices are also effective in reducing both stormwater peak flows and runoff volumes, which increase flooding and sedimentation risks (see Fig. ES-1C). Perhaps the most significant aspects of green infrastructure practices are the volume control and water quality improvement capabilities that almost all these practice offer (and which may not be the case with conventional structures that focus on controlling stormwater release rates). Treatment trains, which combine multiple infrastructures in series, and drainage-basin scale approaches, which combine multiple infrastructures in parallel, may be even more effective than individual green infrastructure practices.

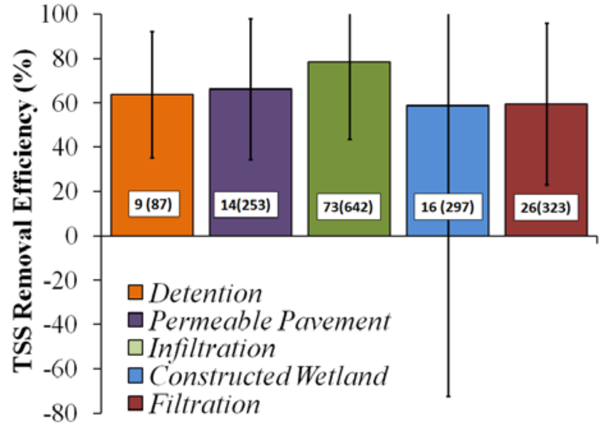
In terms of cost, CNT's Green Values Calculator shows that green infrastructure is frequently 5-30% less costly to construct and about 25% less costly over its life cycle compared with traditional infrastructure. These cost values assume that recommended maintenance is conducted on schedule and that green infrastructure is performing as expected; the same assumptions apply to gray infrastructure, however. In addition, green infrastructure allows for more flexibility in adapting to changes in conditions and/or knowledge, whereas once gray infrastructure is built, it becomes more costly to reverse or modify it.

[5] http://www.bmpdatabase.org.

1A) Effectiveness of Green Infrastructure in Removing Total Nitrogen.



1 B) Effectiveness of Green Infrastructure in Removing Total Suspended Solids



1 C) Effectiveness of Green Infrastructure in Reducing Peak Flows and Runoff Volumes

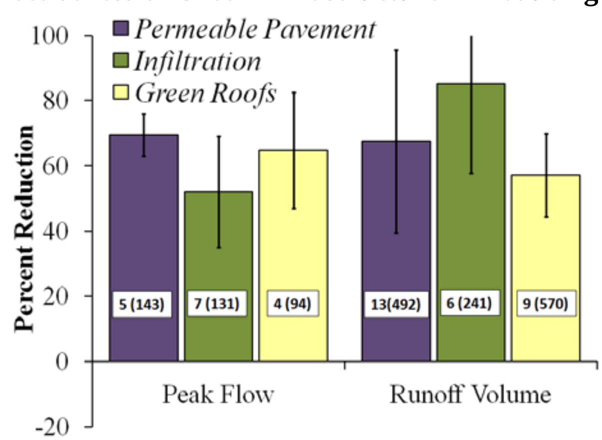


Figure ES-1 (A-C). Effectiveness of Green Infrastructure Practices. These figures show the weighted mean percentage difference between the influent and effluent for TN, TSS, Peak Flow, and Runoff Volume. Means are weighted to remove bias caused by sites monitored for very few storm events. The error bars represent the weighted standard deviation, a measure of how close together the mean removal efficiency values are across all sites. The values on the bars are the number of sites included in the analysis and (in parentheses) the total number of storm events monitored. All data are from peer-reviewed literature on green infrastructure functional efficiency.

III. FUNDING GREEN INFRASTRUCTURE

The Clean Water Act's state revolving loan fund (SRF) program has always been available for use in helping to fund stormwater management projects, although the vast majority of SRF money has typically gone to wastewater treatment projects. The American Recovery and Reinvestment Act of 2009 (ARRA), however, specifically earmarked 20% of its state capitalization grants (the "Green Project Reserve") to State Revolving Loan Funds (SRFs) for innovative stormwater management practices such as green infrastructure in addition to energy and water conservation initiatives, adding a mandate that some of the money be provided as grants as opposed to low interest loans. This allows counties and municipalities to readily tap these funds for green infrastructure without needing to generate the taxes, charges or fees needed to repay their loans from the SRFs.

Notwithstanding the financial incentives provided by the Green Project Reserve, cost-effectiveness is one of the driving forces behind the increasing, widespread national adoption of green infrastructure practices. In general, national and Illinois examples indicate that properly scaled and sited green infrastructure can deliver equivalent hydrological management of runoff as conventional stormwater infrastructure at comparable or lower costs than conventional conveyance and treatment infrastructure. Moreover, green infrastructure also delivers additional economic, social and ecological benefits that are normally not monetized, contributing value to community health and vitality beyond their hydrologic performance.

When green infrastructure performance for volume control and water quality can offset regulatory requirements, i.e., when using green infrastructure counts as a credit against detention volume requirements, scenarios that evaluate green infrastructure life cycle costs also demonstrate savings in comparison to equivalent conventional infrastructure. For example, Table ES-2 below shows estimated costs and hydrological results of three development scenarios (a suburban subdivision, and urban townhouse project, and a commercial building) using CNT's Green Values® Calculator.

IV. CURRENT PRACTICES

We reviewed three types of current stormwater regulatory programs with performance standards incorporating green infrastructure concepts. First, we reviewed the Illinois statewide stormwater permit, known as the MS4 Permit. Second, we reviewed existing county and municipal stormwater management ordinances in Northeastern Illinois, the region with the greatest experience in using green infrastructure. Finally, we reviewed five state programs outside Illinois that have in place statewide stormwater management performance standards that expressly encourage or require the use of green infrastructure as a means of meeting those standards.

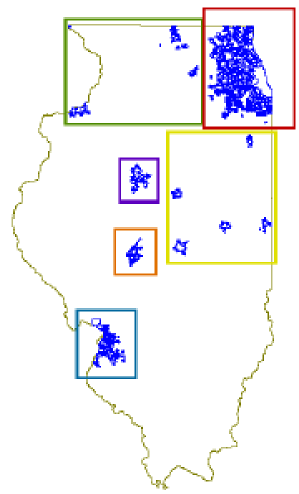
Table ES-2. Comparison of Green and Conventional Stormwater Technology Costs for Three Case Studies

Case Study	Description	Green Components	Construction Cost Savings for Green Scenario	Green Construction Savings as % of Conventional	30-year Life Cycle Savings for Green Scenario	Green Life Cycle Savings as % of Conventional	Green Scenario Annual Hydrologic Benefits
Exurban Development	20-acre site with 14 homes on undeveloped land	Rain gardens, native vegetation, trees, and roadside swales	$190,800	31%	$507,800	24%	1,411,000 gallons reduced runoff through increased groundwater recharge
Blue Island Riverfront	3.0-acre site with 59 townhomes on former parking lot	Rain gardens, permeable pavement, trees, and roadside swales	$91,900	23%	$168,600	29%	2,409,000 gallons reduced runoff to sewers
Chicago Center for Green Technology	3.3 acre site with office building, parking and wetland on former industrial land	Partial green roof, cisterns, vegetated swales, gravel parking lot, wetland and native vegetation	$18,100	4%	$161,500	20%	2,468,000 gallons reduced runoff

ILLINOIS MS4 PERMIT

Under the Clean Water Act, states must issue National Pollution Discharge Elimination System (NPDES) permits for stormwater discharges from industrial, construction and municipal activities. The permit for small municipalities, those with fewer than 100,000 people, is known as the small "municipal separate storm sewer system" or "MS4" permit. IEPA issued its first MS4 permit in February 2003, designated as "General NPDES Permit No. ILR40."[6] There are about 440 Illinois municipalities, townships and state agencies now subject to the permit, all concentrated in about six regions of the state (see Figure ES-2).[7]

Figure ES-2. Illinois MS4 Communities



In 2009, IEPA revised its MS4 general permit to require that permittees adopt "green infrastructure" stormwater management strategies and techniques as part of their programs. These revisions included requiring information on green infrastructure practices in education and outreach programs, the incorporation of green infrastructure techniques in stormwater management practices used during construction (including the construction and reconstruction of municipally-owned impervious surfaces, along with the training of municipal employees and contractors in green infrastructure practices). Post-construction storm water management must also incorporate green infrastructure strategies of infiltration, evapo-transpiration and harvesting for reuse, and must favor these strategies over conventional ones.

LOCAL PROGRAMS

We met with local officials in northeastern Illinois and surveyed local and county ordinances to identify stormwater management programs that employ green infrastructure practices. Our findings indicate that an important objective of most stormwater management ordinances is to limit the stormwater runoff rate to a prescribed maximum, typically through onsite detention storage and other best management practices (BMPs). Some ordinances also establish retention requirements, to permanently reduce the volume of stormwater runoff that enters the stormwater sewer conveyance systems. Some ordinances encourage or require the use of green infrastructure practices to meet these retention performance standards. These well-established local programs in northeastern Illinois can serve as models for other communities in Illinois that have to manage urban stormwater discharges under the state's MS4 permit program.

Local and county ordinances specify required storage volume based on the size of the development project and other factors, and require detention basins to limit the rate at which they release water. Required storage volume varies, although maximum release rates are relatively consistent throughout the region. These ordinances also address the use of green infrastructure practices to control runoff volume

[6] A "general permit" is essentially a regulation that applies to all regulated entities in a class of entities. Each permittee in the class must meet the exact same permit requirements.

[7] For the Illinois Environmental Protection Agency's list of municipalities and townships currently holding MS4 permits, *see* http://www.epa.state.il.us/water/permits/storm-water/ms4-status-report.pdf.

and water quality, but the requirements and level of detail in the ordinances' language on green infrastructure practices vary by county. These standards and practices are summarized in Table ES-2, below. A number of municipal stormwater ordinances and plans were also reviewed for green infrastructure implementation, due to existing green infrastructure interest and experience. These municipalities included the cities of Aurora, Chicago, and Crystal Lake and the village of Homer Glen.

We interviewed staff of the region's stormwater management agencies and the Illinois Department of Transportation to identify the most significant issues involving the implementation and administration of green infrastructure practices in the state, in order to better assess the transferability of these practices state-wide. During these discussions, the interviewees also identified what they believed were some potential barriers to further implementation of green infrastructure, although many of these concerns (such as site variability and maintenance) might apply equally to conventional stormwater infrastructure as well. These perceived issues and barriers include:

- Difficulties in requiring and crediting green infrastructure practices against traditional detention requirements, given the diverse soils, cold winters and high urban densities in parts of the state;
- The specialized maintenance requirements of green infrastructure needed to ensure its long-term performance;
- Difficulty in funding and administering the installation and maintenance of green infrastructure (since it typically does not generate fees needed to retire bonds or repay loans from SRFs);
- Recognition that the benefits of increasing groundwater recharge by encouraging stormwater infiltration can also increase the risks of aquifer contamination; and,
- Perceptions about the poor aesthetics of low-impact design and natural landscaping, and, in some cases, the lack of political will to mandate green infrastructure practices on private property.

STATE PROGRAMS

Maine, Maryland, Minnesota, New Jersey, and Wisconsin all use statewide stormwater performance standards that go beyond the Clean Water Act's NPDES requirements and that also require or encourage the use of green infrastructure to meet those standards. These states can serve as models for Illinois. Table ES-4, below, summarizes the types of performance standards contained in these programs.

Chapter V. RECOMMENDATIONS

PERFORMANCE STANDARDS

Illinois EPA should adopt, at the very least, a set of stormwater retention performance standards or volume control requirements that can vary according to the conditions at a particular site. Such performance standards have become the norm around the country, and are seen as the best method of reducing flooding and sewer overflows while improving water quality at the same time. In its 2008 Urban Stormwater Management report, the National Research Council recommended that "flow and related parameters like impervious cover should be considered for use as proxies for stormwater pollutant loading" because of the difficulty and expense of compliance monitoring urban stormwater for specific pollutants.   A flow reduction requirement – such as retaining the first inch or half-inch of runoff on-site by using green infrastructure practices – is a stormwater management proxy that makes sense for Illinois,

Table ES-3. Local and County Stormwater Ordinances in Northeast Illinois

Governing Body	Release Rate	Volume Control Mechanism	Water Quality Measures	Green Infrastructure Allowance
Draft Cook	2-year, 24-hour: 0.04 cfs/acre 100-year, 24-hour: 0.15 cfs/acre	The first 1" of runoff to be retained on site	Infiltration and flow-through practices	Retention based practices, e.g. permeable pavements, infiltration basins and trenches are required to achieve volume control requirement
DuPage	100-year, 24-hour: 0.10 cfs/acre	Requires BMPs be incorporated to the maximum extent practical	Requires BMPs to provide water quality benefits	Green Infrastructure, e.g. vegetated filter strips and permeable pavers are incorporated into a BMP Manual
Kane	100-year, 24-hour: 0.10 cfs/acre	The first 0.75" of runoff to be retained below the primary gravity outlet of the site	Native wetland plantings required	Stormwater BMPs may be implemented in lieu of traditional detention practices for developments which require less than 1 ac/ft.
Kendall	2-year, 24-hour: 0.04 cfs/acre 100-year, 24-hour: 0.15 cfs/acre	Hierarchy to minimize increases in runoff volumes and rates	Promotes retention and infiltration to provide water quality benefits	Promotes the use of BMPs and native plantings for increased infiltration and evaporation
Lake	2-year, 24-hour: 0.04 cfs/acre 100-year, 24-hour: 0.15 cfs/acre	Runoff Volume Reduction Hierarchy	Runoff Volume Reduction Hierarchy and mechanical measures	Preserving natural infiltration is incorporated into the Runoff Volume Reduction Hierarchy through a number of BMPs
McHenry	2-year, 24-hour: 0.04 cfs/acre 100-year, 24-hour: 0.15 cfs/acre	BMP Hierarchy to during site design incorporates practices which will reduce volume	Requires that a number of BMPs be evaluated for site design incorporation	Addressed in Conservation Design and Subdivision Ordinances that require the use of BMPs and use density bonuses for open space that is placed under conservation easements maintained by professional land managers
Will	2-year, 24-hour: 0.04 cfs/acre 100-year, 24-hour: 0.15 cfs/acre	The first 0.75" of runoff to be retained below the site's primary gravity outlet	Utilize BMPs before discharging on to agriculture land	The Will County Subdivision Ordinance offers density bonuses for BMPs and the provision of open space
City of Chicago	Variable depending on development type and local sewer capacity	Capture the first 0.5" of runoff from impervious surfaces or reduce impervious surfaces by 15% from existing conditions	Requires BMPs for sites directly discharging to waters	Requires the use of BMPs, including green infrastructure, through volume control requirements and for sites directly discharging to waters

Table ES-4. Performance Standards in Reviewed State Programs

	Maine	Maryland	Minnesota (CRWD)	New Jersey	Wisconsin
Reduce impervious surface		X		X	
Volume control	X	X	X		X
TSS removal	X		X	X	X
Groundwater recharge		X		X	
Groundwater protection	X				X
Erosion & Sediment control	X	X	X	X	X
Detention release rates	X	X	X	X	
County water Resource Management plans			X		
County ordinance or model		X			X
Local plans			X	X	
Local ordinances or model		X	X	X	X
Maintenance	X	X		X	
Spill prevention	X				
Temperature Control	X				
Watershed Planning	X				

because (a) infiltration, evapotranspiration and harvesting stormwater for reuse are already accepted practices in Illinois that are effective in retaining stormwater on site and (b) reducing the volume of stormwater discharge with green infrastructure practices reduces the amount of pollution reaching our urban streams, while also reducing associated flood risks. Using one simple, clear performance standard also means that less training is needed and landowners have the freedom to choose a mix of different green infrastructure practices to meet the standard, based on their project design and site characteristics.

Other performance requirements that should be considered include those that are currently in use in other states and in some Illinois counties, such as the development of stormwater management plans, erosion and sediment control measures, detention release rates, removal of Total Suspended Solids, temperature reduction, groundwater recharge and protection, and long-term plans and agreements for the maintenance of stormwater management facilities. **Some flexibility is needed in developing a regulatory program using green infrastructure practices.** Because of variations in soils, infiltration rates, surficial geology, proximity to waterways, slopes structures and other physical factors affecting the amount and rate of runoff discharge and its environmental impacts, a state-wide “one size fits all” will not work.

Illinois’ green infrastructure standards should be phased-in over time, to enable communities to develop the training and experience needed to manage urban stormwater using green infrastructure practices. The planning and preparation for the wide-spread use of green infrastructure would be improved if communities were either encouraged or required to set long-term goals to gradually increase the amount of their existing impervious surfaces subject to the green infrastructure performance standard.

The process we recommend is based on the concept of a “portfolio standard,” similar to the one adopted by Illinois to phase-in a gradually larger portion of renewable energy as part of its mix (or portfolio) of energy resources, with an increasing percentage of the state’s energy budget being met by renewable energy until a target percentage (25%) is reached at some target date (2025). **We recommend that Illinois EPA work with county and local officials, stormwater agencies, drainage districts, soil and water conservation districts and others to initiate a process that establishes realistic annual goals for adopting green infrastructure practices statewide in a timely manner**. These collaborations should additionally identify the boundaries for the portfolio standards (i.e., whether they should coincide with a HUC-12 watershed or with county or municipal boundaries) and use a percentage of effective impervious area as a potential proxy for the adoption of green infrastructure practices.

Staff and financial resources must be dedicated to program elements that create economic incentives and train county, municipal, stormwater management agency and drainage district staff in using green infrastructure practices until their use not only is accepted by county and municipal staff and within the development community but becomes the standard for stormwater management programs statewide. **Illinois should fund staff and other resources needed to bring green infrastructure and its benefits into practice in all communities.**

ADMINISTRATION

The National Research Council recommends that urban stormwater should best be managed on the watershed level, rather than on the local scale. In Illinois, counties are the governmental units whose jurisdictions best correspond to watershed-scaled management, so **we recommend that IEPA rely on the counties to develop appropriate rules and ordinances to locally administer the performance standards established at the state level** and work directly with municipalities to promote the use of green infrastructure to meet those standards and their other MS4 program responsibilities. **The state should also provide adequate resources to meet these responsibilities or authorize the counties to charge fees sufficient to cover the costs of the program.** Counties also have, or can readily develop, the technical expertise necessary to train municipal staffs on how best to use green infrastructure as a component of their local urban stormwater management programs and can also turn to the existing regional expertise that may be available to assist them in promoting green infrastructure practices.

This expertise includes the staffs of regional planning agencies, county stormwater management agencies, soil and water conservation districts, and drainage districts. County stormwater management agencies exist in all the collar counties of northeastern Illinois, while both soil and water conservation districts (which are currently revising the Illinois Urban Manual to embrace green infrastructure) and drainage districts are also highly respected agencies in more rural areas of the state. **We therefore recommend that more financial resources (through grants and stormwater management fees) also be provided to these agencies and districts** to assist the counties in their stormwater management responsibilities. Counties should consider entering into intergovernmental agreements with these other agencies and districts to provide technical services, training and monitoring the use and effectiveness of green infrastructure for urban stormwater management.

APPLICABILITY

We recommend that the stormwater retention performance standard first apply to all projects and entities currently subject to a NPDES stormwater permit in Illinois, including MS4s of all sizes, industrial sites, and construction projects. **Over time, applicability of the standards should be expanded to include more urban and suburbanizing areas, based on the density of impervious surfaces, rather than on population**. At the watershed level, studies show that it is very difficult to maintain predevelopment stream quality when watershed development exceeds ten to 15 percent impervious cover (Schuyelr and Holland 2002). Using the percentage of impervious cover within a watershed to guide the state's stormwater management efforts would have the dual benefits of (a) applying the standards first to those areas most significantly affecting water quality and (b) encouraging a limitation on new impervious surfaces, which will have many of the same benefits as applying the standards.

We also recommend that the standards apply to existing as well as new development, to publicly-owned as well as private property. For example, there should be a commitment by government agencies to apply the standards to manage stormwater runoff whenever public infrastructure undergoes significant maintenance, repair or replacement, or when private development is substantially improved or redeveloped. State agencies and regional governments should also set an example by using green infrastructure in their construction and maintenance activities, to help build awareness and experience with these practices. Green infrastructure retrofits are already part of the Illinois MS4 program. The state should develop guidance to ensure that green infrastructure practices are used appropriately to work most effectively in reducing pollution, erosion and sedimentation, and flood risks, while providing the additional benefits of healthier, cooler communities, improved habitat and aquifer recharge opportunities.

FUNDING GREEN INFRASTRUCTURE

The Clean Water Act's state revolving loan fund (SRF) program has always been available for use in helping to fund stormwater management projects, although the vast majority of SRF money has typically gone to wastewater treatment projects. In fact, in Illinois, the statutory language that originally gave IEPA authority to administer the SRF program specifically limited eligibility only to wastewater projects. The American Recovery and Reinvestment Act of 2009 (ARRA), however, specifically earmarked 20% of its state capitalization grants to State Revolving Loan Funds (SRFs) for innovative stormwater management practices such as green infrastructure (the Green Project Reserve) in addition to energy and water conservation initiatives, adding a mandate that some of the money be provided as grants as opposed to low interest loans. This required the Illinois legislature to amend the IEPA authority language to expressly include such grant funding.

The Fiscal Year 2010 federal appropriation bill passed in October 2009 provided another round of exceptionally large water infrastructure grants to states and repeated the mandates for green infrastructure projects and grants. We understand, based on comments made by U.S. Environmental Protection Agency officials, that in the current draft of the Fiscal Year 2011 federal appropriation bill, Congress intends to continue these two requirements for the foreseeable future in its annual appropriations. To make best use of these federal funds, **Illinois EPA must adopt a clear prioritization system that determines which municipal green infrastructure projects will receive funding under its earmarked Green Project Reserve**. This system should be designed to encourage applications for a wide variety of green infrastructure project all over the state.

Historically, the SRF program has funded only about ten percent of the water infrastructure needs of the applicants. Therefore, the SRF cannot be relied on for funding a major portion of either the sorely-needed upgrades to existing conventional wastewater and stormwater infrastructure or the green projects that will be completed in the next few years to supplement that infrastructure. Instead, the State of Illinois and its counties and municipalities should be hard at work developing additional funding sources for these projects. For example, the responsibility for stormwater management on private land should begin with the landowners, by requiring all developers to meet the performance standards described above, and to encourage and credit the use of green infrastructure practices to meet these standards in their projects.

The costs of constructing and maintaining stormwater infrastructure on private property should be borne by the landowner – by the developer during construction and by the occupants after construction. The residual runoff from such property should continue to be managed by local government. However, instead of using the general tax revenues to fund stormwater infrastructure, **the state should encourage local governments to adopt a stormwater management fee system, in which rate-payers are given clear information on the costs associated with such infrastructure.** This should ensure that polluted runoff is not treated as an economic externality, and that landowners causing the runoff pay for the treatment and management of runoff flow and volume needed to protect our urban streams – in the same way that landowners pay for the connection fees and sewage treatment charges for pollution discharged directly into streams by publicly-owned sewage treatment plants. **Green infrastructure practices should be eligible for appropriate performance credit against stormwater fees to encourage their adoption.** If green infrastructure practices do not receive credit, land managers are less likely to utilize them because they would represent additional cost above otherwise required and compliance-credited measures.

MAINTENANCE

Green infrastructure practices – like conventional “grey” stormwater infrastructure -- require maintenance to ensure continued effectiveness over time and performance as initially designed. **We recommend that communities which encourage or require the use of stormwater infrastructure, including green infrastructure practices, employ restrictive covenants to ensure that all stormwater infrastructure used on private property is adequately maintained.** These agreements should be filed in land records, so they are perpetual and subsequent owners know their responsibilities.

If a fee system established to fund stormwater management allows credits for the use of green infrastructure practices, as we recommend above, **periodic performance monitoring and compliance**

reporting (perhaps every 3-5 years) should be included with other green infrastructure measures to promote long-term reliability and performance. Such monitoring and reporting will ensure that the green infrastructure is still performing as designed and will monitor compliance with stormwater credit requirements. **The State or municipalities should establish an easement authority to enter properties receiving compliance credit for green infrastructure practices,** and to charge responsible parties who neglect to maintain their green infrastructure features, similar to the nuisance regulations currently used to prevent neglect of conventional landscape maintenance. Under such easements, based on the compliance reports, municipalities could enter the property to undertake maintenance if the landowner is unwilling or unable to do so, and then to charge the landowner or Home Owners Association for these services.

As part of our recommendation that the State encourage regional and local governments to utilize a stormwater fee system instead of general tax revenues for stormwater management, these **governments should also consider establishing stormwater utilities with budgets that are independent of wastewater and drinking water budgets**. An alternative to landowner maintenance is for such a utility to be given the right and obligation to maintain all stormwater facilities, whether on private or public land, and charge the landowners for the service.

RESEARCH NEEDS

Although both published, peer-reviewed literature and the technical reports and studies comprising the "grey literature" (including many entered into the U.S. EPA's International Stormwater BMP Database) find that green infrastructure practices are as effective as conventional stormwater facilities in reducing flood and pollution risks, **additional data still needs to be collected and assessed on green infrastructure practices.** Published data are absent for numerous types of green infrastructure, important details regarding infrastructure design and scaling are often missing from published accounts, and little information is available about the use of multiple infrastructure in combination in treatment trains or across watersheds.

There is also a need for more consistent reporting of green infrastructure performance. Monitoring green infrastructure performance and submitting the data to the BMP Database will provide a larger and more consistent dataset and will assist practitioners with selecting the most appropriate infrastructure for each project. We recommend that the State select appropriate projects and that the monitoring results from the use of green infrastructure in these project be provided to the BMP Database. Over the next few years, **Illinois EPA should work with county and local officials, regional stormwater management agencies, soil and water conservation districts, and drainage districts to begin to develop uniform protocols for the green infrastructure compliance monitoring and state-wide guidance for the reporting requirements**.

CHAPTER I. INTRODUCTION

The use of natural areas, or green infrastructure practices, to replace or supplement conventionally-engineered urban stormwater management systems has gained considerable interest both within the United States and internationally.[8] Our report explores the science of green infrastructure practices and evaluates existing and potential policies, regulations and administrative tactics that could be adopted in the State of Illinois to promote the widespread, appropriate use of green infrastructure stormwater management strategies and techniques.

Our research is intended to assist the Illinois Environmental Protection Agency (IEPA) in evaluating and documenting the specific criteria mandated by section 15 of P.A. 96-0026, the "Illinois Green Infrastructure for Clean Water Act," adopted by the Illinois General Assembly and signed into law in July, 2009. Specifically, Section 15 requires the agency to examine and report back to the General Assembly by June 30, 2010, their recommendations on the following seven issues:

a. The nature and extent of urban storm water impacts on water quality in watersheds in Illinois;

b. Potential urban storm water management performance standards to address flooding, water pollution, stream erosion, habitat quality, and the effectiveness of green infrastructure practices to achieve such standards;

c. The prevalence of green infrastructure use in Illinois;

d. The costs and benefits of green versus grey infrastructure;

e. Existing and potential new urban storm water management regulatory programs and methods and feasibility of integrating a State program with existing and potential regional and local programs in Illinois

f. Findings and recommendations for adopting an urban storm water management regulatory program in Illinois which includes performance standards and encourages the use of green infrastructure to meet those standards; and

g. The feasibility and consequences of devoting 20% of the Water Revolving Fund to green infrastructure, water and energy efficiency improvements, and other environmentally innovative activities on a long-term basis.

[8] Reductions in stormwater runoff using green infrastructure principles have also been mandated for all federal facilities with footprints exceeding 5,000 square feet by section 438 of the Energy Independence and Security Act of 2007. Further, congressional recognition of the benefits of promoting green infrastructure practices is reflected in the American Recover and Reinvestment Act of 2009 (ARRA), where state Clean Water State Revolving Loan funding was expressly earmarked for green infrastructure, energy conservation and other innovative projects.

Stormwater discharges from urbanization remain a significant water quality issue in Illinois. Impervious surfaces, such as the roofs, alleys, roads, sidewalks and parking lots characteristic of urban development, change the hydrology of cities compared with undeveloped areas. Rain is unable to infiltrate on site, and the resulting stormwater becomes runoff. Runoff contributes to erosion, combined sewer overflows, sedimentation, and nonpoint-source pollution and threatens human and ecosystem health. At the same time, the lack of infiltration prevents our groundwater resources from being recharged, which in turn reduces the ability of the aquifers to contribute to and maintain the flow rates and water levels of our urban lakes and streams.

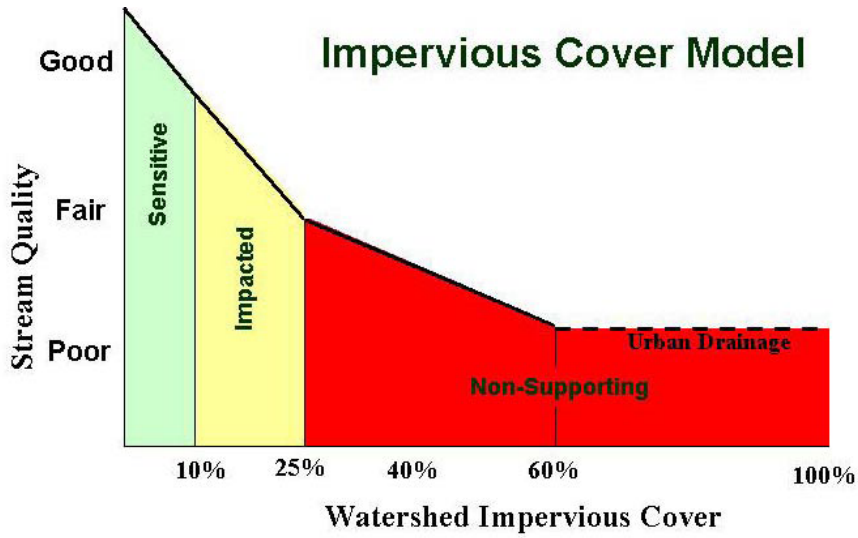
Recent research suggests that urban streams begin to become impaired when the impervious surface within a watershed exceeds ten percent of the watershed's land area (Center for Watershed Protection 2003). As the Center for Watershed Protection notes (p. 1):

> "When evaluating the direct impact of urbanization on streams, researchers have emphasized hydrologic, physical and biological indicators to define urban stream quality. In recent years, impervious cover (IC) has emerged as a key paradigm to explain and sometimes predict how severely these stream quality indicators change in response to different levels of watershed development. The Center for Watershed Protection has integrated these research findings into a general watershed planning model, known as the impervious cover model (ICM). The ICM predicts that most stream quality indicators decline when watershed IC exceeds 10%, with severe degradation expected beyond 25% IC."

Especially in our urbanized areas, our conventional stormwater systems are inadequate to handle our future (and in some places, current) stormwater management needs. According to the Illinois EPA, 1,218 stream miles are already impaired by urban runoff and storm sewer discharges (IEPA 2009). The National Research Council also found a direct relationship between urban land cover and the biological condition of downstream receiving streams, confirming that the alterations in hydrology caused by urbanization poses severe threats to the nation's waterways, and recommended that "a number of additional actions, such as conserving natural areas, reducing hard surface cover (e.g., roads and parking lots), and retrofitting urban areas with features that hold and treat stormwater are recommended (National Research Council 2008)." See Figure 1, below.

Conventional stormwater management infrastructure consists of the integrated systems of curbs and gutters, stormwater grates and catch basins, stormwater sewer systems, oil and grit separators, detention and retention basins (both wet and dry bottom), and outfalls and control structures, all of which are designed to catch and manage runoff, the precipitation or snowmelt that cannot naturally infiltrate into the ground because development activity has changed the natural hydrology of a site (by grading, removing vegetation, compacting the soils, or paving over the ground). The principal design function of these conventional systems is to reduce flood risks by allowing runoff to be discharged to adjacent waterways over a longer period of time, which reduces the stream levels, peak flows and the velocity of the stream-flow (which can erode stream banks). If the runoff is detained for a sufficiently long time in the conventional system before being discharged, then some attenuation of the pollutants carried by the stormwater is possible, by being settled out of the standing water, by being taken up by plants within the basin, or by natural processes within the soils (e.g., by filtration, sorption or ion exchange).

Fig. 1. The Center for Watershed Protection's Impervious Cover Model



Source: CWP, 2003. p. 2

Green infrastructure practices, in contrast, use natural and engineered systems to manage urban stormwater discharge to waterways through preserving and mimicking natural pre-development hydrology.[9] Green infrastructure practices address the specific stormwater management goals of reducing runoff flow rates and minimizing the pollutant loads entering waterways, the same goals addressed by conventional stormwater infrastructure. But it also offers additional valuable community benefits not provided by conventional infrastructure, such as groundwater recharge, runoff volume reduction, improved air quality, temperature moderation and energy cost savings, increased open space for recreation and wildlife habitat and increased land values. Landscaping and design guidelines for using green infrastructure to improve wildlife habitat are presented in Appendix I.

Green infrastructure can be applied on the site, neighborhood, or regional scales. On the regional scale, green infrastructure can be an interconnected network of natural areas. On the neighborhood scale, green infrastructure strategies include smart design -- such as encouraging cluster development that minimizes impervious surfaces -- which aim to preserve the natural hydrology of a site to the greatest extent possible.

[9] Section 5 of PA 96-0026 defines "green infrastructure" in part as "any storm water management technique or practice employed with the primary goal of preserving, restoring, or mimicking natural hydrology. Green infrastructure includes, but is not limited to, methods of using soil and vegetation to promote soil percolation, evapotranspiration, and filtration." Green infrastructure practices have also been called "best management practices (BMPs)," "stormwater control measures (SCMs)," or "low-impact development (LID) practices" by various practitioners. We deem all these phrases to be functionally synonymous, and will employ the phrase "**green infrastructure practices**" in this report to describe any of the urban stormwater management techniques relying on natural systems to provide on-site stormwater infiltration, pollutant and nutrient attenuation, and volume and peak flow reductions.

Green infrastructure used at the site level includes the practices set forth in Table 1. Some examples of what these practices look like when constructed and in place are presented in Appendix II. These examples are drawn largely from green infrastructure in use in the Chicago metropolitan region and more information about the design and effectiveness of these practices is also presented in this Appendix.

Table 1: Description of Stormwater infrastructure Practices Assessed in this Study

Infrastructure	Description
Bioinfiltration	Vegetated systems designed to facilitate the infiltration of stormwater and remove pollutants through infiltration media and/ or vegetation uptake. Examples: bioretention areas, swales, infiltration basins.
Permeable Pavement	Pavement which allows stormwater to infiltrate into underlying soil. Filters some pollutants.
Filtration	A variety of devices which actively or passively filter pollutants out of stormwater. Many are proprietary designs. Often used in conjunction with other green infrastructure or as retrofits to existing storm drains.
Green Roof	Roofs with a vegetated surface and substrate designed to reduce runoff through transpiration and evaporation and filter rainwater through media, vegetation, and geotextiles
Constructed Wetland	Manmade wetland intended to intercept runoff, reduce peak flows, decrease runoff volume and mitigate pollution

CHAPTER II. THE EFFECTIVENESS OF GREEN INFRASTRUCTURE

Stormwater management is a challenge faced by urban and agricultural development at all scales. As the percent of impermeable cover within a watershed increases, stormwater volume, peak flow and concentration of non-point source pollutants increase (USEPA 1983). In urban areas, traditional gutter and storm sewer systems are inadequate for reducing the quantity of stormwater or decreasing pollutant loads (Hood et al. 2007). In agricultural or rural areas, drainage systems quickly channel large volumes of water, sediment, and dissolved pollutants to waterways (Nelson 2002). In both urban and rural settings, inadequate stormwater management can lead to flooding, erosion, and impaired aquatic habitats (Finkenbine et al. 2000).

Best management practices (BMPs), such as detention and retention basins, are typically recommended by planning agencies to control discharge rates in developed and developing areas. However, the effectiveness of such measures is very sensitive to context and the identification of “best” can be difficult. Moreover, many common practices ignore the broader interactions in the hydrological cycle and thus fail to support other functions of a sustainable system, especially groundwater recharge.

The need for improved stormwater management has led to increased interest in the use of green infrastructure and a number of state and local governments are actively promoting the use of green infrastructure (USEPA 2000). In particular, the present review is motivated by legislation being proposed by the state of Illinois that would incorporate green infrastructure into urban areas to preserve pre-development levels of runoff (Illinois Public Act 96-0026). It is our intent to synthesize data on green infrastructure effectiveness to inform stormwater management policy and encourage the informed adoption of green infrastructure where appropriate.

At the regional scale, green infrastructure is broadly defined as a network of green spaces that provide natural ecosystem function and benefits to people through recreation, aesthetics and ecosystem services (Schilling and Logan 2008). In the context of stormwater management at the neighborhood scale, green infrastructure includes low impact development (LID) strategies implemented at the site level, such as vegetated swales, green roofs and permeable pavement, which aim to minimize the generation of urban stormwater runoff and associated pollution by using and mimicking natural systems to collect, treat, and infiltrate rain where it falls (Montalto et al. 2007).

Green infrastructure can facilitate stormwater management in several ways and at different scales. Runoff volume can be reduced through infiltration, evaporation, and evapotranspiration by plants (Hatt et al. 2009). Mechanisms for pollution removal include sedimentation, plant uptake (Vought et al. 1994), filtration (Urbonas 1999), biofiltration (Hatt et al. 2007), biodegradation, sorption and biosorption (Volesky and Holan 1995). Biofiltration encompasses a wide variety of engineered systems with specially selected media and vegetation combinations designed primarily to filter but also to infiltrate stormwater (Hatt et al. 2009). Green infrastructure such as swales or constructed wetlands are designed to achieve both runoff quantity and quality goals, while others are primarily designed to improve water quality (e.g.

filters) or to reduce runoff volume (e.g. rain barrels) (USEPA 2000, Larson and Safferman 2008). Our goal is to consolidate and analyze effectiveness data for all categories of green infrastructure from peer-reviewed literature and inform decisions on green infrastructure adoption.

Does green infrastructure work effectively to reduce the impacts of stormwater? This is probably the most important question which must be addressed in a systematic manner prior to implementation of a statewide green infrastructure policy. To answer this question, we examined data in published, peer-reviewed studies to evaluate the effectiveness of green infrastructure. Such studies have all undergone a critical evaluation by several experts in the field, and only studies that are able to stand up to this scrutiny are published. We also looked at some of the literature that was not rigorously peer-reviewed, including the U.S. Environmental Protection Agency's International Stormwater Best Management Practices Database.[10]

Our goals with this review include summarizing the current literature on green infrastructure and providing scientific background for policy decisions. We begin our review by identifying the stormwater quality and quantity metrics that we used to compare the effectiveness of green infrastructure. Since our aim is to inform policy with science, our sources of data include only compiled peer-reviewed studies. We found sufficient published data to examine effectiveness of buffers, constructed wetlands, bioinfiltration systems, filtration systems, permeable pavement and green roofs, and to compare them to traditional stormwater approaches like retention and detention basins. Following the review, we examine possible sources of variability in the effectiveness of green infrastructure, including design, scaling, influent pollution, geographical variation and climate, and maintenance. We further compare our findings to the US EPA/American Society of Civil Engineers (ASCE) International Stormwater Best Management Practices Database (BMP Database), a prominent resource for BMP practitioners, to identify commonalities, disparities, and shortcomings in both sources of information. Finally, we discuss the policy implications of our findings. Our recommendations in Chapter V identify important data gaps that should be filled to inform policy-making.

Indicators of Effectiveness

We selected four relevant and widely used criteria to compare the effectiveness of green infrastructure: runoff volume, peak flow, total suspended solids, and total nitrogen. Each of these factors is representative of common stormwater management challenges in urban areas. Runoff volume and peak flow are both measures of the quantity of runoff produced by a storm. The impervious surfaces that accompany urbanization lead to increases in runoff volume, or the amount of surface water resulting from a given storm event, and peak flow, which is the maximum runoff volume per unit time. Changes in runoff volume and peak flow are responsible for many of the negative impacts of stormwater (i.e. flooding, combined sewer overflows, erosion, low baseflow, and streambank entrenchment) (Finkenbine et al. 2000, Montalto et al. 2007). Because reducing runoff volume and peak flow is a fundamental goal for most green infrastructure, it is vital to include these metrics in this performance assessment. These two metrics have been suggested as key performance standards for green infrastructure and tools have been developed to predict how green infrastructure implementation will affect them. Calculators are available which estimate the impact of green infrastructure on peak flow and runoff volume (Center for

[10] http://www.bmpdatabase.org.

Neighborhood Technology 2009), but ultimately an analysis of field data on green infrastructure effectiveness is needed to evaluate real-world performance capabilities and inform policy-making.

Runoff quantity measurements do not tell the full story of how green infrastructure benefit urban environments; therefore, we also compared effectiveness in terms of water quality. While dozens of chemicals are found in stormwater, it is prohibitively expensive to monitor all possible contaminants. As a result, agencies that regulate urban nonpoint source pollution typically use surrogate measures of water quality to manage the cost of stormwater monitoring (Wisconsin Department of Natural Resources 2002, Turner and Boner 2004). Two commonly used surrogate measures of water quality are total suspended solids (TSS) and total nitrogen (TN).

Total suspended solids, the amount of particulate matter suspended in water, is both easy to monitor and an important component of water quality(Horowitz 2009). Suspended solids in stormwater can cause sedimentation in rivers and streams and aid in the transport of heavy metals and phosphorous (Thomson et al. 1997, Kayhanian et al. 2007, Horowitz 2009). However, TSS is not highly correlated with dissolved pollutants, so removal of TSS through sedimentation and other techniques will not necessarily reduce concentrations of all metals and nutrients, especially nitrogen which exists primarily in dissolved form (Bolton et al. 1991, Horowitz 2009).

A thorough evaluation of water quality should therefore include at least one pollutant which is found predominantly in dissolved form. We selected total nitrogen, the sum of the organic and inorganic nitrogen in a water sample, as a surrogate for dissolved pollutants. Although TN may include a small proportion of insoluble organic nitrogen, TN measurements for runoff consist primarily of soluble forms of nitrogen. This is particularly important to monitor because excess nitrogen causes eutrophication and algal blooms, leading to reductions in dissolved oxygen and degradation of aquatic communities (Carpenter et al. 1998). Although TSS, TN, peak flow and runoff volume are not the only metrics which we could have used to compare green infrastructure effectiveness, we feel that they are sufficient to represent the most important threats to ecosystem and human health caused by stormwater: sediment and associated particulate pollutants, dissolved nutrients, flow, and volume.

Sources of Data for Assessing Green Infrastructure Effectiveness

Our review focused on seven categories of green infrastructure for which sufficient published data exist to evaluate removal efficiency of TSS and TN and reduction of runoff volume and peak flow (Table 2). We used keyword searches on ISI Web of Knowledge to compile an initial database of 236 peer-reviewed journal articles with data on green infrastructure published in October 2009 or earlier. We excluded pilot studies and other research with no form of replication and those exclusively quantifying within-infrastructure characteristics such as the distribution of pollutants among sediment layers. Finally, we excluded those articles which did not specify the number of storm events monitored and those which included only pollutant load data, not pollutant concentration. This resulted in a sample size of 57 journal articles and 173 sites in our review.

To evaluate the relative effectiveness of various green infrastructures, we separated similar infrastructure into categories and tallied the following information for each paper: the number of infrastructures (or infrastructure configurations) monitored over time, the number of storm events monitored, percent change in peak flow, runoff volume, TN, and TSS and standard deviations (Table 2). To simplify terminology throughout the paper, we used the term “site” to indicate a single infrastructure configuration that was monitored over time, whether it was a set of all identical replicates in a laboratory study or a field site such as a permeable pavement installation, a bioswale, a single wetland, or a green roof. Lab studies constituted 43.5% of sites and the remaining studies were conducted in the field (56.5% of sites).

To compare the relative effectiveness of green infrastructure at removing both dissolved and particulate fractions of contaminants (TN and TSS), we summarized data on percent removal, or removal efficiency—a common, dimensionless measure of effectiveness. In sites where removal efficiencies were not reported but runoff pollutant concentrations were reported for both treated and untreated water, we calculated the percentage difference between treated and untreated water for both TSS and TN (Hossain et al. 2005). We used removal efficiency of each site to calculate the weighted average removal efficiency for TN and TSS for each infrastructure category, weighted by the number of storm events monitored for each site. Weighted averages were used to avoid unwarranted biases in the data introduced by a small number of outliers. For example, a site monitored for a single storm which caused the release of accumulated sediments could potentially cause the average TSS removal efficiency across all sites to be artificially low. We also calculated the weighted standard deviations for each green infrastructure category using least squares regression and used a weighted variance equation which includes both between-storm-event and between-site variation to calculate standard deviations (Ledolter and Hogg 2009, Millsap and Maydeu-Olivares 2009).

Green Infrastructure Performance

We calculated the weighted average reduction and weighed standard deviations for runoff volume and peak flow for each type of green infrastructure. Standard deviations were weighted only by the number of sites, not the number of storm events because between storm-event standard deviations were reported for only 7 out of 20 sites for peak flow and 8 out of 34 sites for runoff volume, making it impossible to fill in missing data. This is different from the standard deviation calculation for TN and TSS which incorporated between storm-event variability values (SD or variance) reported for sites. We calculated weighted average runoff volume or peak flow reductions for permeable pavement, bioinfiltration, and green roofs.

The number of storm events monitored at a site ranged from 1 to 72 (mean = 13.8) for TN and from 1 to 64 (mean = 12.4) for TSS. Sample sizes ranged from 8 (Permeable Pavement) to 40 (Infiltration) sites for TN and from 9 sites (Detention) to 73 sites (Bioinfiltration) for TSS. There were insufficient data to calculate weighted average removal efficiency for either TSS or TN by buffers for green roofs or for TN by biofiltration. Because we did not have the raw data and all studies in our review did not use the same measure of variability, it was not possible to test for statistical differences in removal efficiency between infrastructure types.

Table 2: List of Green Infrastructure with Brief Descriptions and the Number of Individual Sites with Data on TN Removal Efficiency, TSS Removal Efficiency, Peak Flow Percent Reduction and Runoff Volume Percent Reduction[11].

Infrastructure	Total Sites	Total Articles	TN	TSS	Peak Flow	Runoff Volume	Definition
Bioinfiltration	77	16	40	69	7	6	Vegetated systems designed to facilitate the infiltration of stormwater and remove pollutants through infiltration media and/ or vegetation uptake. Examples: bioretention areas, swales, infiltration basins
Permeable Pavement	23	14	8	11	5	12	Pavement which allows stormwater to infiltrate into underlying soil. Filters some pollutants.
Filtration	26	8	N/A	26	N/A	N/A	A variety of devices which actively or passively filter pollutants out of stormwater. Many are proprietary designs. Often used in conjunction with other green infrastructure.
Green Roof	9	6	N/A	N/A	6	6	Roofs with a vegetated surface and substrate designed to reduce runoff through transpiration and evaporation and filter rainwater through media, vegetation, and geotextiles
Constructed Wetland	19	9	10	16	N/A	N/A	Manmade wetland intended to intercept runoff, reduce peak flows, decrease runoff volume and mitigate pollution

[11] Some articles include multiple sites and some sites had data for multiple parameters. N/A = not enough data available for analysis.

Removal Efficiency for TSS and TN

Our analysis indicated that green infrastructure generally succeeds in reducing both TSS and TN event mean concentration. The ability of an infrastructure to reduce TSS was highly variable between and within infrastructure types, removing between 58 and 86% of TSS (Figure 2). Weighted standard deviations ranged from 28.5% (Detention) to 131.0% (Constructed Wetlands) (Figure 2A). Variability was high and without access to the raw data and standard deviations for all sites, it was not possible to determine the most effective types of green infrastructure. Detention basins had the lowest standard deviation and therefore appear to be the most consistent in performance. Constructed wetlands were the least consistent in their performance, evident in the very large standard deviation in TSS removal efficiency. This may be because wetlands sometimes release sediments during very large storm events (Carleton et al 2001). Despite the variability, we conclude that green infrastructure—with the possible exception of constructed wetlands—is a viable option for reducing TSS concentration in stormwater and potentially reducing the associated negative impacts on aquatic ecosystem health related to sediment and particulate heavy metals.

Although green infrastructure reduced concentrations of TSS by 58 to 80%, we found that they were less successful at ameliorating nitrogen pollution; no infrastructure consistently reduced the concentration of TN by more than 58% (Figure 2B). Small sample sizes, ranging from 8 sites (Permeable Pavement) to 40 sites (Bioinfiltration) and a high degree of variability (between storm-event standard deviation: 0.95 – 83.05 %) hinder our ability to determine the most effective infrastructure types. Weighted standard deviations ranged from 10.0 (for filtration devices) to 287.7 (for green roofs). Our findings are consistent with other studies indicating that, while green infrastructure is successful at reducing concentration of TN (USEPA 2000), dissolved pollution is generally more difficult to remove from stormwater than particulate pollution (Vymazal 2006).

Reduction in Runoff Volume and Peak Flow

In addition to examining water quality measures, we also evaluated the effectiveness of green infrastructures at reducing runoff volume and peak flow. Runoff quantify is particularly important because it is strongly related to pollution removal. This is because reductions in runoff volume, even absent any change in pollutant concentration, result in lower total pollutant loads entering stormwater systems.

In our sample of papers, runoff volume and peak flow reductions were reported less frequently than TN or TSS removal efficiency (Figure 2C). We calculated weighted average runoff volume or peak flow reductions for permeable pavement, bioinfiltration, and green roofs, which generally reduced both peak flow and runoff volume. Reductions in average peak flow ranged from 52 to 70% while 57 to 85% of runoff volume was mitigated by green infrastructure (Table 2). Detention and the other categories of green infrastructure did not have sufficient data for analysis.

The potential of green infrastructure to reduce peak flow by 50% or more may alleviate impacts on aquatic systems such as overflows in combined sewer systems, flooding, and structural changes including erosion, bank scouring and stream entrenchment in waterways. Additionally, reducing overall runoff volume has the potential to reduce the risk of flooding and combined sewer overflows and increase groundwater recharge.

The International BMP Database

The BMP Database was started in 1996 and is funded and managed today by a coalition of water resources and civil engineering entities including the USEPA. It is widely used as a source of information by practitioners (Strecker et al 2001). However, there are well-documented shortcomings in this dataset (Barrett 2008). For example, while the database contains 238,292 water quality data points from 264 BMPs throughout the US, over 50% of data points originate from 24 sites. Only 20 states are represented in the BMP database and more than half of all sites are in 4 states with year-round moderate to warm climates (California, Florida, Virginia, and Texas).

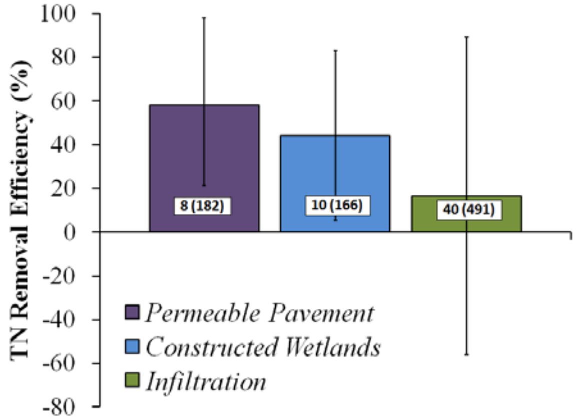
Despite its shortcomings, the BMP database represents one of the most accessible and comprehensive source of information about the effectiveness of green infrastructure. Therefore, we compared our data to the data in the most recent (December 15, 2009) version of the BMP database as a way to validate our findings. We began our comparison by determining the percentage of field sites from our review which had also been entered into the BMP database. Laboratory studies were excluded from this analysis because they are not typically included in the BMP Database. Only 22 out of the 66 field sites (33.3%) in the United States in our analysis were included in the BMP Database. None of the studies in our dataset that were conducted outside of the United were entered in the BMP database. Only two international sites (one each in Canada and Sweden) are included in BMP Database, and neither was published in the peer-reviewed studies included in this review.

We cannot directly compare our effectiveness data to data in the BMP database because information required to fully evaluate effectiveness is missing for a considerable fraction of the sites. However, Geosyntec Consultants and Wright Water Engineers analyzed water pollution data in the BMP database (2008) using 95% confidence intervals to determine whether effluent had significantly lower concentrations than influent for a number of pollutants. Removal efficiencies were not reported. They found that runoff quality improvements varied by infrastructure type. Detention basins (n=22), constructed wetlands (n=17) and hydrodynamic filters (n=30) did not show a significant effect on TSS removal. However, biofilters (a type of bioinfiltration, n=56), media filters (n=33), and retention ponds (n=43) showed a statistically significant difference between influent and effluent for average TSS concentration. For TN, this analysis showed that detention basins (n=9), biofilters (n=46), retention ponds (n=12), and channel-type constructed wetlands (n=3) showed a significant reduction in average TN removal. However, hydrodynamic filters (n=4) and other constructed wetlands (n=5) had no significant effect on TN and media filters (n=19) showed a significant net increase in TN. To summarize, they found that retention basins and biofilters were the only infrastructure which resulted in significantly lower concentrations of both TN and TSS.

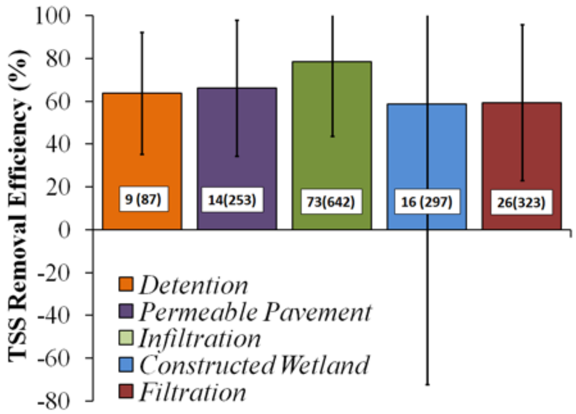
Overall, the shortcomings in the BMP database mirror the issues we encountered with published manuscripts on green infrastructure effectiveness. Together, the published sites we evaluated and those in the BMP Database account for a very small proportion of all green infrastructure in use (Strecker et al. 2001), which underscores the need for more widespread monitoring, publication, and data sharing, especially for infrastructures in regions with cold winters.

Figures 2A-C: Weighted Mean Percentage Difference Between the Influent and Effluent for TN, TSS, Peak Flow, and Runoff Volume[12]

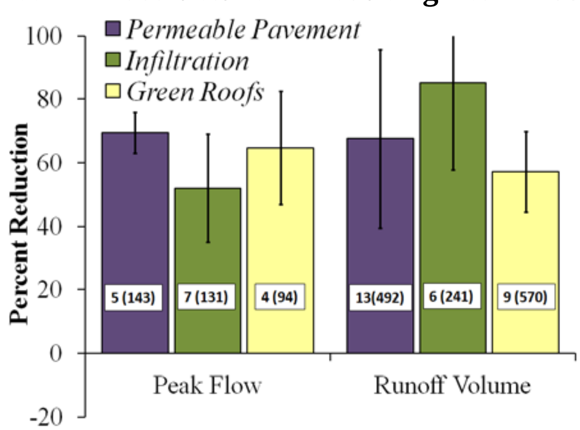
2A) Effectiveness of Green Infrastructure in Removing Total Nitrogen.



2 B) Effectiveness of Green Infrastructure in Removing Total Suspended Solids



2 C) Effectiveness of Green Infrastructure in Reducing Peak Flows and Runoff Volumes



[12] Means are weighted to remove bias caused by sites monitored for very few storm events. Error bars represent the weighted standard deviation, a measure of how close together the mean removal efficiency values are across all sites. Values on the bars are the number of sites included in the analysis and , in parentheses, the total number of storm events monitored. All data are from peer-reviewed literature on green infrastructure functional efficiency. Only infrastructure types with data from three or more sites are presented in each graph.

Sources of Variation

Although we found that green infrastructure generally removed pollutants and reduced peak flows and runoff volumes, our most notable finding was how variable the effectiveness could be within a particular infrastructure type. For example, among the 16 sites of constructed wetlands with data on TSS, removal efficiencies ranged from -170% to 100%. While this was one of the largest ranges we found, it was not atypical of our dataset as a whole. In fact, the variability in effectiveness extended to all categories of green infrastructure that we investigated.

Because understanding the sources of variation may assist practitioners in selecting the most suitable green infrastructure for a given site, we evaluated the variability in effectiveness of each green infrastructure with regard to differences in design, scaling, influent pollution, geographical distribution, climate and maintenance. Although we were unable to directly test whether these variables influenced the effectiveness of green infrastructure, we looked for trends in our dataset and also summarized the current state of knowledge related to each potential source of variability.

Design Variation and Effectiveness

Green roofs, permeable parking lots, constructed wetlands, swales and other bioinfiltration systems, and detention basins are designed individually for each site based upon criteria including soil types, average rainfall, magnitude of storm events, and the percent impervious surface in the catchment (Wong and Somes 1995, Murray-Guide et al. 2005, Getter et al. 2007, Davis et al 2009). Variation in green infrastructure design may be partially responsible for the variability we found in pollutant removal and runoff volume and peak flow reduction. Substrate choice may impact the ability for a green infrastructure to infiltrate and filter stormwater. For example, the percentage of fine grains in the substrate is often modified in engineered substrates to maximize removal of targeted pollutants (Hunt 2006b).

Plant species choices for systems which include biological elements can also influence how the infrastructure functions. Studies have shown that pollutant removal can vary markedly between plant species, with some species up to 20 times better at removing certain pollutants than other species (Read 2008). Underdrains may impact the effectiveness of rain gardens, a type of bioinfiltration (Dietz and Clausen, 2006). Generally, the authors provided limited information about the design parameters. For example, only 70% of field sites in our dataset reported the size of the infrastructure in meters or hectares and only 58% of the sites reported both infrastructure size and drainage area.

Design variations extend not just to scale, substrate, and biota, but also to all other engineered aspects. We investigated whether pollutant removal effectiveness for commercially available stormwater filters varies among designs. Our study encompassed several distinct categories of filters, including hydrodynamic separators (number of sites = 8), sand filters (number of sites = 3), and several types of proprietary filtration devices which rely on a combination of screening, absorption, adsorption, and/or sedimentation (number of sites = 15). We calculated weighted averages and standard deviations for TSS removal by these three types of filtration systems (TN removal data was only available for one filtration site).

In general, TSS removal was very similar for the three filter designs. Hydrodynamic separators removed on average 54% of TSS (SD=36%), sand filters removed 60% (SD=34%), and proprietary filtration systems removed on average 60% (SD=36%). Other studies have found that the effectiveness of various filter designs varies, and filters can serve different purposes depending upon the design (Morgan et al. 2005, Hipp et al. 2006, Wilson et al. 2009). For example, zeolite filters did not remove any TSS from synthetic stormwater, however, Xsorb filters removed almost 95% of TSS under the same conditions (Hipp et al. 2006). Similarly, the AbTech Catch Basin Insert was almost four times better at removing total suspended solids than the Aquashield Catch Basin Insert under the same conditions (Morgan et al. 2005). It is important that practitioners take into consideration the wide range of design variability when selecting filtration systems for a given site (Morgan et al. 2005. Hipp et al. 2006).

Scaling

Green infrastructure must be properly scaled for its site. For most infrastructures, engineers use data regarding the size of the drainage area, proportion of impervious surface, and historical rainfall data to create a design which will be effective for a given size of storm. Generally, these variables are highly site-dependent, and an ideal ratio of infrastructure size to drainage area has not been defined (Heitz et al. 2000, Akan 2002, Mungasavalli and Viraraghavan 2006). However, for constructed wetlands, design guidelines recommend a ratio of wetland area to drainage area of at least 1 to 100 (Carleton et al. 2001). To examine the effect that scale might have on variation in effectiveness, we compared the removal efficiency for TSS, TN, and the reduction in runoff volume and peak flow for wetlands which were small for their drainage areas to those which were properly sized. Properly scaled wetlands (infrastructure to drainage area ratio ≥ 0.01) were no more effective at removing TN or TSS from effluent than those with a ratio below 0.01. Although scaling is expected to be important for green infrastructure design, we didn't find sizing to be a prominent source of variability in constructed wetland performance. This is consistent with the results of Carleton et al. (2001) who found that detention time and hydraulic loading rates (the amount of water flowing into a wetland each day) were the most important determinants of the effectiveness of constructed wetlands, regardless of the scale.

Geographic Variation and Cold Climate Studies

Variability in effectiveness of green infrastructure may be related to geographical and climatic variation. For example, cold temperatures are known to adversely affect pollution removal and infiltration capacity (Roseen et al. 2009). Although we were not able to directly test this, it is likely that climatic and geographic variation play a role in the variability we found in the effectiveness of green infrastructures.

Seasonal variability in runoff infiltration, due to lower hydraulic conductivity in lower temperatures, has been demonstrated in climates with frequent winter freezes (Emerson and Traver 2008). Concentrations of pollutants such as chlorine are higher in winter runoff in places where road salt is used (Semadeni-Davies 2006). Some, but not all, infrastructures have reduced winter performance at removing pollutants. For example, winter and summer TSS removal performances were similar for filtration, bioinfiltration, and retention infrastructure but winter removal efficiency declined for stone swales and hydrodynamic separators (Roseen et al. 2009). Seasonal effects can also vary by pollutant. Previous studies have shown that wet detention ponds show decreased removal efficiency for lead, zinc, and TSS during winter, but no declines in cadmium and copper removal (Semadeni-Davies 2006).

Regional differences in climate may also impact the effectiveness of green infrastructure. Studies in our dataset were primarily located in humid continental, marine west coast and dry summer subtropical temperate climates. We were particularly interested in studies in humid continental climates since this is the dominant climatic zone in most of the eastern half of the United States and it is characterized by wet, freezing winters.

Maintenance and Effectiveness

Regular maintenance, or lack thereof, can greatly impact effectiveness of green infrastructure. We noted for each article in our dataset whether maintenance issues were addressed. Although the data did not allow for a detailed analysis of the impact of maintenance on green infrastructure effectiveness, we found that about half of the articles in our initial database contained data or recommendations concerning maintenance. Clogging was the most common concern, followed by ineffective maintenance regimes.

Bioinfiltration, permeable pavement and filtration infrastructure have reduced effectiveness when clogged. Le Coustumer et al. (2007) tested hydraulic conductivity in 40 biofilters which were 8 years old and younger and found that infiltration rates in more than 40% of sites were below Australian guidelines. Without maintenance, sedimentation can completely impede infiltration, causing bioinfiltration infrastructure to retain water and possibly facilitating pollutant leaching into groundwater (Datry and Gilbert 2004). Older infiltration basins (>20 years old) which have not been maintained tend to have both lower infiltration rates and higher pollutant concentrations in sediments compared with equivalent infiltration basins (Dechesne et al. 2005).

The infiltration rate for permeable pavements is also affected by clogging. Researchers have postulated that without maintenance to alleviate clogging, permeable pavement is unlikely to provide a water quality benefit (Barrett 2008). Clogging effects may vary with local conditions and the choice of paving materials. Within a permeable pavement installation, localized clogging may occur, especially in heavy traffic areas and places where snow is piled in winter (Boving et al. 2008). However, Pratt (1995) reported that concrete block pavers in a nine-year old parking lot continued to have acceptable infiltration rates despite an absence of maintenance.

Another important maintenance step relates to filters: pollution removal can be maximized by customizing the maintenance regime for the surface area of the filter, the amount of impervious surface in the catchment area and the typical rainfall. Filters with smaller surface areas compared to the percent of impervious area in their catchments will clog more rapidly and require more frequent maintenance (Hatt et al. 2007). Modeling techniques can reliably predict sediment trapping in some types of filters and may be useful in determining maintenance schedules and maximizing performance (Siriwardene et al. 2007).

Reducing initial pollution concentrations in runoff through source control, education, and street sweeping is another strategy worth consideration. Studies have shown that a 15% reduction in pollutant loads can be achieved on a catchment scale through source control (Davis and Birch 2009). Education and street sweeping may achieve additional load reductions, however limited data are available on the effectiveness of these techniques (Sartor and Gaboury 1984, Davis and Birch 2009).

Conclusions

Our review showed that green infrastructure decreases pollutant concentrations in effluent and reduces runoff volume and peak flow. Together, reduced concentrations and reduced volume result in lower total pollutant loads. No infrastructure has clear performance superiority. Variability is high for all types of green infrastructure, but cannot be directly attributed to climate, design of filtration or bioinfiltration systems, influent concentration, maintenance (or lack thereof), or infrastructure size. There is a need for more consistent reporting of green infrastructure performance. Most sites we found in the literature have not been included in the BMP database. More widespread utilization of this database will provide a larger and more consistent dataset and will assist practitioners with selecting the most appropriate infrastructure for each project.

We found that the performance of green infrastructure is at the very least comparable to traditional approaches to stormwater management, and thus recommend its wide-scale adoption for both water quality and volume control of stormwater runoff. Although we are not able to conclude that green infrastructure demonstrates superior performance when compared to conventional detention basins, it provides additional environmental benefits and is more cost effective. Many types of green infrastructure offer green space, increase the natural beauty (and economic value) of developed areas, provide habitat and connectivity for plants and animals, and improve hydrological functions. Systems such as green roofs and rain gardens that include biological components may improve air quality and provide benefits for the climate.

Given the variability in performance observed in the scarce data available, we recommend two types of measures accompanying any green infrastructure regulation. The first is the implementation of a systematic monitoring and reporting program requiring submission of standardized data to the BMP Database in the format required by this database. Initially, incentives may need to be provided to educate and recruit stakeholders for this purpose. In parallel, any regulation of green infrastructure adoption for stormwater management will need to build in flexibility as more information is collected and the knowledge base is developed further to update the regulation.

CHAPTER III. FUNDING GREEN INFRASTRUCTURE

There are two dynamics affecting the economics of green infrastructure practices. The first involves direct subsidies while the second is the cost-effectiveness of the practices relative to conventional stormwater management facilities. Subsidies for green infrastructure are offered by state revolving loan programs, which received large influxes of funding last year from the federal government's economic recovery legislation (the American Recovery and Reinvestment Act of 2009). The cost-effectiveness of green infrastructure practices can be best assessed by reviewing municipal studies that have compared green and conventional infrastructure costs. In addition, various economic models have been developed, including one by the Center for Neighborhood Technology called the "Green Values Calculator" that enables the hydrological and economic benefits of green infrastructure to be projected for different scales of projects over different time horizons. Almost all of these models indicate that, in most cases, green infrastructure practices are more economical than conventional stormwater infrastructure over their respective useful lives. The various approaches for analyzing the economics of green infrastructure are surveyed in this chapter.

The American Recovery and Reinvestment Act (ARRA)

The Clean Water Act's state revolving loan fund (SRF) program has always been available for use in helping to fund stormwater management projects, although the vast majority of SRF money has typically gone to wastewater treatment projects. In fact, in Illinois, the statutory language that originally gave IEPA authority to administer the SRF program specifically limited eligibility only to wastewater projects. The American Recovery and Reinvestment Act of 2009 (ARRA), however, specifically earmarked 20% of its state capitalization grants to State Revolving Loan Funds (SRFs) for innovative stormwater management practices such as green infrastructure (the Green Project Reserve), adding a mandate that some of the money be provided as grants as opposed to low interest loans. This required the Illinois legislature to amend the IEPA authority language to expressly include such projects.

The Clean Water Act State Revolving Loan Fund program was established by Congress to assist local communities in paying for upgrades and expansions of their waste water treatment systems. Each year a federal appropriation feeds the state funds, to be combined with a state match and loan repayments from the previous years' projects. Illinois has historically used the money from its Clean Water State Revolving Fund (CWSRF) to fund dozens of waste water treatment projects around the state. This CWSRF, as distinguished from a similar fund under the Safe Drinking Water Act, contained about $224 million for project funding in 2009.

The picture changed significantly with the passage of the American Recovery and Reinvestment Act of 2009 (also known as the "Stimulus Bill" or "ARRA"). The ARRA contained $4 billion for states to invest in water infrastructure under the Clean Water Act, and $2 billion more for projects under the Safe Drinking Water Act, and determined that that project funding should be managed through the existing SRFs. In Illinois, the ARRA added $177 million to the 2009 CWSRF, for a total of about $400 million.

The ARRA also imposed strict requirements on states for the use of this stimulus money, and states were forced to modify their programs in order to ensure that they would be allowed to spend their ARRA capitalization grants. For example, it required that 20% of the money be set aside for "green infrastructure, energy and water efficiency improvements and other environmentally innovative activities", also known as the Green Project Reserve (GPR). Eligible projects in each of these categories were described by the U.S. Environmental Protection Agency in a March 2, 2009 guidance document entitled "Award of Capitalization Grants with Funds Appropriated by P.L. 111-5, the "American Recovery and Reinvestment Act of 2009."[13] For many states, including Illinois, funding such "green" projects was new.

Another requirement of the ARRA was that 50% of the federal grant was required to be used for principal forgiveness, negative interest loans or grants, or any combination of these. Illinois did not have the legal authority to provide these kinds of subsidies, and the Illinois General Assembly amended the state law to allow for it. Large stimulus-type grants were again made by Congress to the SRFs in an appropriation bill in October 2009 for calendar 2010[14], and Illinois' grant for the 2010 CWSRF was about $94 million. The 20% green project reserve set aside was included again as a requirement in the appropriation bill. Furthermore, at least 30% of the federal grant in the new appropriations bill is still required to be used for principal forgiveness, negative interest loans and grants.

It is clear that Illinois municipalities and regional storm water management agencies need additional funding for green infrastructure projects. Aside from having to manage storm water with small budgets, these municipalities face new green infrastructure requirements in the revised MS4 general permit, ILR-40. In some areas where outreach and education have been strong, municipalities have shown a great interest in using green infrastructure. For example, DuPage County has established a green infrastructure grant program, and for the last 3 years have been funding portions of such projects all over the county.

In spite of all the benefits of green infrastructure and the regulatory requirements, however, municipal interest in green infrastructure has been spotty. At least in Illinois there has not been an outpouring of applications for green project funding from the CWSRF, and municipalities have only rarely invested their own money in such projects. The first and most important reason for this is the lack of knowledge of the benefits of, and experience working with, green infrastructure.

That situation is slowly changing, but it has been further delayed by the limited nature of IEPA's funding of such projects in 2009 and 2010. IEPA's effort to reach out to municipalities and encourage them to apply for the ARRA and 2010 funds for green projects was inadequate to generate any real interest. This was compounded by the policy decision to provide grant funding for only 25% of project costs, a number many municipalities said would not support an application for innovative projects. In contrast, states with strong education and outreach

[13] See: http://www.epa.gov/water/eparecovery/docs/2009-03-02_Final_ARRA_SRF_Guidance.pdf, Attachment 7.

[14] Fiscal Year 2010 Appropriation Law (P.L. 111-88), see: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_public_laws&docid=f:publ088.111.pdf.

programs have received many applications for green infrastructure projects and have given out millions of dollars in grants for green infrastructure project costs. We conclude that outreach and education are critical elements of any program attempting to increase interest in, and use of, green infrastructure practices, and we recommend that IEPA significantly increase the resources and effort in this portion of its program.

With respect to the SRFs in general, historically they have been able to fund only about 10% of estimated infrastructure project costs, nationally, and this number may be even lower in Illinois. We recommend that IEPA use its current SRF prioritization policy effort to clarify that in the future the majority of projects will not be funded from the SRFs. Instead of applicants putting off necessary infrastructure upgrades because of the hope that someday they will be funded from the SRFs, IEPA should encourage them to take several steps to ensure that they can cover their long-term infrastructure costs without the need for SRF funding. For example, municipalities should

a. engage in long-term planning to identify the "least-cost" methods of maintaining their infrastructure;

b. establish alternative funding sources, such as fee programs and utilities to ensure that there is a permanent, dedicated revenue stream for important infrastructure projects; and

c. Develop prioritization policies that favor projects with multiple benefits and that have the lowest life-cycle costs so that they are less likely to require additional outside funding in the future. These projects will more likely be funded from the SRFs.

The Cost-Effectiveness of Green Infrastructure

If green infrastructure does work as intended, is it still affordable when compared to the costs of the conventional technologies used to manage urban stormwater? To assess the cost-effectiveness of green infrastructure, we used a literature review, data from past research and a green infrastructure economic model called the Green Values® Calculator, developed by the Center for Neighborhood Technology (CNT) to compare different urban stormwater management technologies – both green and conventional -- over their useful lives at various scales (municipal, neighborhood and site) and in various settings (suburban and urban).

Cost-effectiveness is one of the driving forces behind increasing, widespread national adoption of green infrastructure practices. In general, national and Illinois examples indicate that properly scaled and sited green infrastructure can deliver equivalent hydrological management of rainwater/stormwater at comparable or lower costs than conventional conveyance and treatment infrastructure. Green infrastructure features also deliver a range of additional economic, social and ecological benefits, contributing community health and vitality beyond their hydrologic performance.

The following section examines evidence of green infrastructure's cost and effectiveness. It includes life-cycle cost and benefit comparisons of a sampling of individual green infrastructure practices, which can be seen as the building blocks of a community scale green infrastructure programs. Because green infrastructure practices tend to be designed in combinations to fit context-specific conditions, the analysis also considers scenarios and examples of site and neighborhood scale developments.

Cost and benefit ranges cited here derive from nationally published studies evaluated within CNT's Green Values® Calculator, from CNT monitoring of Northeast Illinois demonstration sites, and from recently published results from St. Paul, MN's Capitol Region Watershed District's (CRWD) green infrastructure program, conducted in climatic and urban development conditions like those in Illinois. Potential scenarios apply the cost and performance values within the Green Values® Calculator to example development sites. Finally, community-scale green infrastructure programs from other metropolitan areas give indications of how cities are recognizing the performance and additional benefits of green infrastructure approaches at this scale. The degree to which green infrastructure's benefits accrue to either utilities, property developers or the public depends in part on policy measures. We discuss policy factors affecting cost effectiveness at the conclusion of this section

The U.S. EPA study *Reducing Stormwater Costs through LID Strategies and Practices*[15] evaluated construction costs at development/neighborhood scale projects employing green infrastructure (Low Impact Development or LID) in their construction. The report concluded that "In the vast majority of cases, the U.S. Environmental Protection Agency (EPA) has found that implementing well-chosen LID practices saves money for developers, property owners, and communities while protecting and restoring water quality." Of 13 cases where green and conventional comparisons were feasible, 12 projects demonstrated capital (construction) cost savings by using LID, saving from 15-85%. The EPA study, however, examined only construction costs, where many infrastructure systems are evaluated based on their full life-cycle cost.

The following Table 3 indicates the unit costs, over a 30 year life-cycle, for a sample group of green infrastructure practices. The table contains information from three sources: CNT's research during the past three years, research reported by the Capitol Region Watershed District of Minnesota[16], and a review of national of data sources that have been incorporated into the Green Values® National Calculator at http://greenvalues.cnt.org. Gross construction and maintenance costs are allocated two ways: BMP construction costs per square foot of its surface area; and the cost per cubic foot of runoff that is expected to be intercepted during the 30-year life cycle. Life cycle costs are based on the net present value of the construction cost and estimated annual maintenance costs discounted by a rate of 3.1% per year over 30 years.

CNT has constructed and monitored the performance of four rain gardens, two bioswales, one vegetated swale and one permeable pavement facility during 2007 through 2009. The ranges of construction costs experienced for rain gardens and bioswales are reflected in the table. (It should be noted that monitored demonstration BMPs can be more expensive than their community counterparts: costs for 20 CNT non-research demonstration rain gardens range from zero to $10

[15] U.S. EPA (2007). *Reducing Stormwater Costs through LID Strategies and Practices*, Washington, DC, Document #EPA 841-F-07-006.

[16] Capital Region Watershed District, *Stormwater BMP Performance Assessment and Cost-Benefit Analysis*, St. Paul, MN 2010.

per square foot, depending on how much work is done by the owner and volunteers and whether the plants are donated.) The relatively low cost per cubic foot for the permeable pavement results from a design where only a portion of the parking lot is permeable: water from 18.3 square feet of

Table 3. Costs of Green Infrastructure

BMP	CNT research		CRWD		CNT National Calculator	
	$/sq.ft.	$/cu.ft.	$/sq.ft.	$/cu.ft.	$/sq.ft.	$/cu.ft.
Rain Gardens	$9.00-$32.00	$0.04-$0.11	$8.55	$0.04-$0.07	$7.00	$0.25
Bioswales	$13.00-$31.00	$0.02-$0.03			$7.10	$0.39
Vegetated Swales	$2.40	$0.01				
Infiltration Trenches			$11.77	$0.02-$0.03		
Permeable Pavement	$7.10	$0.01			$7.10	$0.59
Green Roofs					$15.75	$0.58

Source: CNT 2009

impermeable pavement drains to each square foot of pervious concrete that surrounds the parking lot drains. The construction costs reported by the CRWD are averages for 8 rain gardens and 8 infiltration trenches, two infiltration-oriented BMPs that comply with the CRWD ordinance. The CRWD costs per cubic foot are based on measured volumes of runoff reduction during 2007 and 2008 (CRWD also estimated the amount and cost of removal of pollutants, but those data are not included here.)

Construction costs for the Green Values® National Calculator estimates are mid-points selected from the ranges of costs identified in the Calculator's 2009 update (the low and high values identified for construction costs are also available)[17]. The higher National Calculator costs per cubic foot result because the BMPs are designed to meet regulatory on-site storage volumes, but calculations give no credit for infiltration of the stored water. Many green infrastructures practices are designed to infiltrate runoff, so the cost presented here per cubic foot of water intercepted is conservative. Costs per volume of water managed would be significantly lower if infiltration volume were taken into account.

[17] Center for Neighborhood Technology (2009) Green Values® Calculator Cost table, http://greenvalues.cnt.org/national/cost_detail.php.

Counting avoided costs stemming from green infrastructure features can provide an additional level of comparison with conventional stormwater conveyance and treatment infrastructure. When green infrastructure performance for volume control and water quality can offset regulatory requirements, scenarios that evaluate green infrastructure life cycle costs also demonstrate savings in comparison to equivalent conventional infrastructure. The following examples in Table 4 estimate cost and hydrological results of three development scenarios using the Green Values® Calculator.

- The first scenario evaluates a "greenfield" new, low density residential development in McHenry County with 14 lots spread across 20 acres. It employs rain gardens, native plantings, trees and swales to replace nearly half of otherwise required detention, saving life-cycle cost and contributing more than 1.4 million gallons of equivalent annual groundwater recharge.
- The second assesses a residential re-development sited in an existing parking lot, assuming 59 townhomes on a three-acre site. Rain gardens, porous pavement, swales and trees could eliminate required detention, with accompanying life-cycle savings, while removing approximately 2.4 million gallons of runoff per year from sewers.
- The third scenario assesses the Chicago Center for Green Technology, a retrofit of an existing commercial building on a 3.3 acre brownfield that employs a partial green roof, native plantings, water harvesting in cisterns, permeable pavement and a constructed wetland.

Although the actual construction costs for this project were likely higher than what the Green Values Calculator estimates (since the project was a first-generation demonstration completed in about 2002), the scenario evaluates costs and performance assuming the same features were constructed at 2009 rates. The result, which the city has monitored as diverting 81% of annual runoff volume, would reduce life cycle costs by 20% and prevent nearly 2.5 million gallons of runoff from entering sewers.

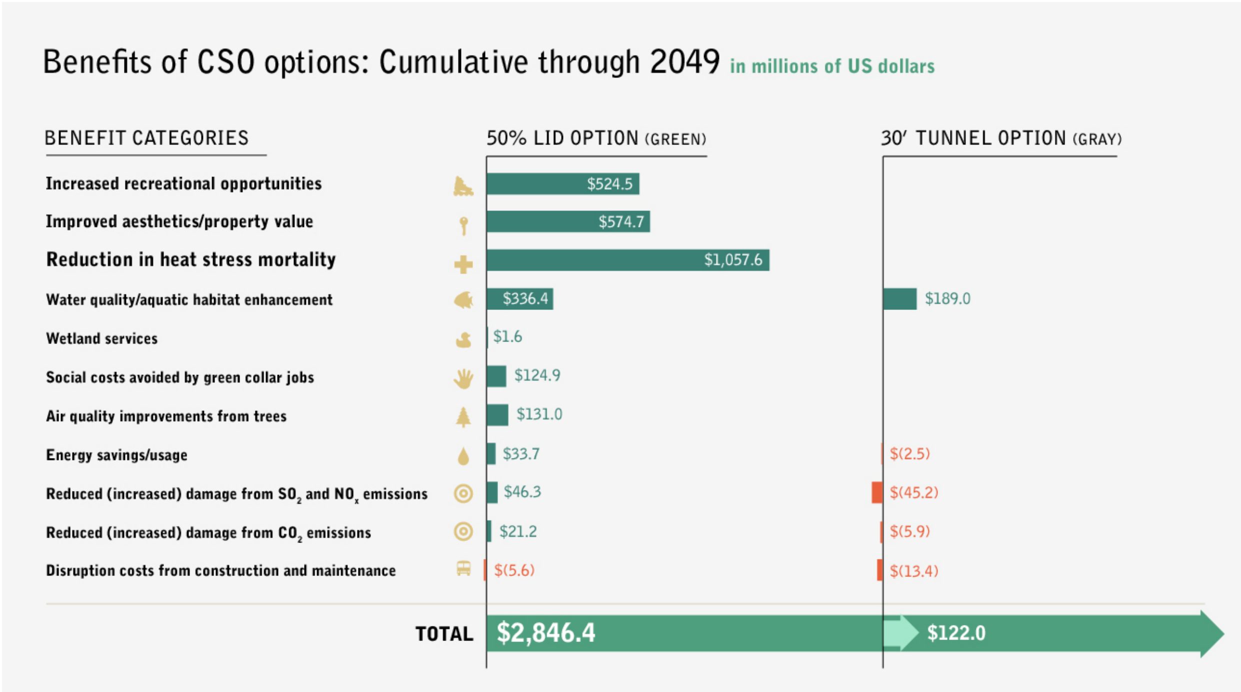
Cost-benefit calculations from the Green Values® Calculator include preliminary estimates of selected additional benefits that green infrastructure practices have been documented to produce, such as ground water recharge, energy savings, and carbon sequestration.[18] Philadelphia evaluated the additional economic and social benefits stemming from a community scale program of green and conventional stormwater practices, designed to deliver similar stormwater performance in several watersheds. The analysis tallied estimated benefits in 11 categories, attributing a greater than $2.7 billion additional benefit to the option utilizing 50% green infrastructure (Table 5).

[18] See http://greenvalues.cnt.org/national/benefits_detail.php for a list of benefits associated with green infrastructure practices and published references to their quantification.

Table 4. Estimated Costs, Savings, and Hydrologic Benefits for Use of Green Infrastructure in Three Development Scenarios

Case Study	Description	Green Components	Construction Cost Savings for Green Scenario	Green Construction Savings as % of Conventional	30-year Life Cycle Savings for Green Scenario	Green Life Cycle Savings as % of Conventional	Green Scenario Annual Hydrologic Benefits
Exurban Development	20-acre site with 14 homes on undeveloped land	Rain gardens, native vegetation, trees, and roadside swales	$190,800	31%	$507,800	24%	1,411,000 gallons increase groundwater recharge
Blue Island Riverfront	3.0-acre site with 59 townhomes on former parking lot	Rain gardens, permeable pavement, trees, and streetside swales	$91,900	23%	$168,600	29%	2,409,000 gallons reduced runoff to sewers
Chicago Center for Green Technology	3.3 acre site with office building, parking and wetland on former industrial land	Partial green roof, cisterns, vegetated swales, gravel parking lot, wetland and native vegetation	$18,100	4%	$161,500	20%	2,468,000 gallons reduced runoff

Table 5. Benefits of Green vs. Conventional Infrastructure to Manage CSO Issues



Source: Philadelphia Watersheds (Stratus Consulting) 2009[19]

Kansas City, Missouri, has also developed a city-scale plan for green infrastructure as part of its combined sewer overflow long-term control plan. Evaluating the degree to which planned conventional upgrades could be eliminated with street trees, pervious pavement, green roofs, stormwater planters, and curb extension swales, local authorities identified three sub-watersheds that can achieve equivalent stormwater service using green infrastructure as at least a portion of the infrastructure investment. [20] See Table 6. Kansas City also recognized that green infrastructure solutions leverage private investment, in the form of anticipated green roofs and permeable pavement on private property, so that "Public investment can be reduced with significant investment by (the) private sector."

Kansas City's analysis also includes estimates of construction costs for GI practices. Depending on the type of BMP, the cost estimates range from $2.28 to $7.13 per gallon (rain garden or bioretention retrofits) to $10.86 per gallon for curb extension swales, $5.50 per gallon for permeable parking lots, $11.24 per gallon for permeable sidewalks, $22.68 per gallon for green roofs.[21]

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[19] Stratus Consulting (2009). *A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds: Final Report*, Philadelphia Office of Watersheds.

[20] Leeds, Terry. "Greening Up Kansas City's LTCP", presentation at EPA Green Infrastructure for Wet Weather workshop, Chicago, September 2008.

[21] Kansas City Water Services Department (2008). Overflow Control Plan: Green Alternatives for Outfalls 059 and 069, File 0770-04-27-00 (http://www.kcmo.org/idc/groups/water/documents/adacct/mbrgray_green.pdf.pdf)

Table 6. Comparisons of Green and Grey Project Costs in Kansas City, MO

Watershed	Area	Grey Cost	Grey Cost/gallon	Grey + Green
OK Creek	4,770 acres (52% impervious)	$256 million	$5	$295 million ($230 million green)
Brush and Town Fork Creeks	6,930 acres (45% impervious)	$439 million	$8.70	$552 million ($274 million green)
Middle Blue River	744 acres (34% impervious)	$51 million	$17	$35 million – all green

Source: Leeds (2008)

The degree to which green infrastructure's benefits accrue depend in part on policy measures, particularly the degree to which a property owner or developer gains credit for compliance with local ordinance requirements. For the benefits cited in the scenario examples above, for example, savings occur when green infrastructure measures are deemed to replace conventional detention or other storage. If, as is often the case, local ordinances allow partial credit against detention, cost savings related to green infrastructure can be limited or disappear, because the property owner must construct the conventional drainage structures regardless.

Similarly, the degree to which private or public interests receive benefits can also affect green infrastructure implementation. Adoption of green infrastructure features on private property, as envisioned in the Kansas City plan, will benefit public infrastructure performance. When policies, such as stormwater utility/service fee or tax credits are in place, private property managers have incentive to invest in GI practices. In addition, some of green infrastructure's additional community benefits such as potential climate cooling, energy reduction, and neighborhood amenity improvement, are shared public-private benefits. Financing and investment criteria that recognize and prioritize the additional benefits may be necessary to encourage practices that meet multiple social, ecological, and economic objectives.

One problem is the manner in which water infrastructure projects are funded by local government. It is common for such infrastructure to be funded either with general tax revenue or with the proceeds of bond issues that are then paid back with taxes. Either way, it seems clear that municipalities have not been willing to increase taxes to the level required to adequately maintain their water infrastructure, which includes traditional waste water infrastructure as well as stormwater green infrastructure. There are exceptions to this generalization, of course. The City of Chicago has over four million square feet of green roofs on city buildings either completed or proposed. The city is determined to reduce stormwater volume in its sewers through the evapotranspirative properties of these green roof projects. A number of other cities around the country have also benefitted from large investments in green infrastructure. Yet, in order for the skeptics to commit money to green infrastructure at this point in time, a strong financial incentive appears to be required.

CHAPTER IV. CURRENT PRACTICES

Section 15(e) of the Green Infrastructure for Clean Water Act requires that this study review and report on "existing and potential new urban storm water management regulatory programs and methods and feasibility of integrating a State program with existing and potential regional and local programs in Illinois."[22] To address this mandate, we reviewed current stormwater regulatory programs with performance standards that incorporate green infrastructure concepts. First, we reviewed the Illinois statewide stormwater permit, known as the MS4 Permit. Second, we reviewed existing county and municipal stormwater management ordinances in Northeastern Illinois, the region with the greatest experience in using green infrastructure. We also assessed the transferability of green infrastructure state-wide and identified issues that might impede the wider use of these practices. Next, we reviewed five state programs outside Illinois that have in place statewide stormwater management performance standards that expressly encourage or require the use of green infrastructure as a means of meeting those standards. Finally, we examined the utility of adopting a state green infrastructure portfolio standard – similar to the renewable energy standard currently in place in Illinois – that could be used to help phase-in green infrastructure practices, statewide.

THE ILLINOIS MS4 PERMIT

States issue permits for stormwater discharges from industrial, construction and municipal activities. The permit for small municipalities, those with fewer than 100,000 people, is known as the small "municipal separate storm sewer system" or "MS4" permit. It is of interest here because it regulates stormwater management activities on public and private land both during development and post-construction, and because the Illinois MS4 permit contains requirements for municipalities to use or require the use of green infrastructure practices. It is important to understand the reach and limits of this permit to determine the need for additional stormwater regulations in Illinois as suggested by P.A. 096-0026.

The Illinois Environmental Protection Agency (IEPA) issued its first MS4 permit[23] in February 2003, designated as "General NPDES Permit No. ILR40". Such permits must be reviewed and revised every five years, and on February 20, 2009, IEPA issued a revised MS4.[24] Among other revisions, the new permit requires permittees to adopt "green infrastructure" stormwater management strategies and techniques as part of their programs.

IEPA defines small MS4s generally as municipalities serving fewer than 100,000 people in an urbanized area (the list also includes several state and federal agencies with similar sized populations of employees

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[22] For this review, we have utilized a website maintained by StormwaterAuthority.org, including a page linking to summaries of all the state stormwater management programs in the country: http://www.stormwaterauthority.org/regulatory_data/state.aspx. We have quoted liberally from these summaries and refer the reader to them for further research.

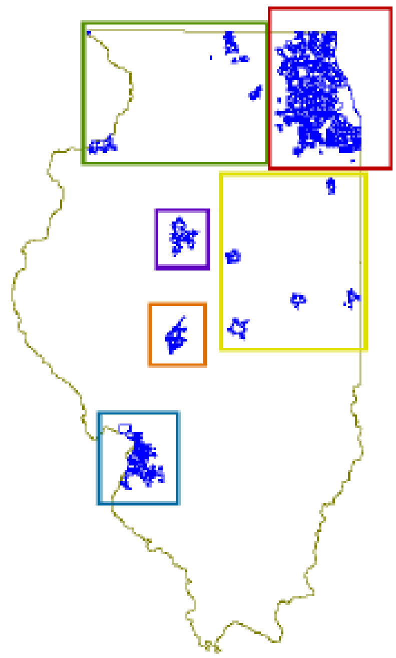
[23] A "general permit" is essentially a regulation that applies to all regulated entities in a class of entities. Each permittee in the class must meet the exact same permit requirements.

[24] Additional information about the Illinois MS4 general permit and related documents may be found on the Illinois EPA's website at: http://www.epa.state.il.us/water/permits/storm-water/ms4.html.

within the State).[25] In accordance with federal regulations, IEPA has waived permit coverage for most systems serving fewer than 10,000 people. The resulting list of permittees in Illinois contains about 440 municipalities, townships and agencies that are subject to Permit ILR40, generally concentrated in six regions.[26] See Figure 3, below.

The most significant new green infrastructure requirements are contained in Part IV.B. of the Permit, which requires that MS4 stormwater management programs address the following six issues, which are discussed in more detail below:

Fig. 3. Illinois MS4 Communities



1. Public education and outreach on stormwater impacts
2. Public involvement/participation
3. Illicit discharge detection and elimination
4. Construction site stormwater runoff control
5. Post-construction stormwater management in new development and redevelopment
6. Pollution prevention/good housekeeping for municipal operations

Section IV.B.1. – **Public education and outreach on stormwater impacts**. The revised subsection requires that each permit-holder to incorporate information about green infrastructure strategies into its education materials, discuss the benefits and costs of such strategies and provide guidance to the public on implementation.

Section IV.B.4.a.ii. and iv. – **Construction site storm water runoff control**. MS4 programs have always been required to reduce pollutants in stormwater runoff from construction activities. The revised subsection contains specific new requirements to use green infrastructure practices to meet this goal "when appropriate and practicable". This ensures that green infrastructure will be part of the project design and in place prior to the commencement of construction.

Section IV.B.5.a. and b. – **Post-construction stormwater management in new development and redevelopment**. The new subsection says that each permittee should "adopt strategies that incorporate

[25] An urbanized area as delineated by the Bureau of Census is defined as a central place or places and the adjacent densely settled surrounding area that together have a residential population of at least 50,000 people and an overall population density of at least 500 people per square miles. (See IEPA's website explanation at http://www.epa.state.il.us/water/permits/storm-water/ms4.html.)

[26] For the Illinois Environmental Protection Agency's list of municipalities and townships currently holding MS4 permits, *see* http://www.epa.state.il.us/water/permits/storm-water/ms4-status-report.pdf.

stormwater infiltration, reuse and evapotranspiration of stormwater into the project to the maximum extent practicable."

Subsection B.5.b. provides a definite structure for incorporating green infrastructure practices into site design. "When selecting BMPs [best management practices] to comply with requirements contained in this Part, the permittee should adopt one or more of the following general strategies, in order of preference. Proposal of a strategy should include a rationale for not selecting an approach from among those with a higher preference.

i. preservation of the natural features of development sites, including natural storage and infiltration characteristics;
ii. preservation of existing natural streams, channels, and drainage ways;
iii. minimization of new impervious surfaces;
iv. conveyance of stormwater in open vegetated channels;
v. construction of structures that provide both quality and quantity control, with structures serving multiple sites being preferable to those serving individual sites; and
vi. construction of structures that provide only quantity control, with structures serving multiple sites being preferable to those serving individual sites."

The first four of these strategies represent accepted green infrastructure practices, in declining order of effectiveness at addressing water quality and runoff volume problems. The final two strategies can incorporate green infrastructure practices, traditional BMPs, or a combination of the two stormwater management practices.

Section IV.B.5.c. and d. – **Post-Construction stormwater management in new development and redevelopment**

Local stormwater ordinances typically apply only to new private development and redevelopment and not to existing developed land (sometimes called "retrofits") or the construction or reconstruction of public buildings and surfaces such as roads, sidewalks, alleys and parking lots. However, in recognition of the fact that these existing impervious surfaces have caused the current degradation in water quality and stream conditions, and that development in any given year affects less than one percent of impervious surfaces, the revised language expands the applicability of stormwater management provisions to clearly include municipal development and redevelopment activities, as well as activities on developed, private land.

New Training Requirement. In another important revision, the new Section IV.B.5.c. requires municipal permittees to provide appropriate training for all MS4 employees and contractors who manage or are directly involved in (or who retain others who manage or are directly involved in) the routine maintenance, repair or replacement of public surfaces in current green infrastructure or low impact design techniques applicable to such projects.

The new language in the MS4 Permit should result in permittees and their communities becoming more familiar with green infrastructure through the education and training requirements. However, the permit still lacks clear performance standards for the use of green infrastructure practices. For example, permittees and developers must "minimize the volume of stormwater runoff and pollutants…through the use of BMPs that…result in…load reduction, increased infiltration, evapotranspiration and reuse of stormwater." Yet, permittees are not told exactly how much they must "minimize" runoff and pollution. There are no objective performance goals imposed, such as a specific volume of stormwater to be retained on site or the percentage of pollutant loading to be removed. Such standards are becoming commonplace in ordinances and state regulations, as we explain in the following sections.

LOCAL PROGRAMS

Northeastern Illinois has been a leader in stormwater management since the 1960s when flood control and stream improvement projects were implemented. The Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) was one of the first agencies to require detention storage in 1972. That same year the Tunnel and Reservoir Plan (TARP) was adopted. TARP is a series of underground tunnels and above ground reservoirs that hold stormwater runoff during large storm events to limit the number of Combined Sewer Overflows (CSOs)[27].

In 1986 and 1987 the Chicago area experienced two devastating storm events. The 1986 storm was preceded by two weeks of consistent rainfall. In 1987, 13 inches of precipitation fell during a single storm in less than 24 hours. Although the two storms were quite different, they both resulted in widespread flooding and record river levels[28]. These events spurred the General Assembly to pass Public Act 85-905 (55 ILCS 5/5-1062.2), which gave several northeastern Illinois counties the authority to create a Stormwater Management Planning Committee (SMPC) to prepare a stormwater management plan, to implement it through a countywide ordinance, and to fund stormwater management activities through a property tax levy. These counties were DuPage, Kane, Lake, McHenry and Will, and each has passed a countywide ordinance. In P.A. 94-675 (55 ILCS 5/5-1062.2) the authority was extended to Kendall and five other counties. Kendall currently has an ordinance that is applicable only in unincorporated Kendall County. P.A. 93-1049 (55 ILCS 5/5-1062.1) gave the MWRDGC the authority to develop a countywide stormwater management program for Cook County. MWRDGC has completed its stormwater management plan and is now drafting the Cook County ordinance.

This unique system is central to stormwater management in northeastern Illinois and allows each county to prepare its own stormwater management plan, ordinance, and projects. The ordinances are adopted by the County Board and provide minimum standards for all municipalities and unincorporated areas within the county, although a municipality may then create stricter criteria if it chooses to do so.

The objective of most stormwater management ordinances is to limit stormwater runoff to a prescribed maximum. This is accomplished mainly through onsite detention storage. Traditionally detention basins were constructed to hold a specified amount of runoff. This amount is based on the specific county ordinances as well as the size of the project and a number of other factors. Each detention basins is equipped with a flow restrictor to only release flow at a specified release rate. These release rates are relatively consistent throughout the region and are summarized in Table 7.

Ordinances also address issues regarding volume control and water quality, which can involve the use of green infrastructure practices. Volume control practices require that a specified amount of runoff volume

[27] http://www.mwrd.org/irj/portal/anonymous/tarp
[28] http://dnr.state.il.us/owr/chicago.htm

be infiltrated on site when possible. Some regulations specify a certain volume be retained on site while others require practices that encourage water infiltration. Water quality requirements typically specify that stormwater best management practices be incorporated into site design or that mechanical devices treat stormwater runoff. We reviewed the ordinances in northeastern Illinois for release rate, volume control and water quality practices (Table 7).

Cook County

As discussed above MWRDGC was one of the first entities to require stormwater detention storage in the 1970s. For the purposes of this study the Draft Cook County Watershed Management Ordinance[29] was reviewed. The ordinance was under public review in the later part of 2009 and is now under revision after the public comment period. It is important to note that the final ordinance may be different from what was studied and included in this report. The current draft of the ordinance requires the first inch of runoff be treated by a retention based practice. These practices include:

- Infiltration trenches
- Infiltration basins
- Porous pavement
- Dry wells
- Open channels
- Retention storage
- Constructed wetlands with forebays

These practices also provide water quality benefits. The ordinance allows for flow through practices for areas that are not required to provide volume control. The retained volume of water can be credited against the required detention volume. The ordinance calls for a dual release rate requirement of 0.04 cubic feet per second per acre (cfs/acre) and 0.15 cfs/acre for the 2-year, 24-hour and the 100-year, 24-hour storm events respectively.

Green Infrastructure Allowance: The draft ordinance currently requires retention based practiced to be used to control a specified volume of water. Many of the approved retention based practices incorporate the use of green infrastructure.

DuPage County

The DuPage County Countywide Stormwater and Flood Plain Ordinance[30] was first adopted in September 1991 and has since been amended a number of times most recently in August 2008. The ordinance incorporates a Best Management Practice Hierarchy to reduce the runoff rates, volumes and pollutant loads. The hierarchy contains the following elements:

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29 http://www.mwrd.org/irj/portal/anonymous?NavigationTarget=navurl://2eee6bcf4aa1e461b1e99d195d53321f&LightDTNKnobID=114980813

30 http://www.dupageco.org/emplibrary/SW%20Ordinance2008%20(complete).pdf

Table 7: Summary of Current Stormwater Management Practices in Northeastern Illinois

Governing Body	Release Rate	Volume Control Mechanism	Water Quality Measures	Green Infrastructure Allowance
Draft Cook	2-year, 24-hour: 0.04 cfs/acre 100-year, 24-hour: 0.15 cfs/acre	The first 1" of runoff to be retained on site	Infiltration and flow through practices	Retention based practices, e.g. permeable pavements, infiltration basins and trenches are required to achieve volume control requirement
DuPage	100-year, 24-hour: 0.10 cfs/acre	Requires BMPs be incorporated to the maximum extent practical	Requires BMPs to provide water quality benefits	Green Infrastructure, e.g. vegetated filter strips and permeable pavers are incorporated into a BMP Manual
Kane	100-year, 24-hour: 0.10 cfs/acre	The first 0.75" of runoff to be retained below the primary gravity outlet of the site	Native wetland plantings required	Stormwater BMPs may be implemented in lieu of traditional detention practices for developments which require less than 1 ac/ft
Kendall	2-year, 24-hour: 0.04 cfs/acre 100-year, 24-hour: 0.15 cfs/acre	Hierarchy to minimize increases in runoff volumes and rates	Promotes retention and infiltration to provide water quality benefits	Promotes the use of BMPs and native plantings for increased infiltration and evaporation
Lake	2-year, 24-hour: 0.04 cfs/acre 100-year, 24-hour: 0.15 cfs/acre	Runoff Volume Reduction Hierarchy	Runoff Volume Reduction Hierarchy and mechanical measures	Preserving natural infiltration is incorporated into the Runoff Volume Reduction Hierarchy through a number of BMPs
McHenry	2-year, 24-hour: 0.04 cfs/acre 100-year, 24-hour: 0.15 cfs/acre	BMP Hierarchy to during site design incorporates practices which will reduce volume	Requires that a number of BMPs be evaluated for site design incorporation	Addressed in Conservation Design and Subdivision Ordinances that require the use of BMPs and use density bonuses for open space that is placed under conservation easements maintained by professional land managers
Will	2-year, 24-hour: 0.04 cfs/acre 100-year, 24-hour: 0.15 cfs/acre	The first 0.75" of runoff to be retained below the primary gravity outlet of the site	Utilize best management practices before discharging on to agriculture land	Addressed in the Will County Subdivision Ordinance which offers density bonuses for BMPs and the provision of open space
City of Chicago	Variable depending on development type and local sewer capacity	Capture the first 0.5" of runoff from imp surfaces or reduce imp by 15% from existing conditions	Requires BMPs for sites directly discharging to waters	Requires the use of BMPs through volume control requirements and for sites directly discharging to waters

- All runoff from rooftops and parking lots, and discharge from sump pumps that does not discharge into a site runoff storage facility shall be diverted onto vegetated swales or filter strips for a distance of 50 feet;
- Vegetated swales shall be utilized, where appropriate, as an alternative to storm sewers to promote infiltration of stormwater and the infiltration of stormwater pollutants;
- Effective impervious surface area should be limited by site designs which minimize the area of streets, parking lots, and rooftops and or/utilize permeable paving material such as concrete grids in low traffic areas;
- Other BMPs such as infiltration basins and trenches (where permeable soils are present) and filtration basins and sand filters (on highly impervious or industrial developments) shall be utilized where appropriate

The ordinance also has a 100-year, 24-hour allowable release rate of 0.10 cfs/acre for all areas other than those designated Stormwater Economic Redevelopment Zones (SERZ), where a two-year, 24-hour allowable release rate of 0.04 cfs/acre will be in effect instead of the 100-year provision. DuPage County does not utilize a dual release rate.

Green Infrastructure Allowance: In March 2008, DuPage County developed the Water Quality Best Management Practices Technical Guidance document[31] which defines and describes a number of BMPs including conservation design, permeable pavers, infiltration systems and grit chambers. These techniques are intended to improve water quality and reduce stormwater runoff volume.

Kane County

The Kane County Stormwater Management Ordinance[32] was adopted on January 1, 2005. This ordinance applies to the entire county (in both incorporated and unincorporated areas) as well as in other counties where Kane County municipalities straddle the county's boundaries.

For volume control measures, the ordinance requires that runoff from up to a 0.75 inch rainfall event over the hydraulically connected impervious area of the new development shall be stored below the elevation of the primary gravity outlet (retention) of the site's runoff storage facility. The storage facility may be designed to allow for evapotranspiration or infiltration of this volume into a subsurface drainage system and shall not be conveyed through a direct positive connection to downstream areas. Native plantings are also required to be incorporated into storage facility design, specifically requiring that the area not be covered by more than 25% of the following species, Buckthorn, Reed Canary Grass, Purple Loosestrife and Giant Reed.

A release rate of 0.10 cfs/acre is required under the Kane County ordinance for the 100-year storm, 24-hour event and applies to disturbed areas only. The ordinance allows for credit for various green infrastructure practices, including leaving soils undisturbed during construction or preparing them to maximize infiltration, and planting deep-rooted grasses or other vegetation to promote infiltration and

[31] http://www.co.dupage.il.us/emplibrary/Final%206-18-08.pdf

[32] http://www.co.kane.il.us/kcstorm/ordinance/adoptord.pdf

evapotranspiration. This credit can be used to reduce the amount connected impervious area in the detention requirement calculations.

Green Infrastructure Allowance: Under the requirements of the Kane County Ordinance, stormwater BMPs may be implemented in lieu of traditional detention practices for developments which require less than 1 acre-foot of detention.

Kendall County

The Kendall County Stormwater Management Ordinance[33] was adopted in October 2002. Unlike the other ordinances in northeastern Illinois, this is not a county-wide ordinance, i.e. it only applies to unincorporated areas. Currently, the county is undergoing a process to develop a stormwater management plan that may lead to the development of a county-wide ordinance.

The ordinance requires that there should be no change in run-off volume and flow rate from pre-development conditions. The county employs a hierarchy for volume reduction that requires the following, in order from the most to the least preferred option:

- Minimize impervious surfaces and establish best management practices consistent with the needs of the project;
- Preserve, establish, and/or restore native plantings and natural areas to increase and promote infiltration and evaporation;
- Preserve natural resource features of the development site, including but not limited to flood plain, wetlands, prairies, and woodlands;
- Attenuate flows through the use of open vegetated swales and natural depressions;
- Preserve, enhance, and incorporate existing natural stream channels and quality wetlands, stream channels and drainageways;
- Infiltrate runoff on-site;
- Provide stormwater retention facilities;
- Provide stormwater detention facilities;
- Construct storm sewers

Release rates allowed under the Kendall County Ordinance are 0.04 cfs/acre for the 2 year, 24 hour event and 0.15 cfs/acre for the 100-year, 24 hour event.

Infiltration, retention and the use of native plantings are measures that the ordinance employs for addressing water quality. Additionally, the ordinance requires that stormwater storage facilities be designed to give preference to wet bottom and wetland designs and to incorporate multiple uses where practicable, so that portions of the property are not used exclusively for stormwater management. Uses considered compatible with stormwater management include open space, aesthetics, aquatic habitat, recreation (boating, trails, playing fields), wetlands and water quality mitigation.

[33] http://www.co.kendall.il.us/zoning/ordinances/StormwaterManagement.pdf

Green Infrastructure Allowance: The Kendall County Stormwater Management Ordinance promotes the use of BMPs and native plantings for increased infiltration and evaporation.

Lake County

The Lake County Stormwater Watershed Development Ordinance[34] became effective on October 18, 1992. The current ordinance requires that an applicant adhere to the following release rates: two-year, 24-hour of 0.04 cfs/acre and a 100-year, 24-hour of 0.15 cfs/acre. There is also a provision for alternate release rates if specified by an approved basin plan or floodplain study. The applicant is required to choose from the following strategies to minimize the increase in runoff volumes and rates:

- Preservation of natural resource features on site (wetlands, floodplains and water features designated as Isolated Waters of Lake County);
- Preservation of exiting natural streams, channels and drainageways;
- Minimize impervious surfaces;
- Utilize open vegetated swales and channels;
- Preserve natural infiltration and storage characteristics on a site;
- Incorporate structural measures that provide water quality and quantity control;
- Incorporate structural measures that provide only quantity control and conveyance.

The ordinance further specifies that, prior to discharging runoff to the Waters of US, Isolated Waters of Lake County or adjoining property, all development shall divert and detain at least the first 0.01 inches of runoff for every 1% of impervious surface for the development with a minimum volume equal to 0.2 inches of runoff. The ordinance also ensures that wetland hydrology is being maintained by requiring that 80 to 150% of the existing runoff from the 2-year, 24-hour storm event be maintained and routed to Isolated Waters of Lake County

Green Infrastructure Allowance: Green Infrastructure is encouraged through the Runoff Reduction Hierarchy listed above. Lake County Stormwater Management Commission is currently drafting a volume control component to the ordinance that would require a specified volume of water to be retained on site through green infrastructure practices.

McHenry County

The McHenry County Stormwater Management Ordinance[35] was adopted on April 2008. Volume control standards in the current ordinance apply only to developments that discharge into Isolated Waters of McHenry County. These standards are require that the design maintain between 80% and 150% of the existing condition storm event runoff volume to the wetland up through the 2 year-24 hour storm event. Developments also must meet either the total off-site release rate requirements of the ordinance, or the

[34] http://www.lakecountyil.gov/Stormwater/Documents/Regulatory/WDO%2011-18-08.pdf

[35] http://www.ci.mchenry.il.us/PDF/City%20Code/McHenry%20Co%20Storm%20Water%20Management%20Ordinance.pdf

minimum single pipe outlet size requirements (four-inch diameter). The following treatment methods shall be evaluated and incorporated wherever feasible to reduce pollution and stormwater volumes to the maximum extent possible: wet detention facilities, sedimentation facilities, infiltration basins, infiltration strips, filer strips, and vegetated swales.

Similar to other counties in the region, the release rate requirements in McHenry County are: 0.04 cubic feet per second per acre for the 2-year, 24-hour storm event and 0.15 cubic feet per second per acre for the 100-year, 24-hour storm event. For water quality management, the ordinance lists the following best management practices, ordered hierarchically:

- Preservation of natural resource features;
- Preservation of existing natural streams;
- Minimization of impervious surface;
- Use of natural landscaping;
- Use of vegetated channels, filter strips, and infiltration;
- Preservation of natural infiltration and storage characteristics;
- Installation of structural measures that provide water quality and quantity control;
- Installation of structural measures that provide water quantity control.

In addition to the McHenry County Stormwater Management Ordinace, developmend are subject to provisions and standards laid out in the recently completed work of the Groundwater Recharge Taskforce. For example, this taskforce recommends the following: "*for Residential Development, 90% of the pre-development infiltration volume should be maintained. For Commercial/ Industrial Development, 60% of the pre-development infiltration volume should be maintained*." Additionally, the county is considering further amendments to the stormwater ordinance that incorporate requirements from the Crystal Lake watershed-based ordinance. See Local Stormwater Management Programs (p. 13) for a review of the Crystal Lake ordinance.

Green Infrastructure Allowance: In addition to the Groundwater Taskforce recommendations, McHenry County has Conservation Design and Subdivision Ordinances that require the use of BMPs for stormwater management and use density bonuses for open space that is placed under conservation easements maintained by professional land managers. Several green infrastructure practices are included in the BMP hierarchy.

Will County

The Will County Stormwater Management Ordinance[36] was adopted in March 2004. The ordinance requires that the runoff generated from a 0.75-inch rainfall over any new impervious area be stored below the primary outlet of the site storage facility. Release rates shall not exceed 0.04 cfs/acre for the 2-year, 24-hour storm event, or 0.15 cfs/acre for the 100-year, 24-hour storm event.

[36] http://willcountylanduse.com/DevReviewDiv/SubEng/SubEngDocs/StormwaterOrd.pdf

The ordinance also calls out a number of practices that are to be used when over 25,000 square feet or more of development or construction occurs. These approved practices are:

- Vegetated Grass Waterways
- Contour Buffer Strips
- Critical Area Planting and Cover Crops
- Terrace Ridges and Diversions
- Contour Strip Cropping
- Contour Farming
- Crop Rotation
- Conservation Tillage and Crop Residue Management
- Other conservation planning standard practices in accordance with Natural Resources Conservation Service (NRCS) Field Office Technical Guide or approved by Will County (NRCS) District Conservationist

The Will County Subdivision Ordinance offers density bonuses for incorporating green infrastructure techniques and BMPs. Within the Ordinance, there is a chapter devoted to conservation design, which requires limits to impervious areas and BMPs to protect water quality and preserve natural hydrology. Furthermore, the county has taken steps to remove the administrative barriers against conservation design developments in zoning processes. Before these changes, developments following conservation design principles were treated as Planned Unit Developments, which is a separate review process.

Green Infrastructure Allowance: The Subdivision Ordinance gives density credits to incentivize the use of green infrastructure and other BMPs.

Will County identified a number of local municipalities for further study, based on their existing green infrastructure interest and experience. With few exceptions, all of the municipalities must have at a minimum the requirements of the applicable county ordinance.

City of Aurora

The City of Aurora adheres to Kane County's Stormwater Management Ordinance. There are a few differences between the City and County Ordinance. One difference is that the City of Aurora has created a specific Rainfall-Frequency data[37] set that must be used in calculating ordinance requirements. The City has also created vision plans for neighborhoods that have land use controls and require green infrastructure. One such plan is the Countryside Vision Plan[38] created in 2001. Requirements include 40 foot open space setbacks between lots and road drainage to swales. One of the goals of this plan was to disconnect impervious surface runoff from detention basins through the use of swales. Four subdivisions have since been developed under this plan and all have implemented backyard swales and native vegetation.

[37] http://www.aurora-il.org/publicworks/engineering/standardspecs/sectionfour.php
[38] http://www.aurora-il.org/documents/planning/Countryside_Vision_Plan.pdf

The City is currently developing a Naturalized Stormwater Management Corridor Plan which aims to reduce nonpoint source pollution and reduce combined sewer overflows through the use of green infrastructure techniques and BMPs. As part of this plan, a number of demonstration sites are being constructed in the downtown area. One such project, located in a residential area, is a series of bio-infiltration facilities featuring ornamental, aesthetically pleasing native plantings in the right-of-way between the street and sidewalk. This project was funded in part under Section 319 of the Federal Clean Water Act.

City of Chicago

The City of Chicago is unique because of its age, density and combined sewer system; and the Chicago Stormwater Ordinance[39] reflects these characteristics. The Ordinance has been in place for over two years (took effect on January 1, 2008) and places an emphasis on impervious area reduction and implementation of green infrastructure techniques. The ordinance requires either the capture of 0.5 inch of runoff from all impervious surfaces or a 15% reduction in impervious surfaces from existing conditions[40]. The City has developed a Microsoft Excel Spreadsheet to help applicants in meeting these requirements. The City also has an integrated process in which the Stormwater Reviewer has a seat on the Concept Review Committee. This allows stormwater requirements to be incorporated in the initial design process and review. The City of Chicago has only issued 1 variance since the ordinance has been in place and considers this is a sign of the success and feasibility of the requirements. The City itself has incorporated green infrastructure into retrofit projects as well as in new construction. One example of this is the City Hall Green Roof, Figure 4.[41]

City of Crystal Lake

The City of Crystal Lake became a certified community under the McHenry County Stormwater Committee on January 1, 2005 with the creation of the Crystal Lake Stormwater Ordinance[42]. The City is concerned about the quantity and quality of stormwater reaching the lake, and this ordinance provides consistent regulation for the entire Crystal Lake Watershed[43]. The current program includes design implementation plan and a design manual. The design manual has specifications for design and pretreatment requirements. An emphasis is placed on pretreatment because soils within the Crystal Lake Watershed have high infiltration rates, which increases the risks of potential water quality impacts. The manual discusses a number of BMPs as well as green infrastructure techniques aimed to accomplish the goals of the program.

[39] http://www.cityofchicago.org/city/en/depts/water/provdrs/engineer/svcs/2009_sewer_constructionandstormwatermanagementrequirements.html

[40] 15% reduction only for developments that do not directly discharge to waters or a municipal separate storm sewer

[41] http://www.explorechicago.org/city/en/about_the_city/green_chicago/Green_Roofs_.html Courtesy of the City of Chicago, Summer 2004.

[42] http://www.crystallake.org/Modules/ShowDocument.aspx?documentid=234

[43] Email dated 3/23/10 from the City of Crystal Lake

Figure 4: Chicago City Hall Green Roof

Village of Homer Glen

The Village of Homer Glen Water Resource Ordinance[44] uses the same release rates as the Will County ordinance requirements, namely 0.04 cfs/acre for a two-year, 24-hour storm event and 0.15 cfs/acre for the 100-year, 24-hour event. In addition to the requirements set forth by the Will County Ordinance, the Homer Glen ordinance stipulates that increases in run-off be minimized through a BMP hierarchy. This hierarchy includes the preservation of natural features, restoration of wetlands, preservation of existing swales, drainage ways, streams, and depressions, minimization of impervious surfaces, and the preservation of natural infiltration characteristics of sites. Furthermore, the ordinance contains infiltration provisions that require the use of BMPs to insure that the post development infiltration volume is 90% of the predevelopment for residential and 60% for non-residential sectors.

Of particular interest is the regional detention clause in the ordinance which encourages adjacent properties to utilize a common regional detention basin through owner participation in cost sharing. Management of water quality is addressed in wet detention basin requirements through provisions for water-tolerant native vegetation for the bottom and shorelines of the facilities.

Local Program Transferability

Currently, parts of the state have legislation that enables the establishment of Stormwater Management Planning Committees and the preparation of countywide plans for management of stormwater run-off and for setting minimum standards for floodplain and stormwater management.[45] The counties covered under

[44] http://www.homerglenil.org/regulations/WaterResourceManagement.aspx

[45] Illinois General Assembly: (55 ILCS 5/5‑1062.2)

this legislation have largely taken the necessary actions to adopt and enforce stormwater management ordinances. Several municipalities built on this initiative by implementing regulations that exceeded county-wide stormwater management rules. Meanwhile, some areas in the state that do not have the enabling legislation have enacted erosion control ordinances to manage stormwater run-off. Ordinances adopted in 2004 in Peoria County require on-site stormwater retention so that post-development run-off rates must not exceed pre-development rates. The Peoria County Soil and Water Conservation District is under contract with the county to review development plans. If property owners/developers wish to employ green infrastructure practices, they have to prove that such practices meet the release rate requirements. Other communities, such as the City of Decatur, have chosen to adopt the Illinois Urban Manual for Best Management Practices strategy.

The City of Bloomington started charging stormwater utility fees based on area of impervious surface in 2004. Billing is based on Impervious Area Units (IAU) which is defined as 1 IAU = 1,000 square feet of impervious area. Additionally, property owners may receive stormwater rate reduction credits by proving that on-site stormwater facilities reduce peak run-off rates according to specified ordinance criteria. By contrast, the City of Moline charges a flat rate for stormwater utility for properties up to 2 acres. For larger size properties, service is charged based on Equivalent Hydraulic Acreage, which is a formula calculated to assess impervious coverage of a site. The Village of Rantoul adopted a similar approach in 2001 upon the implementation of the Storm Drainage Tax. Residential properties have a flat rate while non-residential properties are charged according to lot size and land use. The funds collected in the above examples are mostly used to maintain and improve existing stormwater infrastructure systems.

From the analysis above, it is clear that many communities in the state are re-thinking stormwater management to add flexibility that can potentially allow the incorporation of green infrastructure practices. However, all communities in the state still face the same barrier, mainly funding for the implementation of green infrastructure. The problem is more severe for areas that do not have staff or resources for stormwater management due to lack of enabling legislation that permits the establishment of commissions and the necessary staffing. In spite of this setback, some regional planning councils, e.g. the Tri-county Regional Planning Commission of Peoria, Tazewell and Woodford counties, have undertaken significant initiatives to address stormwater management by providing unified model stormwater ordinances, watershed planning activities and incorporation of stormwater management in comprehensive planning such as Long Range Transportation Plans. Some communities have benefited from these initiatives and many adopted proposed ordinances and/or recommendations from watershed plans that aim to protect the more sensitive areas that have the greatest impact on surface waters. It is important that value is added to regional planning agencies and Soil and Water Conservation Districts to continue assisting communities that do not have the staff resources to promote green infrastructure in stormwater management.

To better understand the issues involving the transfer of green infrastructure practices from northeastern Illinois to downstate communities, we met with local stormwater managers in the Chicago metro region as to what they considered the most significant impediments to the wider use and adoption of these practices. During our discussions with the staff of the region’s stormwater management agencies and the Illinois Department of Transportation, we gathered data on the state of green infrastructure in the region and explored their perceptions about the potential barriers to further or future implementation of green infrastructure practices. Through these conversations, the following issues were identified.

Feasibility under Diverse Conditions

The overall feasibility of requiring green infrastructure in the state of Illinois was a reoccurring issue. The general consensus was that green infrastructure has definite benefits, including water quality improvements and water quantity reductions. However requiring green infrastructure and crediting it against traditional detention could pose complications especially when considering the long term integrity of the green infrastructure. Some of these concerns will be further addressed under Maintenance Issues.

Also, the northeastern region has a very diverse soil composition. Successful infiltration practices rely on underlying soils with good infiltration rates. Figure 5 shows the diversity of the soil throughout the region.[46] The dark green regions are areas with soils that have poor infiltration characteristics. The National Association of Floodplain and Stormwater Management Agencies (NAFSMA) provided testimony to the U.S. House of Representatives Committee on Transportation and Infrastructure, Subcommittee on Water Resources and the Environment regarding Green Infrastructure[47]. One of the barriers they cited was poor soils, stating the following:

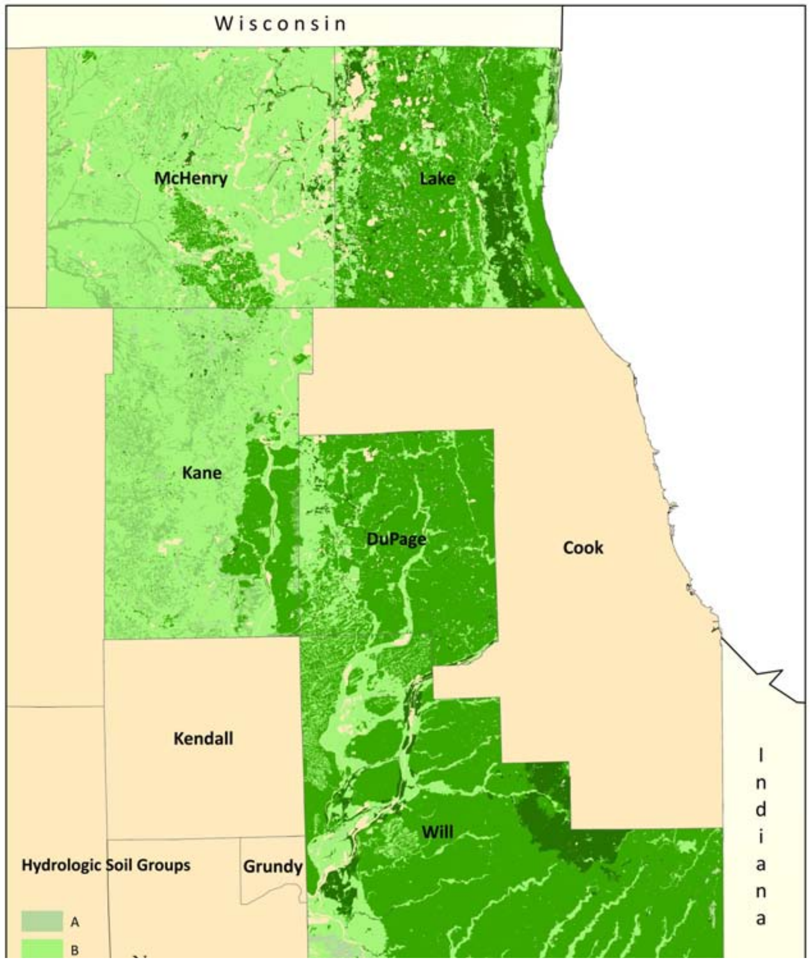
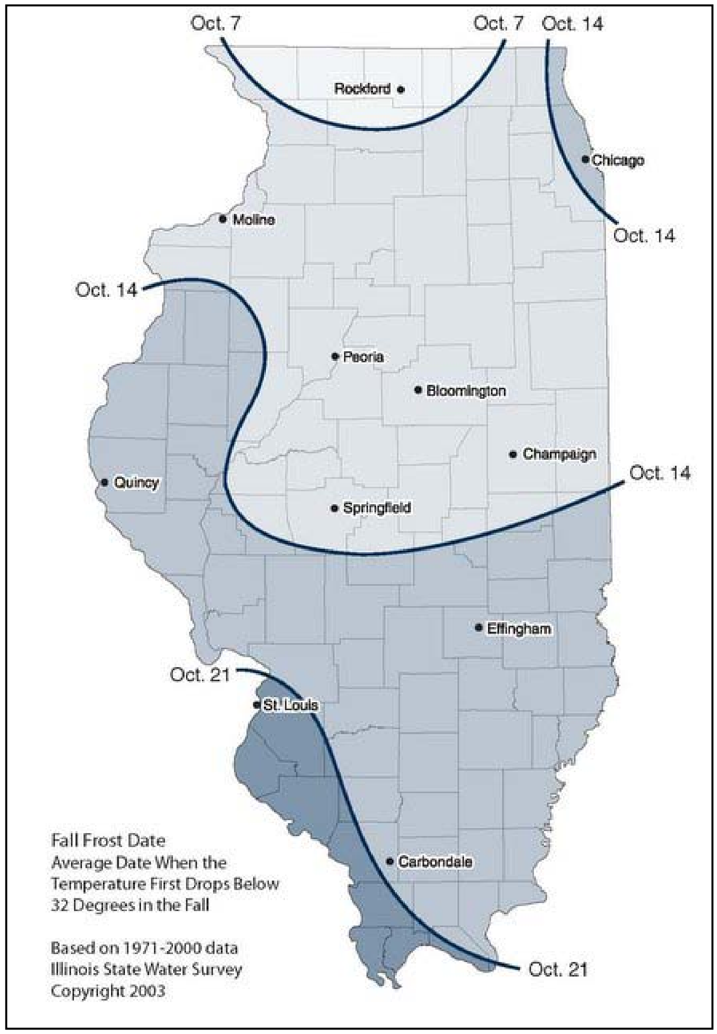


Figure 5: Hydrologic Soil Characteristics in Northeastern Illinois

> *"Naturally occurring clay and plastic soils limit infiltration measures, making them very difficult, ineffective and expensive to construct and maintain. These areas rely on modifications to Green Infrastructure techniques including, but not limited to providing pipe systems to drain the system artificially, thus providing treatment with minor reductions in runoff and little groundwater recharge. If Green Infrastructure is to be used in such areas, it will be necessary to supplement those techniques with conventional stormwater management techniques to achieve pollutant removal efficiencies necessary to meet regulatory requirements and accomplish clean water goals."*

[46] SSURGO data is currently not available for Cook and Kendall Counties
[47] http://www.nafsma.org/pdf/2009-annual-meeting/NAFSMAGI-LID%203-19-09%20final.pdf

Figure 6: Illinois Fall Frost Date Map[48]



The performance of infiltration based practices drastically decreases as the ground freezes. Figure 6 displays the date of the first fall frost in Illinois. The concern is that during the fall, winter and spring months, the evapotranspiration and infiltration potentials will be drastically reduced and precipitation will mostly be converted to surface run-off.

The overall perception of lack of performance data of green infrastructure practices as they pertain to Illinois conditions is a barrier to implementation. However, this is only a perceived barrier. As our research shows, more than 57 peer-reviewed research articles have been published with data on the effectiveness of green infrastructure at removing TSS, TN, reducing peak flow, and reducing runoff volume. This does not include research on green infrastructure's impact on other pollutants or data which has been submitted to the BMP Database. Furthermore, many successful green infrastructure projects have been implemented throughout the state despite these perceived barriers. The issues identified can be addressed during the proper site design phase and continued maintenance can help to ensure the long time integrity of these structures. There are many examples of successful green infrastructure projects throughout the region which have overcome these design issues.

Maintenance Issues

Maintenance was a major concern when talking to regional stormwater agencies. Green, as well as grey, infrastructure requires specialized long term maintenance. Some green infrastructure techniques, e.g. permeable pavement and porous asphalt, rely on void space to treat and retain stormwater runoff. These void spaces can become clogged with debris and sediment over time requiring routine maintenance. Furthermore, the small scale and cumulative nature of green infrastructure techniques may apparently make implementation inefficient particularly in an urban environment and/or higher density areas. NAFSMA cites this as a concern also stating the following:

[48] Illinois State Water Survey http://www.isws.illinois.edu/atmos/statecli/Frost/first_fall_frost.htm

"Since the techniques employed in Green Infrastructure seek to mimic pre-development conditions, it is necessary to capture stormwater runoff at or near its source... This requirement creates the need to construct many small structural features, such as rain gardens to accomplish this… As a result, administration and maintenance is simplified, aesthetic and functional issues are more easily addressed, the inspection and logistics of repair are reduced, and effectiveness of performance is more easily maintained[49]."

In addition, responsibility for and funding of maintenance of structures are not broadly addressed in current regulations which is a cause for trepidation for stormwater managers. These are all issues that can be addressed when developing a green infrastructure program. Answering the following questions listed in Table 8 will help to structure a successful program.

Table 8. Detailed Questions on Maintenance of Green Infrastructure

- **Who will be responsible for this maintenance once green infrastructure is implemented?**
- **If it is residential development, is the homeowner knowledgeable in green infrastructure maintenance?**
- **Should there be requirements to hire professional landscaping companies to maintain private property?**
- **Once the property changes hands, who will be responsible for maintenance?**
- **Is it the stormwater management agencies responsibility to ensure that green infrastructure is still properly being maintained?**
- **If so, how are they to fund and staff these inspections?**

The regulating agencies can also aid landowners, homeowners associations and individual homeowners in performing appropriate maintenance by providing educational brochures and workshops. Lake County Stormwater Management Commission for example hosts free workshops for associations and property owners who are responsible for maintaining detention ponds, wetlands and natural areas[50]. Such programs can ease the burden on property owners as well as raise awareness on maintenance requirements.

Funding

Although there is a recognition that green infrastructure may be more cost-effective in the long term, specifically if the value of water quality improvements and reduced flooding incidents are added in the calculations, the short term payback periods for investments in some green infrastructure practices may be several orders of magnitude greater than conventional means. This is particularly true for large-scale

[49] http://www.nafsma.org/pdf/2009-annual-meeting/NAFSMAGI-LID%203-19-09%20final.pdf

[50] http://www.lakecountyil.gov/Stormwater/Documents/Public%20Information%20and%20Mapping/Educational%20Workshops/2010/2010FlyerAgendaMap.pdf

execution of permeable pavements.[51] While permeable pavements may not have to be frequently replaced, there are still costs associated with maintenance, as is the case with other green infrastructure measures. In most cases, such maintenance requires professional personnel and/or equipment to insure long term integrity of structures, all of which come with a price tag that necessitates the availability of a secure funding source. A study conducted by The Civic Foundation[52] cited cost as one of the barriers to green infrastructure implementation for many of the same reasons listed above. Although some communities use Special Service Areas to fund stormwater management, e.g. several municipalities in Kane County, others do not and the necessary political will to enact such procedures might be absent. Additionally, there is a general feeling among northeastern Illinois stormwater managers that current budgets do not include funding for maintenance or enforcement of green infrastructure practices

Culture

Although in many cases green infrastructure is being viewed as an attraction and an amenity, some communities still face resistance in implementing green infrastructure. There is a belief among many that native plantings appear weedy and are not aesthetically pleasing. We heard this concern from one community encouraging homeowners to install rain gardens to remedy nuisance backyard flooding. Residents are reluctant to plant native plantings because they are not aware of the multitudes of options.

Demonstration sites with many species of native plants with varied colors and heights could help convince residents that native plants can be aesthetically pleasing. The Conservation Foundation is very active in providing information to individual property owners and municipalities throughout northeastern Illinois about native plantings and green infrastructure through their Conservation@Home[53] Program. Figure 7 was provided by The Conservation Foundation as an example of aesthetically pleasing native plantings.

Figure 7: Natural Landscaping

There is a belief that stormwater management is not necessary in more rural areas. Since agricultural areas are often exempt from stormwater management requirements, adjacent properties may feel they should be also. Implementation of green infrastructure regulations may potentially be viewed as infringement on property rights. These are issues that may be overcome with increased awareness of the benefits of green infrastructure.

Groundwater quality

[51] An analysis of the Elfstrom Stadium in Kane County (The Cougar Stadium) which was fitted in 2004 with permeable pavers, shows that initial costs were 75% higher when compared to the initial construction costs of asphalt pavement. However, over 48 years, the total costs of the permeable pavement, which included initial costs and maintenance/replacement costs, was that same as the total for asphalt pavement. Source: Kane County Department of Environmental and Building Management.

[52] http://www.cnt.org/repository/GreenInfrastructureReportCivicFederation%2010-07.pdf

[53] http://www.theconservationfoundation.org/index.php?option=com_content&view=article&id=323&Itemid=200038

One of the acknowledged benefits of green infrastructure is that it can potentially increase groundwater recharge. Although initially this is a benefit, many communities are concerned about possible groundwater contamination. Many infiltration based practices are designed to capture the "first flush" of runoff which typically contains an increased amount of pollutants.

Unless proper treatment is also incorporated in the design of these practices shallow groundwater contamination is possible. NAFSMA also cited this concern in their testimony stating: *"Infiltration of surface waters to groundwater has been shown to, in some instances, increase certain pollutant concentrations in groundwater. These potential risks must be considered when evaluating Green Infrastructure as a stormwater system component*[54]*."* As previously stated, pretreatment prior to infiltration can help ensure groundwater quality protection.

STATE PROGRAMS

Section 15(e) of the Green Infrastructure for Clean Water Act requires that this study review and report on "existing and potential new urban storm water management regulatory programs and methods and feasibility of integrating a State program with existing and potential regional and local programs in Illinois."[55] We selected five state programs that have in place statewide stormwater management performance standards that go beyond the Clean Water Act NPDES permit requirements adopted by Illinois, and encourage or require the use of green infrastructure as a means of meeting those standards.

We reviewed the stormwater management programs of Maine, Maryland, Minnesota, New Jersey, and Wisconsin, including the statutes, regulations, and guidance manuals. We also contacted staff within the office of the agency administering each program to obtain personal descriptions of the programs and candid views of their strengths and weaknesses. Each of these five states administers a Clean Water Act National Pollution Discharge Elimination System (NPDES) Permit Program which includes stormwater permitting. However, our focus here is on statewide stormwater regulations separate from the NPDES programs, with specific performance standards and provisions that require or encourage the use of green infrastructure to meet those standards.

In describing each state program, we briefly report on the format and content of the state statutory law, in part to illustrate the different levels of detail other state legislatures have used when authorizing their state environmental agencies to establish stormwater performance standards. This should be useful to the Illinois General Assembly and the IEPA as they contemplate the development of a stormwater regulatory program here in Illinois. We focus more attention on the regulations and performance standards themselves, as well as technical guidance manuals relied on in each program. Finally, we provide state contact information, notes from our interviews with state program staff and website and other reference information for the reader wishing to pursue further research.

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[54] http://www.nafsma.org/pdf/2009-annual-meeting/NAFSMAGI-LID%203-19-09%20final.pdf

[55] For this review, we have utilized a website maintained by StormwaterAuthority.org, including a page linking to summaries of all the state stormwater management programs in the country: http://www.stormwaterauthority.org/regulatory_data/state.aspx. We have quoted liberally from these summaries and refer the reader to them for further research.

Maine. The Maine Department of Environmental Protection (MEDEP) is responsible for administering the state's stormwater management program, which includes the NPDES permit program and separate stormwater regulations. The Department maintains a helpful website that provides links to the statutes, regulations and guidance documents at: http://www.state.me.us/dep/blwq/docstand/stormwater/index.htm.

The contact for the Maine program is:

Don Witherill
Director, Division of Watershed Management, Bureau of Land & Water Quality
Maine Department of Environmental Protection
17 State House Station
Augusta, Maine 04333
(207) 287-7725

1. Statutory provisions

Maine's stormwater program is based on three statutes:

a. "Site Law", Title 38 of the Maine Revised Statutes, Sections 481 to 490
b. "Stormwater Management Law", 38 M.R.S. §420-D
c. "Waste Discharge Law", 38 M.R.S. §413

The Site Law, 38 M.R.S. §484, contains language governing the siting of new development and requires compliance with the Stormwater Management Law, 38 M.R.S. §420-D. The Stormwater Management Law lays out the framework for the stormwater management regulations, as well as the authority for the DEP to adopt them. The Waste Discharge Law provides the basis for the state license by rule standards for stormwater infiltration contained in Appendix D of the regulations.

2. Regulatory provisions – Code of Maine Regulations 06-096 Chapter 500

Maine's stormwater regulations, contained in this one Chapter of the Code, are easily located on the above website. The regulations originally took effect in July 1997, were significantly revised on November 16, 2005, and have been amended since then. They focus on four primary stormwater treatment objectives: pollutant removal, temperature reduction, channel protection, and flood control. To achieve these goals, the regulations establish six categories of stormwater performance standards. They can be summarized as follows:

1. **Basic standards** – all projects disturbing one or more acres must meet the basic standards. They include grading, erosion and sedimentation control, inspection and maintenance, and housekeeping. Threshold: one acre of disturbance.

2. **General standards** – in addition to the basic standards, a general retention standard applies to developments over a certain size in the watershed of an impaired stream. Projects must include treatment systems that reduce erosive channel flows, remove pollutants and reduce water temperature. The primary mechanism for achieving these objectives is either detention or retention of the runoff volume equivalent to 1.0 inch over the impermeable surface and 0.4 inch over the landscaped area. The general standards also contain a slightly less stringent retention standard for linear projects, such as roads.

Threshold: one acre of disturbance AND 20,000 square feet of impervious surface or 5 acres of developed area in the direct watershed of an urban impaired stream or one acre of impervious surface in any non-urban stream, coastal or wetland watershed.

Of particular note is the following language inserted in the body of the section:

> Note: The department strongly encourages applicants to incorporate low-impact development (LID) measures where practicable. LID addresses avoidance of stormwater impacts by minimizing developed and impervious areas on the project site. LID project design considers the location of any protected natural resources, and maintaining natural drainage patterns and pre-construction time of concentration. If practicable, LID incorporates runoff storage measures dispersed uniformly throughout a site rather than single point collection of stormwater through conventional end-of-pipe structures.

3. **Phosphorus standard** – in lake waters, this standard applies instead of the general standards. DEP establishes a phosphorus allocation on a project-by-project basis, based on current water quality, water chemistry of the watershed, land use, volume and flushing rate, and projected population growth.

4. **Urban impaired stream standard** – applies in addition to the other standards to larger projects located in the watershed of an urban impaired stream or a listed stream. This standard requires either the payment of a fee to compensate for the adverse impacts of the project or the mitigation of those impacts through treatment or the reduction or elimination of impervious surface.

5. **Flooding standard** – applies in addition to other standards where a project involves three acres or more of impervious surface or 20 acres or more of developed area. Stormwater management systems for these projects must detain or retain the additional volume from the project for the 2-year, 10-year and 25-year storm such that the peak flow is not increased by the project.

6. **Additional standards** – apply to projects that involve concentrated discharges, discharges to freshwater or coastal wetlands, threatened or endangered species habitat and other special cases as determined by the DEP.

7. **At-risk and threatened watersheds.** The DEP has identified "watersheds most at risk from new development", as well as those that are "sensitive and threatened," and the more stringent performance standards apply to those waters.

3. Manuals

Maine Stormwater Best Practices Manual:
http:/www.state.me.us/dep/blwq/docstand/stormwater/stormwaterbmps/index.htm#manual

The Maine DEP also maintains a number of guidance documents for stormwater management, some of which are linked to the following website:
http://www.maine.gov/dep/blwq/docwatershed/materials.htm#cpfh

LID Guidance Manual for Maine Communities - Approaches for Implementation of Low Impact Development at the local level. September 21, 2007. The purpose of this guidance manual is to help municipalities implement Low Impact Development (LID) practices on small, locally permitted development projects. This manual provides a recommended set of low impact development (LID) standards and guidance on implementing LID practices to comply with those standards.

Maine DEP has undertaken an effort to map the imperviousness of its urban areas: http://www.state.me.us/dep/blwq/docstand/stormwater/stormwaterbmps/index.htm#manual

4. Notes from Interview with State Contact: Don Witherill

- Don has been involved in stormwater management for many years, and has been a manager for the last 14 years. He has been the lead staff person since the regulations went into effect in 1997, including two revisions to the regulations.
- The original regulations did not involve the NPDES program, because there were no national requirements until after the Maine regulations took effect. There is some integration of the two programs now.
- An area of Portland with heavy retail businesses and dense residential neighborhoods is associated with an impaired stream. The Conservation Law Foundation petitioned the U.S. EPA to designate the landowners in the area as stormwater permittees. As a result, 110 landowners received notice that they are subject to a general permit that was developed for the watershed under the NPDES stormwater program. More information is provided at www.restorelongcreek.org.
- Did not investigate other states at time regulations were adopted.
- Chapter 500 of the regulations is being redrafted and strengthened. The LID "Note" is expected to be dropped in favor of a requirement to use LID.
- When the regulations were adopted, there was a close vote in the state legislature approving them. In order to make the case, DEP provided information on the degradation of lakes due to stormwater. Maine residents care a lot about their water resources, which probably contributed to the positive outcome.
- Moved away from TSS removal as a performance standard; it did not solve the problem because many BMPs do not remove the nutrients as well as they reduce volume.
- Fees are charged for development applications, but they are not enough to run the program; general fund resources are also required.
- The Maine Department of Transportation and Highway Authority are exempt from the regulations, but are required to have memoranda of agreements with DEP committing to comparable standards in their policies and procedures; BMP Manual standards apply to their projects.
- LID is a very good idea; we need to treat stormwater in a decentralized way, mimicking natural conditions, requiring natural hydrology, getting people's attention on maintenance; landowners are required to certify every five years that their stormwater BMPs are performing well.
- With the $4 million received for the state revolving fund green project reserve in Maine, many LID projects are being done; The Maine Department of Transportation has put in some porous pavement in the Long Creek project; local community organizations have installed bio-retention cells. Contact: Steve McLaughlin: 207-287-7768.
- There are no utilities yet, although some municipalities are considering fees and utilities.

5. Websites

A description of the stormwater program, including the integration of these statutes is set forth in a well organized manner on the DEP's Stormwater Program website at: http://www.state.me.us/dep/blwq/docstand/stormwater/index.htm.

Maryland. The Maryland Department of the Environment (MDE) is responsible for administering the state's stormwater management program. Maryland is one of the most progressive states in the nation with respect to stormwater management, although there has been a recent attempt by members of the business community to repeal some of the newer, more aggressive provisions of the regulations. The program has a history dating back to the passage of the Stormwater Management Act by the Maryland General Assembly in 1982. Under the 1982 Act, all new development was required to use infiltration as the first option for mimicking the two-year and ten-year storm pre-development hydrographs. In 2000, the state adopted regulations and the Maryland Stormwater Manual, which included these requirements. Through this Manual, environmental site design (ESD), another term used to describe green infrastructure practices, is encouraged. In accordance with the Stormwater Management Act of 2007, MDE issued regulations requiring that ESD be implemented to the maximum extent practicable.

The contact for the Maryland program is:

Brian Clevenger
Environmental Program Manager
Program Review Division
Maryland Department of the Environment
1800 Washington Boulevard, Baltimore, MD 21230
410-537-3554
bclevenger@mde.state.md.us.

1. Statutory Provisions

Maryland storm water management regulations are based on the provisions of the state statutes with the following headings[56]:

- Environ. Article, Title 4, §§101 to 116 Sediment Control
- Environ. Article, Title 4, §§201 to 215 Stormwater Management

- **Sediment Control.** In a manner characteristic of statewide programs, the legislative findings are extensive and emphasize the value of the land and waters of the State. The findings describe the degradation of the waters of the state and place the blame squarely on the uncontrolled discharge of eroded materials to land and water. In addition, the findings cite the need for procedures to obtain immediate compliance with the law when violations occur. While findings are not

[56] For complete versions of the Maryland code and regulations, see: http://www.michie.com/maryland/lpext.dll?f=templates&fn=main-h.htm&2.0

enforceable performance standards, they set forth a state's policies and can be worded to give the responsible agency legal support for the development of regulations that contain such standards.

This section of the code also requires developers to have comprehensive grading and sediment control plans. At the same time, the statute requires counties and municipalities to establish ordinances covering grading and construction practices that affect water quality. Somewhat less common is the statutory requirement that managers of construction projects involving on-site clearing and grading must be trained in erosion and sediment control prior to the start of the project.

We also note that MDE is required to review and approve the erosion and sediment control plans for construction to be carried out by a state or federal agency, a recognition of the cumulative impact of government projects on water quality and quantity.

- **Stormwater Management.** The legislative findings in the stormwater management section of the code are broader, though no less powerful in their effect, than those in the sediment control section. They state the intended goal **"**to reduce as nearly as possible the adverse effects of stormwater runoff and to safeguard life, limb, property, and public welfare." This expansive language gives MDE latitude to develop a program with few legal constraints.

  The requirement for each county and municipality to adopt ordinances necessary to implement a stormwater management program within 2 years is also expansive and potentially much more burdensome than the requirement to develop grading and erosion control programs. Because erosion control plans are arguably critical components of comprehensive stormwater management programs, some of these requirements could be considered redundant.

The code directs MDE to adopt rules and regulations to achieve the primary goal of maintaining, after development, the predevelopment runoff characteristics of a site. These regulations are to include the following elements:

- Make allowance for the difference in hydrologic characteristics and stormwater management needs of different parts of the State
- Specify that watershed-wide analyses may be necessary to prevent undesirable downstream effects of increased stormwater runoff
- Specify the exemptions a county or municipality may grant from the requirements of submitting a stormwater management plan
- Specify the minimum content of the local ordinances or the rules and regulations of the affected county governing body to be adopted which may be done by inclusion of a model ordinance or model rules and regulations; and
- Establish regulations and a model ordinance that require
  - The implementation of "environmental site design" to the maximum extent practicable (similar to "green infrastructure")
  - The review and modification, if necessary, of planning and zoning or public works ordinances to remove impediments to environmental site design implementation; and
  - A developer to demonstrate that
    - Environmental site design has been implemented to the maximum extent practicable; and

- Standard best management practices have been used only where absolutely necessary

This level of detail in the statute seems to be appropriate, as it provides good guidance without establishing specific performance standards.

2. Regulatory Provisions

The section of the Maryland regulations implementing the sediment control section of the statute is Title 26, Subtitle 17; Chapter 01: Sediment Control. It does not contain any specific performance standards. In contrast, the regulations implementing the stormwater management section are found in Title 26, Subtitle 17; Chapter 02: Stormwater Management, and contains the following specific requirements and standards:

The primary water quality treatment goal in Maryland is removal of 80% of the annual Total Suspended Solids load and 40% of the Total Phosphorus. Other performance standards include groundwater recharge, volume control through retention, and detention volume and release rates. Only Best Management Practices (BMPs) approved by the MDE and designed in accordance with Maryland's Stormwater Design Manual may be used to meet these treatment objectives. Exceptions may be made in retrofit situations or where the MDE approves a particular device for a unique project.

1. Ordinances – each county and municipality must adopt ordinances that require

- Comprehensive stormwater management plans
- Exemptions and waivers
- Criteria and procedures
- Proper implementation of plans
- Maintenance requirements
- Penalties

2. Applicability – unless a particular activity is exempt, a person may not develop any land without an approved final stormwater management plan

- There is a threshold of 5,000 square feet of more of development
- The plan must conform to the Maryland Stormwater Design Manual
- Redevelopment is required to
  - Reduce existing (disturbed) impervious area by at least 50%
  - Implement ESD to the maximum extent practicable (MEP) to provide water quality treatment for at least 50% of the existing (disturbed) impervious area or
  - Combination of these two approaches

3. Minimum Control Requirements – each county and municipal ordinance must contain the following minimum control requirements as well as those contained in the Maryland Design Manual.

- Must use methods specified in Design Manual to implement ESD to the MEP
- Design must use
  - Sizing criteria and specifications contained in Design Manual

    - Recharge volume – maintain 100% of average annual predevelopment groundwater recharge
    - Water quality volume – minimize nonpoint source pollution
        - Treatment of the WQ_v is required; designed to be 90% of the average annual rainfall; determined to be 0.9: or 1.0 inches, depending on the part of the state
        - Minimum of 0.2 inches per acre must be retained at sites with less than 15% impervious cover
    - Channel protection storage volume – 24 hour extended detention of the one-year, 24-hour storm event
    - Overbank Flood Protection Volume – for 10-year, 24 hour event, maintain predevelopment peak discharge rate; required if local agency has no control over development or conveyance system downstream
    - Extreme flood volume – detention of 100-year 24 hour event to maintain predevelopment peak discharge rates; required if downstream development is located in the 100-year floodplain
    - Structural practices may not be used unless absolutely necessary
- If local agency determines additional control is necessary because of historic flooding and lack of control over downstream development and conveyance system design, control of 2-year or 10-year storm event, or both is required
- Flexibility for approving agency to require more if hydrologic or topographic conditions warrant
- Development may not increase downstream peak discharge for the 100-year event

4. <u>Planning Techniques</u> – ordinances must also require that the following techniques be used to the maximum extent practicable:

- Preserving and protecting natural resources
- Conserving natural drainage patterns
- Minimizing impervious area
- Reducing runoff volume
- Maintaining 100% of the average annual predevelopment groundwater recharge volume
- Using green infrastructure (green roofs, porous pavement, etc.)
- Limiting soil disturbance, mass grading and compaction
- Clustering development

3. Manuals

Maryland Stormwater Management Guidelines: provide information necessary for submittal of stormwater management plans by State and federal agencies

2009 Model Standard Stormwater Management Plan

2009 Model Stormwater Management Ordinance

4. Notes from Interview with State Contact: Brian Clevenger

- Mr. Clevenger has 20 years experience working with the regulations
- Program requires adequate staffing; site by site review; permit fees for dedicated funding source; 8 people on staff, 40-50 field inspectors for all water programs
- Threats of driving development away with new regulations are common and should not deter the administration's objective of protecting the resource

- Need to treat redevelopment differently, consider site conditions
- Volume control or retention requirement is necessary; contained in Design Manual
- Detention is not a recommended practice
- Maintenance may be the biggest problem; local governments need staff support
- It would be wise to address urban stormwater first; regulate impervious surface

5. Websites

For guidance, DOE maintains a website on the stormwater management program at: http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/index.asp, and a good explanation of the program is on line at http://www.mde.state.md.us/assets/document/sedimentStormwater/MSWM_MFR.pdf.

In addition, because of the political effort to roll back the regulations, DOE has issued emergency regulations which provide some grandfathering and exemptions of some activities from the rules. The Department provides up-to-date information on these changes on the following website: http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/swm2007.asp.

Maryland Stormwater Management Guidelines for State and Federal Projects: http://www.mde.state.md.us/assets/document/sedimentstormwater/SWM_guidelines.pdf

Maryland's Stormwater Management Program (two-page summary sheet): http://www.mde.state.md.us/assets/document/sedimentStormwater/SWM_Program_fs.pdf

Maryland Water Quality Standards Website: http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/wqstandards/index.asp

1994 Maryland Specifications for Soil Erosion and Sediment Control: http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/erosionsedimentcontrol/standards.asp

Maryland Stormwater Design Manual, Volumes I and II (Effective October 2000): http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Minnesota. The Minnesota Pollution Control Agency (MPCA) is responsible for administering the state's stormwater management program. Currently, Minnesota does not have stormwater performance standards at the state level. The Minnesota Statutes require the MPCA to develop such performance standards, design standards, or other tools to enable and promote the implementation of "low-impact development" and other stormwater management techniques. "Low impact development" is a term considered synonymous with "green infrastructure." The purpose of this requirement is to ensure that "stormwater is managed on-site and the rate and volume of predevelopment storm water reaching receiving waters is unchanged." Instead of adopting performance standards, MPCA has left this to local governments and watershed districts such as the Capitol Region Watershed District (CRWD). Through its permitting program, the CRWD imposes several performance standards, including erosion & sediment control, volume control, removal of suspended solids and runoff release rates. After taking a brief look at the state statutory provisions, we summarize the CRWD stormwater management regulations.

The contact for the Capital Region Watershed District program is:

Mark Doneux, Administrator, CRWD
1410 Energy Park Dr.
Suite 4
St. Paul, MN 55108
651-644-8888
mark@capitolregionwd.org

1. Statutory Provisions

The provisions of the Minnesota Statutes dealing with stormwater are found in several chapters from Chapter 103A to 114I, as follows.

One section within the Water Pollution Control section of the Minnesota Statutes, Section 115.03(5c)(b), authorizes the Minnesota Pollution Control Agency (MPCA) to adopt and enforce rules regulating point source storm water discharges. Section 115.03(5c)(c) goes on to require the Agency to

> …develop performance standards, design standards, or other tools to enable and promote the implementation of low-impact development and other storm water management techniques. For the purposes of this section, "low-impact development" means an approach to storm water management that mimics a site's natural hydrology as the landscape is developed. Using the low-impact development approach, storm water is managed on-site and the rate and volume of predevelopment storm water reaching receiving waters is unchanged. The calculation of predevelopment hydrology is based on native soil and vegetation.

This section is implemented through Chapter 7090 of the Minnesota Rule, Minnesota Pollution Control Agency, Storm Water Regulatory Program, which requires an NPDES/State Disposal System storm water permit program. However, the MPCA has not developed any state-wide runoff requirements for impaired waters. Instead, runoff control is left to local units of government and to watershed management districts.

The MPCA has developed the Minnesota Stormwater Manual to provide guidance to local governments and watershed management agencies implementing local storm water management programs. It includes recommended on-site BMPs (many of which include green infrastructure practices) and is downloadable from: http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html. There is also an Assessment of Stormwater BMPs Manual prepared by the University of Minnesota that can be downloaded at: http://stormwater.safl.umn.edu/.

Separately, Chapter 103B.101(2) subdivision 9 of the Minnesota Statutes authorizes the state's Board of Water and Soil Resources to:

(1) coordinate the water and soil resources planning activities of counties, soil and water conservation districts, watershed districts, watershed management organizations, and any other local units of government through its various authorities for approval of local plans, administration of state grants, and by other means as may be appropriate….

Chapter 103B.102 gives the state Board of Water and Soil Resources oversight authority over "local water management entities" (including watershed districts, soil and water conservation districts, metropolitan water management organizations, and counties operating separately or jointly in role as local water management authorities under chapter 103B, 103C, or 103G and chapter 114D). The evaluation is to be undertaken every five years and to be posted on the Board's website (103B.103, subdivision 3).

The Board is also charged with the preparation of the state's water resources plan (103B.155), and with the preparation of guidelines, criteria and standards for local water resources plans. It is authorized to review draft plans prepared by local watershed districts (103B.231, subdivision 7) and to approve final plans (subdivision 9) and plan amendments (subdivision 11). The same plan review and approval authority is given the Board of Water and Soil Resources for metropolitan groundwater management plans (103B.255) and for county water management plans (103B.301-335).

2. Regulatory Provisions

Rules adopted by the Capital Region Watershed District were effective October 1, 2006; see: http://www.capitolregionwd.org/documents/AdoptedRule01_07_09.pdf, Highlights of performance standards contained in the Stormwater Management section of the rules are as follows:

<u>Rule C: STORMWATER MANAGEMENT</u>

2. Regulation.

- Permit required for land disturbing activity one acre or greater
- Approved stormwater management plan required

3. Criteria.

- Stormwater management plans must comply with the following:
  - <u>Runoff Rate</u> – runoff rates for the proposed activity shall not exceed existing runoff rates for the 2-year, 10-year, and 100-year critical storm events, and runoff rates may be restricted to less than the existing rates when the capacity of downstream conveyance systems is limited.
  - <u>Runoff volume</u> – stormwater runoff volume retention shall be achieved onsite in the amount equivalent to the runoff generated from one inch rainfall over the impervious surfaces of the development.
  - Infiltration for volume reduction must meet the following requirements:
    - Infiltration volumes and facility sizes shall be calculated using the appropriate hydrological soil group classification and design infiltration rate from Table 1. Select the design infiltration rate from Table 1 based on the least permeable soil horizon within the first five feet below the bottom elevation of the proposed infiltration BMP.
    - The infiltration area shall be capable of infiltrating the required volume within 48 hours for surface and subsurface BMPs.

        - Stormwater runoff must be pretreated to remove solids before discharging to infiltration areas to maintain the long term viability of the infiltration areas.
        - Specific site conditions may make infiltration difficult, undesirable, or impossible. Some of these conditions may qualify the applicant for Alternative Compliance Sequencing.
    - Water Quality – developments shall incorporate effective non-point source pollution reduction BMPs to achieve 90% total suspended solids removal from the runoff generated by a NURP water quality storm (2.5" rainfall). Runoff volume reduction BMPs may be considered and included in the calculations showing compliance with achieving the 90% TSS removal requirement.
    - Maintenance – all stormwater water management structures and facilities, including volume reduction BMPs, shall be maintained to assure that the structures and facilities function as originally designed. The maintenance responsibilities must be assumed by either the municipality's acceptance of the required easements dedicated to stormwater management purposes or by the applicant executing and recording a maintenance agreement acceptable to the District.

3. Manuals

Minnesota Stormwater Manual

4. Notes from Interview with CRWD Contact, Mark Doneux

- CRWD is a special purpose unit of government whose board is appointed by county officials (in order to help insulate it from political pressures).
- The District has tax levy and regulatory authority (as well as eminent domain authority) with respect to stormwater management pemitting, flood hazard mitigation, and wetlands protection within its boundaries.
- CRWD's region is heavily urbanized and is currently 42% impervious.
- The District works with municipalities within its borders, in some cases taking the lead in reviewing and issuing stormwater permits and, in other cases, just monitoring local permits.
- Local governments can adopt their own stormwater regulations; to assist them, the Metropolitan Council has developed a draft stormwater ordinance, which can be found at: http://www.metrocouncil.org/environment/water/planning/model_sw_ord.pdf and its own Urban Small Sites BMP Manual, found at http://www.metrocouncil.org/environment/water/bmp/manual.htm.
- Of the three standards, runoff rate, volume control and water quality, the District stresses volume reduction. The one-inch retention standard was adopted because 90% of the storms in the region are less than one-inch.
- Doneux noted that stormwater retention ponds don't work well in heavily urbanized areas, so infiltration must be required. He also noted that pre- and post-development runoff volumes cannot be calculated accurately, so the District instead focuses on the one-inch on-site retention standard.
- The District sets the standards, but leaves it up to the landowner to determine how the standards will be met – through either grey or green infrastructure, or both (whichever is cheapest for the landowner). They will use the Pollution Control Agency's manual's infiltration rates where there is only general soils information available.

- Public stormwater improvements and facilities are established in a capital improvement program adopted as part of the CRWD's watershed plan. The draft plan can be found at: http://www.capitolregionwd.org/planning.html.
- A strength of the District approach to stormwater management is that it is a tax-levying unit of government and can therefore adequately finance its program.
- CRWD's levy is currently about $14/house/year. Another is the state's requirement that the District and local governments develop and adopt water resources management plans that are reviewed and approved by the Board of Soil and Water Resources. This makes the program proactive (since locals can adopt regulatory standards and policies that meet their own needs).
- The district has also been able to work cooperatively with municipalities in education, monitoring, and the development of Capital Improvement Programs to manage stormwater.
- Weaknesses of the District approach are that the long-term effectiveness of many of the BMPs are unknown – they may work well for five or ten years, but nobody knows if they will still be working in 30-years – and that lack of knowledge makes it hard to know the long-term cost- effectiveness of some practices. Also, some of the municipalities may be half in the district and half out of the watershed, leading to different regulations imposed by cities and the district.

5. Websites

Minnesota Pollution Control Agency Stormwater Program
http://www.pca.state.mn.us/water/stormwater/index.html

New Jersey. The New Jersey Department of Environmental Protection (DEP) is responsible for administering the state's stormwater management program. The New Jersey program has some of the most stringent stormwater regulations in the country. The program is based on parts of several statutes that were passed at different times and with different goals. As a result, a summary of the statutory basis of the regulatory program is somewhat complex, but various provisions of the different statutes may provide useful examples for Illinois. Of note is the requirement that every municipality in New Jersey develop a stormwater management plan and ordinance. Such plans must be approved by the county and coordinated with other plans in the watershed. A number of agencies may be involved. Also noteworthy is the authority given to the state agency, as opposed to the local government, to approve or deny an application for construction in a flood hazard area.

The contact for the state program is:
Sandy Blick, Supervisor
Stormwater Management Unit
Bureau of Nonpoint Pollution Control, Division of Water Quality
New Jersey Department of Environmental Protection,
Camden, New Jersey
609-633-7021.

1. ***Statutory Provisions***

The following statutory sections provide the basis for the State's storm water management regulations:

a. Municipal Land Use Law – NJSA 40:55D-93 through 99
b. Water Pollution Control Act – NJSA 58:10A-1 et seq
c. Water Quality Planning Act – NJSA 58:11A-1 et seq.
d. Flood Hazard Area Control Act – NJSA 58:16A-50 et seq.

Municipal Land Use Law

Highlights:

- Every municipality is required to prepare a storm water management plan and ordinance(s), which must be submitted to and approved by the county planning agency or county water resources association.
- The Department of Environmental Protection is required to adopt regulations to protect the public safety with respect to storm water detention facilities.
- Municipal plans must be coordinated with the appropriate soil conservation district and with any storm water management plans prepared by any other municipality or any county, area-wide agency or the State relating to the river basins located in that municipality.
- Plans and ordinance(s) must conform to federal and state statutes, rules and regulations concerning storm water management or flood control and be designed to:

  a. reduce flood damage, including damage to life and property;
  b. minimize storm water runoff from any new land development where such runoff will increase flood damage;
  c. reduce soil erosion from any development or construction project;
  d. assure the adequacy of existing and proposed culverts and bridges;
  e. induce water recharge into the ground where practical;
  f. prevent, to the greatest extent feasible, an increase in nonpoint pollution;
  g. maintain the integrity of stream channels for their biological functions, as well as for drainage; and
  h. minimize public safety hazards at any storm water detention facilities constructed as part of a subdivision or pursuant to a site plan.

Plans must include structural changes and additional nonstructural measures and practices as may be necessary to manage storm water. "Nonpoint pollution" covers pollution from any source other than from any discernible, confined conveyance, and includes pollutants from agricultural, silvicultural, mining, construction, subsurface disposal and urban runoff sources.

Water Pollution Control Act

Highlights:

- Very broad legislative findings declaring the policy of the State to restore, enhance and maintain the integrity of the State’s waters, protect public health, safeguard fish and aquatic life, scenic and ecological values and enhance domestic, municipal, recreational, industrial and other uses of water
- Authorizes DEP to adopt regulations to carry out intent of act without further elaboration

Water Quality Planning Act

Highlights:

- Again, very broad legislative findings with regard to the need to implement water quality management programs in concert with other social and economic objectives

- Encourages development of area-wide waste treatment management planning processes to restore and maintain the chemical, physical and biological integrity of the waters of the State
- Suggests that planning areas be coterminous with counties where feasible
- Requires plans to identify urban storm water runoff systems and necessary financing
- Plans must identify processes to control the disposal or deposition of pollutants on land to protect groundwater and surface water quality
-

<u>Flood Hazard Area Control Act</u>

Highlights:

- Authorizes DEP to adopt land use regulations for flood hazard areas
- Exempts damaged preexisting structures from the regulations
- Gives DEP the ultimate authority to grant or deny approval of construction in flood hazard areas
- Prohibits municipalities from approving such construction

2. Regulatory Provisions

In spite of the number of pieces of legislation that make up the foundation of the New Jersey stormwater program, its regulations have been consolidated in a single chapter of the Administrative Code: Title 7 Environmental Protection, Chapter 8.

Highlights:

- Threshold is 1 acre of land disturbance ¼ acre of new impervious surface
- There are specific requirements for the content of storm water management plans and programs
- Nonstructural storm water management measures must be incorporated and have priority over structural measures
- Maintenance plans are required in all projects
- Hierarchy used to limit grey infrastructure approaches
- Performance standards include:
  - <u>Erosion control</u>: Minimum design standards are those established under Soil Erosion and Sediment Control Act and implementing regulations
  - <u>Groundwater recharge</u>: the project must maintain 100% of the average annual pre-construction groundwater infiltration volume post-construction for the 2-year storm
  - <u>Runoff quantity</u>: Three alternatives:
    - Demonstrate that pre-construction runoff for 2, 10 and 100-year storm events does not increase post-construction, at all points in storms, demonstrated through hydrologic analysis
    - Demonstrate that increased peak runoff from 2, 10 and 100-year events and the increased volume or change in timing of runoff will not increase damage at or downstream of site, or
    - Design stormwater management measures so that post-construction peak runoff for 2, 10 and 100-year events does not exceed 50, 75 and 80% of pre-construction peaks
  - <u>Pollutant removal</u>:
    - Reduce anticipated post-construction TSS load by 80% (regulation provides presumed removal rates for certain BMPs)
    - Reduce the nutrient load from the site to the max. extent feasible, using a combination of nonstructural and structural measures that optimize nutrient removal while achieving the other performance standards

        - Establish special resource protection areas along waterways of special significance, such as 300-foot zone, no encroachment, no storm water discharge
  - Sensitive areas: Projects must avoid impacts of concentrated flow on sensitive areas
  - Nonstructural practices: Projects must incorporate nonstructural strategies to the maximum extent practicable, identify practices used and explain claims of infeasibility
    - Protect certain areas
    - Minimize or break up impervious surfaces
    - Maximize natural drainage features and vegetation
    - Minimize the decrease in "time of concentration" from pre-construction to post-construction
    - Minimize land disturbance
    - Minimize soil compaction
    - Provide low-maintenance landscaping that encourages infiltration
    - Provide vegetated open-channel conveyance systems
    - Provide controls to prevent or minimize discharge of pollutants into the system
    - Protect land areas used as stormwater control measures by establishing restrictive covenants and conveying to government agencies in perpetuity
  - Maintenance plans: Projects must have plans with specific maintenance tasks, schedules, responsible persons and contact information, as well as
    - Documentation of agreement for responsibility if other than developer
    - Recording on deed if responsible entity is not a government agency
    - Detailed log or other documentation of maintenance activities
    - Annual evaluation of maintenance plan

3. Manuals:

The State of New Jersey has established a Nonstructural Stormwater Management Strategies Point System, the guidance for which may be found at:
http://www.njstormwater.org/pdf/nsps_userguide2006013.pdf

New Jersey Stormwater Best Management Practices Manual
http://www.state.nj.us/dep/stormwater/bmp_manual2.htm

4. Notes from Interview with State Contact, Sandy Blick

- In writing the regulations, New Jersey staff met with people in several other state programs and/or attended many conferences in Maryland, Delaware, Minnesota, California, Florida and Pennsylvania, each of which has program elements that are worth replicating. They also set up an advisory committee of about 20 people, including environmental groups and the development community, that still meets regularly every month or two to discuss the program and possible modifications.
- The program is focused on flood control, water quality and groundwater recharge. The performance standards were selected with these goals in mind.
- Volume control is not used as a performance standard, due to a concern about putting too much water into the ground in confined spaces and creating groundwater mounding. Green infrastructure can result in infiltration rates several times the natural infiltration rate. Site conditions must be carefully evaluated to determine what level of infiltration is appropriate. Instead, the groundwater recharge standard attempts to restore natural filtration rates for the two-year storm event.

- Assistance is provided most efficiently through the state website, phone call and published guidance, such as in manuals.
- The state set up a Permit Efficiency Task Force, which recommended higher staffing levels for storm water management. There are three full time people in the storm water management group and 5 in the NJPDES permit group. There are 506 municipalities that are subject to the programs, and each has storm water staff that we work with. The counties are not very active.
- Other recommended contacts include: Eric Livingston, Florida, Stu Comstock, Maryland, agency staff in Delaware, Bill Hunt, North Carolina, California, Pennsylvania, and Wisconsin; the New England Interstate Water Pollution Control Commission may also be helpful.
- Something that appears to be working well is the point system for non-structural BMPs, which developers can run on-line to help them comply with the regulations.
- The staff spends a lot of time evaluating pretreatment devices and is considering writing some device guidelines or requirements. The University of Florida has a protocol for testing devices. There are 10-15 companies that are marketing new devices in New Jersey.
- Personal opinion, not representing the position of the Department: "Green infrastructure is a great way to go, I am totally supportive. There are many benefits that we did not consider or account for. "

5. Websites

Department of Environmental Protection: Stormwater in New Jersey
http://www.njstormwater.org/.

Wisconsin. Stormwater is currently regulated at the state level in Wisconsin by three agencies: the Department of Natural Resources (DNR), the Department of Transportation (DOT), and the Department of Commerce (COMM). DNR and DOT regulations address runoff from developed urban areas within permitted municipalities as well as construction site and post-construction site runoff from new development larger than one acre. COMM regulations address runoff from new development smaller than one acre as well as stormwater managed through plumbing systems. Each Agency rule contains its own performance standards, although in most cases standards are the same. This summary addresses only the DNR regulations.

The statute requires the Department of Natural Resources (DNR) to develop a state stormwater management plan and performance standards and thresholds for construction activities carried out by state agencies and to encourage municipalities to comply with such standards by including them in their local ordinances. DNR is also required to develop minimum standards for non-state construction activity that meets certain thresholds of size, impervious area or impacts from storm water runoff. DNR must prepare a model zoning ordinance for construction site erosion control and stormwater management and distribute it to any county or municipality that submits a request. Performance standards for construction cover sediment load, suspended solid and peak discharge reduction, infiltration volume as a percent of pre-development volume, a ban on impervious surfaces in "protective areas," and specific practices in developed urban areas. Some performance standards become stricter over time.

These regulations contain standards of performance that determine how stormwater management practices, including proprietary devices, are evaluated for compliance with state laws. Wisconsin's stormwater management program is one of the most stringent in the nation, requiring that stormwater management comply with specific treatment objectives including 80% removal of the annual total suspended solids (TSS) load from new development and 40% removal of the annual TSS load from redevelopment and certain in-fill development. However, enforcement of these standards is limited, and BMP's are often approved on a Maximum Extent Practical basis regarding treatment efficiencies. In addition to the requirements of the federal National Pollution Discharge Elimination System (NPDES) program, which requires stormwater be treated to the maximum extent practicable (MEP), Wisconsin has established specific stormwater treatment requirements for stormwater runoff.

The contact for the Wisconsin program is:

Roger Bannerman, Water Resources Management Specialist
Wisconsin Dept. of Natural Resources
Roger.Bannerman@Wisconsin.gov
608-266-9278

1. Statutory Provisions

Two chapters within the Natural Resources section of the Wisconsin Statutes address storm water management:

Chapter 281 "Water and Sewage" – requires the Department of Natural Resources to establish rules for state agencies and private developers, including performance standards that are enforceable at the state level.

Chapter 283 "Pollution Discharge Elimination" – implements the federal NPDES storm water permitting program.

Both chapters can be found at:
http://nxt.legis.state.wi.us/nxt/gateway.dll?f=templates&fn=default.htm&d=code&jd=top

Highlights:

- The Wisconsin Legislature sets forth in the statutory language the broad purpose of the law to "to grant necessary powers and to organize a comprehensive program under a single state agency for the enhancement of the quality management and protection of all waters of the state, ground and surface, public and private."
- The DNR is required to set performance standards for nonpoint sources that are not agricultural facilities or agricultural practices. The performance standards must be designed to achieve water quality standards by limiting nonpoint source water pollution.
- The department shall, by rule, specify a process for the development and dissemination of technical standards to implement the performance standards under par. (a).
- Note that the stated purpose is to protect water quality, as opposed to reducing flooding or erosion or protecting habitat
- It requires DNR to develop a state stormwater management plan, and performance standards and thresholds for the construction activities of state agencies
- Requires DNR to promulgate regulations with minimum standards for construction activity that meets certain thresholds of size, impervious area or impacts from storm water runoff.
- It requires DNR to prepare model ordinances

2. Regulatory Provisions – Wisconsin Administrative Code; Department of Natural Resources; Environmental Protection – General

   a. Section 151: statewide regulations on storm water management

   b. Section 152: model ordinances

These sections can be found at:
http://nxt.legis.state.wi.us/nxt/gateway.dll?f=templates&fn=default.htm&d=code&jd=top

Highlights:

- Performance standards for non-agricultural construction site stormwater management (NR 151.11)
  - Landowner is responsible
  - Stormwater management plan is required for all projects
  - Sediment load: project must use best management practices (BMPs) that reduce sediment load in runoff by 80% as compared with no controls; a credit is awarded for limiting the duration or the area of activity or other appropriate strategy. If 80% is not achievable, a written explanation must be submitted and sediment load shall be reduced to the maximum extent practicable.

- Performance standards for non-agricultural post-construction stormwater management (NR 151.12)
  - TSS control: BMPs must be designed, installed and maintained to achieve
    - New development – 80% reduction over no control
    - Redevelopment – 40% reduction over no control
    - Infill <5 acres, prior to 10/1/2012 – 40% reduction
    - Infill post 10/1/2012 – 80% reduction
    - If standard is not achievable, written explanation required and sediment load must be reduced to the maximum extent practicable
  - Infiltration:
    - Residential – at least 90% of pre-construction infiltration volume must be maintained, and 25% of post-development runoff volume
    - Non-residential – at least 60% of pre-construction infiltration volume and 10% of post-development runoff volume
    - Pretreatment required to prevent system clogging and protect groundwater
    - Prohibition of infiltration in areas with anticipated contamination
    - Exemptions for low permeability soil; frozen soil, small parcels
    - Credit provided for alternative uses of runoff, such as toilet flushing, laundry or irrigation
  - Protective areas
    - Prohibition of impermeable surfaces
    - If land disturbance occurs, at least 70% vegetative cover required
  - Fueling and vehicle maintenance areas
    - BMPs to prevent visible sheen

- Developed Urban Areas: specific BMPs required (NR 151.13)

- Transportation Facility Performance Standards (NR 151.20-26)
    - Transportation authority responsible
    - Performance standards for construction activities
        - Sediment load: same as non-agricultural standard
        - Additional design requirements to manage the use, storage and disposal of chemical, cement and other compounds on site
    - Performance standards for post-construction activities
        - TSS control: same as non-agricultural standards
        - Infiltration:
            - at least 60% of pre-construction volume, based on average annual rainfall
            - 10% of post-construction runoff volume from the 2−year, 24−hour design storm with a type II distribution
            - Some areas prohibited from infiltration
            - Some areas exempt

- Developed Urban Area Performance Standard
    - Beginning March 10, 2008 – 20% reduction in TSS entering waters of the state as compared with no controls
    - Beginning March 10, 2013 – 40% reduction in TSS

3. Manuals

Wisconsin Storm Water Manual. Originally published in 1994, this technical manual was developed to aid local units of government, developers, contractors, and consulting engineers in controlling storm water pollutants from existing and new developments. Part One is an overview; Part Two is an elaboration of technical design guidelines for storm water management practices. http://www.dnr.state.wi.us/runoff/stormwater/publications.htm#uwex

4. Notes from Interview with State Contact: Roger Bannerman

- Program resources: 1 Engineer in each of 5 regions in Wisconsin; 2 people at the main office; under the program developers need quite a bit of assistance from the state staff, which means human resources. There is a demand for skills in politics, education and psychology.
- Performance standards:
    - The 90% infiltration rate is not unreasonable for a residential subdivision, and 80% for TSS is easy – new numbers are higher
    - 40% TSS in in-fill areas, though not very high, can be a struggle
    - Should look at examples like Iowa, McHenry County, Dane County, WI
    - TMDLs may take over as driving force, due to stresses on fish from dissolved oxygen and chloride
    - Recommends taking an incremental approach to regulations; at the beginning better not to try and address built-out areas. The Wisconsin performance standards are appropriate, but developers need flexibility.
- The Wisconsin DNR's timing was good for using performance standards in an administrative rule to promote green infrastructure. As a nation we had gathered enough information to identify stormwater as a problem and green infrastructure was being demonstrated in many places as part

of the solution. The information published by the Center for Watershed Protection helped establish green infrastructure as a permanent part of stormwater management.

- The work in Wisconsin and of many others around the country has clearly demonstrated the impact of urban runoff on urban water ways. Any solution must address both the increased flows and the level of pollutants. The impact of high flows on stream morphology are highly visible and our biologist describe these impacts in terms of impacts on the health of the stream ecosystems.
- The first challenge is to reduce the impact of new development as much as possible. This is addressed in the administrative rules by reducing the TSS by 80% and requiring some degree of infiltration.
- Although the administrative rules are not prescriptive in how to accomplish the performance standard, we prepared technical standards that supported the use of green infrastructure, such as rain gardens, bioretention, and grass swales.
- Since our engineers accomplish the standards by design, we have also worked hard to provide them with design tools to properly size some of the green infrastructure. We continue to gather information needed to improve our technical standards and design tools.
- The use of green infrastructure to reduce stormwater runoff from new development is showing positive benefits across the state of Wisconsin. Developers have successfully incorporated green infrastructure, such as grass swales, infiltration basins, and rain gardens, into their site designs. Sometimes the green infrastructure becomes another attractive feature to the buyers.
- Side by side comparisons of development with conventional stormwater conveyance and green infrastructure consistently show much less runoff with the green infrastructure.
- Studies of green infrastructure in Wisconsin show large reductions in runoff when green infrastructure is employed. A combination of grass swales, reduce street widths, and infiltration basin can reduce the annual runoff from a medium density residential site by over 90 %.
- Some developers actually save money with cost reducing ideas as reducing the amount of impervious area.
-

4.a. Notes from Interview with Independent Engineer

Matthew R. Bardol, P.E., CFM, CPESC
Natural Resources Group Manager
Cowhey Gudmundson Leder, Ltd.
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Phone: (630) 250-9595 ext. 273
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- Did not work on the development of the regulations, but has worked on projects using the Wisconsin performance standards in Illinois
- In one example, the U.S. Army Corps of Engineers and U.S. Fish and Wildlife Service requested that the developer follow the Wisconsin infiltration ("stay-on") requirement; a natural resource evaluation and soil testing led to the establishment of a watershed-specific infiltration requirement of nearly 80%; the requirement was met by maximizing open space and other best management practices throughout the development site for current and all future phases of the development.
- Recommend that retention standard be higher for more open sites; even with heavier clay soils in Illinois, at least 60% infiltration is a reasonable requirement and usually 80% is achievable; flexibility is critical to a workable standard, but some amount of retention should be required for

all sites. Wisconsin does not have a requirement to detain the 100-year event, but infiltration and detention must be considered in an integrated stormwater management plan for any site.

- Expertise and funding need to be provided at the state level for assistance to developers and municipalities; currently neither the Illinois Department of Natural Resources nor the IEPA has adequate human resources to manage such a program. An Illinois BMP monitoring program should be supported and integrated into the EPA BMP international database.

5. Websites

Primary Stormwater Management website for the Wisconsin DNR:
http://www.dnr.state.wi.us/runoff/stormwater.htm

Common Elements of the State Programs

Legislative findings and policy that underpin the stormwater programs, as well as requirements for the responsible state agency to adopt the relevant regulations, are typically set out within the statutes establishing the state stormwater management programs. While not universal, we frequently find a strong statement regarding the adverse impacts of stormwater and the need to establish a robust program to prevent them. For example, the Maryland statutes, Section 4-101 states in part:

> The General Assembly … finds that lands and waters comprising the watersheds of the State are great natural assets and resources. As a result of erosion and sediment deposit on lands and in waters …, these waters are being polluted and despoiled to such a degree that fish, marine life, and recreational use of the waters are being affected adversely.

The statutes vary in the detail used to direct the state agencies to adopt stormwater regulatory programs. The most important details to be included at the statutory level are the basic structural characteristics of the program. For example, the responsible agency may be required to develop standards for stormwater management at the project level and then enforce these standards through a permit system. In others, the standards developed by the state agency are to be incorporated into county and local ordinances and enforces by those government bodies.

Performance Standards. As shown in Table 9 below, some performance standards are common to virtually all programs, while others are unique to only one or two states. The regulations and the table speak for themselves, but generalizations may be useful to the reader.

Green infrastructure is a priority for all states reviewed. The programs and their performance standards all encourage, require or simply presume the use of strategies and techniques that "infiltrate, evapotranspire, capture and reuse stormwater," or "green infrastructure", although the terminology varies. The contact people in each state were strong proponents of green infrastructure. The Maine program director, Don Witherill, said new regulations being developed currently will require, instead of encourage, the use of green infrastructure.

Erosion and sediment control is a universal performance standard, or set of standards. Most states have a separate, detailed regulatory section addressing erosion and sediment control. This makes sense because sediment from construction activities is said to be the single largest contributor to stream water quality degradation, and controlling the erosion of stream banks is a critical safety, land management and water quality practice.

Table 9: Performance Standards in Reviewed State Programs

	Maine	Maryland	Minnesota (CRWD)	New Jersey	Wisconsin
Reduce impervious surface		X		X	
Volume control	X	X	X		X
TSS removal			X	X	X
Groundwater recharge		X		X	
Groundwater protection	X				X
Erosion & Sed. control	X	X	X	X	X
Detention release rates	X	X	X	X	
County water res. mgt. plans			X		
County ordinance or model		X			X
Watershed planning			X	X	
Local plans			X	X	
Local ordinances or model		X	X	X	X
Maintenance	X	X		X	
Phosphorus removal	X				
Spill prevention	X				
Temperature control	X				
Effective date of regs.	July 1997, Nov. 2005	1983, 2009	Oct. 1, 2006 Jan. 7, 2009	2004	Oct. 1, 2002

Volume control standards are strong components of every program except New Jersey's (although New Jersey does have a groundwater recharge standard). Typically, between 1.0 and 1.5 inches of rainfall or 90% of the average annual rainfall is required to be retained, detained or otherwise controlled on-site, using some type of green infrastructure system.

Detention and controlled release. Most often these standards are expressed as a requirement to maintain or minimize peak runoff to the greatest extent practicable. Stricter rules require such controls at all points during a storm. Traditional dry detention basins are less commonly recognized as an appropriate practice. The emphasis is on wet detention facilities that discharge through a gravel or soil medium or infiltrate into the ground.

Groundwater recharge or protection. Almost all programs have performance standards for either groundwater recharge or groundwater protection.

Removal of total suspended solids (TSS). Reductions in anticipated TSS loads of 80% to 90% are commonly required. Removal of dissolved nutrients to the maximum extent practicable (MEP) is also frequently required, although there is recognition that removal of nutrients is difficult. A recent article published in "Stormwater", is titled "15 Reasons You Should Think Twice Before Using Percent Removal to Assess BMP Performance," [http://www.stormh2o.com/january-february-2008/pollutants-research-bmp.aspx], suggests that there are performance standards for the removal of TSS that are superior to a "% removal of TSS" standard.

Don Witherill, of Maine DEP, indicated that their program has moved away from TSS removal standards in general because the best management practices are much better at reducing volume than at reducing the concentration of TSS in the water. We also note that if the objective is to reduce the total load or mass of suspended solids entering the surface water or treatment plant, a reduction in volume accomplishes this without the need for expensive pretreatment.

Maintenance. Many programs have detailed requirements to ensure the long-term maintenance of green infrastructure systems. Common elements include a requirement to submit a maintenance plan for each stormwater management system as part of the project application, written agreements to perform maintenance activities, the recording of such documents in the land records, and regular inspections of BMPs post-construction. One example where there are no maintenance plan requirements, but enforcement provisions are relied on instead to ensure compliance, is the Capital Region Watershed District in Minneapolis. However, while this might seem a simpler strategy than maintenance plans, deed recording and regular inspections, its success depends upon the District "finding that a person has violated a prohibition or failed to meet a requirement." If there are thousands of stormwater management systems in place on as many private parcels of land, it is difficult to imagine how this process could efficiently be implemented to ensure compliance. We do not recommend this approach.

Manuals. Virtually all programs make liberal use of technical guidance manuals to explain and provide details of practices that are designed properly to meet performance standards. They provide assistance on the development of plans, include model plans and ordinances, and set out technical specifications for green infrastructure practices that are usually considered part of the regulations they support and are enforceable.

STATE PORTFOLIO STANDARDS

The use of green infrastructure for stormwater management in the United States has been somewhat random to this point in time, and has been based more on the attitudes of specific stormwater managers and departments than on broad policies or regulations directing its use. In addition, because stormwater infrastructure in existing urban areas is for the most part already constructed, the systematic addition to, or replacement of, a significant portion of that infrastructure with green infrastructure can only take place over a long period of time, with appropriate planning.

To address this situation, we propose the establishment of a long-term goal for increasing the use of green infrastructure strategies and systems, in order to provide an appropriate framework for the necessary planning with regard to prioritizing the types and sizes of projects, developing budgets, organizing human resources and setting construction schedules.

Many states have approached the need to increase the use of renewable energy sources to produce electricity by establishing just such long-term goals, known as "renewable energy portfolio standards" or "RPSs". These state energy programs typically involve regulations that require major utilities to gradually increase the percentage of the electricity they produce for the local market that is provided from renewable energy sources such as wind, solar and hydroelectric power. For example, the utilities may be required to increase the renewable portion of their energy portfolio by 1% or 1.5% per year, for a number of years, with a final target of 25% or more.

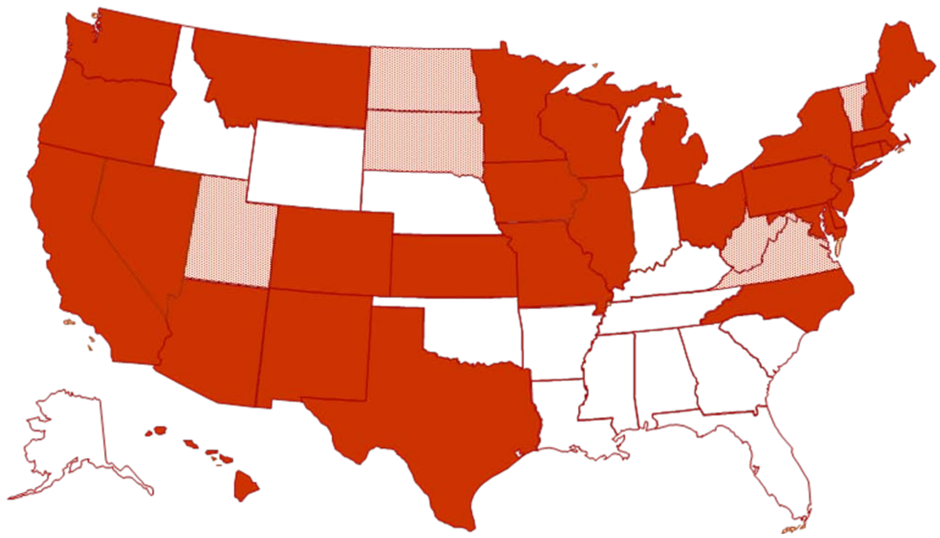
We believe this format could be an excellent tool for increasing the use of green infrastructure for stormwater management. We reviewed four state renewable energy portfolio standard programs and have begun the process of identifying potential elements of a "green infrastructure portfolio standard" (GIPS) program in Illinois, as outlined below.

State Renewable Energy Portfolio Standard (RPS) Programs

Twenty-nine states and the District of Columbia have RPS programs with mandated increases in renewable energy sourcing (see Figure 8). Six more have programs with unenforceable goals. We selected four programs with mandated increases: Illinois, New York, Oregon and Wisconsin. Following are brief descriptions of each program.

Illinois. The Illinois RPS requires that investor-owned power utilities serving more than 100,000 customers provide at least 25% of their power from renewable sources by 2025. The Illinois Power Agency was established to oversee the program and craft plans for the utilities to purchase renewable energy. Retail electricity bill surcharges fund the program, but are strictly controlled by the IPA. As a result, the funding and target renewable requirements vary from year to year. The RPS allows for the trading of Renewable Energy Credits (RECs) to meet the renewable energy sale requirements, including RECs from power produced out-of-state. Priority for the purchases is placed first on cost, then on energy generated in Illinois. The Agency recommends that utilities enter into long-term purchasing agreements with energy producers. Local units of government may apply to the Illinois Department of Commerce and Economic Opportunity (DCEO) for project funding. The utilities help fund commercial, industrial and residential projects.

Figure 8: State RPS Programs



State Renewable Portfolio Standard Source: Interstate Renewable Energy Council

State Renewable Portfolio Goal

New York. New York law requires that 30 percent of the energy produced by investor-owned utilities come from renewable sources by 2015. To accomplish this, the RPS ordered the major utilities to collect $741.5 million from rate payers and distribute that money to the state agency responsible for overseeing the program, The New York State Energy Research and Development Authority (NYSERDA). Because the target percentage increased in 2009 from 25 percent to 30 percent, and the end date was pushed back until 2015, NYSERDA is expecting a new funding requirement from the state legislature. NYSERDA uses the money it receives from utilities to buy 'attributes,' which are similar to Renewable Energy Credits, from energy generators. Attribute contracts stipulate that the energy tied to the attributes must be sold into the New York State wholesale market. NYSERDA also administers a program that provides incentives for small-scale energy projects, such as installing solar panels on a house or hooking up a small wind turbine to a building.

Oregon. Oregon's RPS requires all utilities to scale up their sales of renewable energy—with the three major utilities targeted to sell 25 percent renewable by 2025, combined with smaller targets for the smaller utilities. There are annual scale-up targets for the major utilities, which increase by one percent each year. Oregon allows utilities to trade RECs, each of which represents one megawatt-hour of generated renewable energy. In-state utilities can buy these credits with or without the energy associated with them and they can buy them from most states in the American West, as well as the two southwestern-most provinces of Canada. The RPS stipulates that in lieu of buying energy for a portion of the requirement, utilities have the option of paying into a fund for buying renewable energy in the future or for energy efficiency programs. If the total cost of buying renewableenergy exceeds 4% of annual revenue, utilities are not required to meet the annual target.

Wisconsin. Wisconsin's RPS requires that 10 percent of the energy sold to retail markets must come from renewable sources by 2015. As of March, 2010, all of the utilities are on schedule, with some already meeting that standard. The Public Service Commission of Wisconsin, which enforces the standards, has the authority to impose fines of $5,000 to $500,000 for failure to meet the standard. Renewable energy projects undertaken by utilities are funded either from retail fees or through "green pricing". Green pricing is a program in which utility customers can choose to pay a premium for renewable energy, around 1.25 cents for each kilowatt-hour. The state also allows the trading of RECs, including the purchase of RECs from out-of-state producers, so long as that energy is sold to Wisconsin consumers.

Green Infrastructure Portfolio Standard Program Elements

We are not aware of any existing GIPS programs. The policy choices and program elements identified here are preliminary, based on our understanding of green infrastructure concepts and stormwater management in general, as well as discussions with several stormwater managers in northeastern Illinois.

1. Covered Area. At the state level, an RPS typically requires major utilities to meet the increasing standards each year, and the electricity supplied to all customers in the utilities' coverage area within the state must come from the required balance of energy sources. One option in the stormwater context would be to have the GIPS applicable to all entities subject to the NPDES MS4 general stormwater permit. Under such an approach, coverage should later be expanded to include more areas, using the percentage of impervious surface as the guide.

2. Green Infrastructure Portfolio Standard. In RPS programs, the unit of measure is typically a kilowatt hour. In the GIPS program, we recommend that the unit of measure be the area of impervious surface managed with green infrastructure practices to meet a performance standard, such as retention of the first 1" of rainfall on-site. For example, in the "Covered Area" the GIPS would require using green infrastructure to achieve the equivalent of retaining the first 1" of rainfall on a minimum percentage of the impervious surface; at least 1% more than the baseline within 12 months of the effective date of the requirement, and increasing by at least 1% each year thereafter up to at least 25%. Incentives should be provided for larger annual increases or achievement of the final goal in a shorter period of time.

3. Baseline Determinations. Just as utilities must determine the baseline percentage of energy derived from renewable sources, MS4 permittees will have to determine both the baseline quantity of impermeable surface within their jurisdiction and the baseline percentage of that surface meeting the performance standard using green infrastructure. Because permeability is a variable, such impermeable surface assessments should take into account the range of permeability of surfaces in the Covered Area, based on their "curve numbers". A set of simple example permeability credits are shown in Table 10, below. The numbers in the "Retention Credit" column refer to the number of inches of rainfall the listed condition is assumed to retain. These numbers are for purposes of illustration only, and not based on scientific research.

4. "Retention of rainfall" defined. There is more than one objective of retaining rainfall on-site, including reducing the volume of water reaching the stormwater conveyance (sewer) system, recharging groundwater, recharging surface water, irrigating the land, infiltrating the water

through the soil, improving water quality and reducing the volume of potable water used for non-drinking purposes. Therefore, "retention" should include any practice or system that prevents a measurable amount of precipitation falling on the Covered Area from reaching the municipal storm sewer conveyance system, by using green infrastructure practices to infiltrate into the ground, evapotranspirate or capture the rain water for reuse. For simplicity, we recommend that the equivalent of one-inch of rainfall on a totally impervious surface be used as the standard retention requirement.

Table 10: Example of Site Retention Credits

Condition	Assumed Impermeability	Retention Credit
Conventional pavement surfaces **Compacted developed surfaces**	0.65 – 1.00	0.0
Compacted and Non-compacted lawn **Small green infrastructure practices with low infiltration, evapotranspiration or capture**	0.30 – 0.65	0.5
Garden **Forest** **Green infrastructure practices with amended soils and high infiltration, evapotranspiration or capture**	0.0 – 0.30	1.0

5. Retention Values and Green Infrastructure Credit System. In RPS programs it is relatively simple to measure the kilowatt hours derived from different sources of energy. For the Green Infrastructure Portfolio Standard, it may be more complicated, since actual retention cannot easily be measured. Therefore, we recommend that the state establish a set of assumed retention values applicable to common site conditions and stormwater management systems, as shown in Table X, above. The state should establish a similar set of assumed values for eligible green infrastructure practices (GIP) that meet minimum standards set forth in the Illinois Urban Manual, including appropriate maintenance plans. This combined set of retention values could be used to plan development projects and to provide standardized retention credits for projects once approved and constructed. The aggregate of all the net credits from installed GIPs would determine the permittee's compliance with the GIPS.

6. Green Infrastructure Portfolio Standard Resources Fund. RPS programs have a variety of sources of funding. Even though municipalities already impose taxes or charge fees to cover stormwater management services, the state and MS4 permittees may wish to consider establishing separate GIPS resource funds, to assist permittees and developers with the cost of new GIP installation, by

providing loans or grants. To receive funding from the GIPS resource fund for a proposed GIP project, an applicant must meet all the requirements set forth in the IUM for such a project. In addition, an MS4 should be required to demonstrate continuous compliance with the MS4 permit.

7. Procurement Requirement. RPS programs typically require that the renewable energy sourced electricity sold to meet the standard be generated or purchased from sources within the state or region. Similarly, administrators of GIPS resource funds may want to consider some requirement concerning the source of the services and materials paid for from the fund.

8. Maintenance Plan and Agreement. To obtain retention credit, a GIP should be required to have a maintenance plan, a demonstration of financial ability to carry out the plan, and an agreement to carry out the plan approved by the state and recorded on the land records upon completion of the project, as we recommended in conjunction with the establishment of state regulations in an earlier section of this report.

9. Verification and Recording. Upon installation of a GIP, MS4 permittee should be required to verify compliance with the construction standards and the efficacy of the project and that the maintenance plan and agreement, running with the land, have been filed with the recorder of deeds.

10. Eligible GI Practices. There are many green infrastructure practices that have measurable retention benefits, and some are known by more than one name. We provide here a list of some of the more typical green infrastructure practices as examples of what we believe should be eligible for credit in a GIPS program.

    i. green roofs
    ii. porous pavement
    iii. bio-infiltration
    iv. disconnected downspout program
    v. tree planting
    vi. porous piping, dry wells
    vii. collection systems

11. Education Program. The MS4 stormwater management education and outreach program provides an excellent opportunity to inform the public in general and the regulated community in particular about the purpose and objectives of the GIPS.

12. Funding; Fees; Stormwater Utility. We recommend that MS4 permittees be required to revise their stormwater service fee structures over time to move gradually toward full cost pricing of stormwater services and the generation of adequate funding dedicated directly to program needs.

Table 11 below shows information about the state renewable energy programs we reviewed and examples of equivalent elements for a GIPS program, for illustratio

Table 11. RPS Elements and GIPS Equivalents

	Renewable Portfolio Standard				
	Illinois	**New York**	**Oregon**	**Wisconsin**	**Green Infrastructure Portfolio Standard (proposed)**
Objective	Increase in percentage of electric power from renewable sources	Same	Same	Same	Increase in percentage of rainfall on impervious surfaces managed with green infrastructure
Administration	Illinois Power Agency	The New York State Energy Research and Development Authority (NYSERDA)	Oregon Dept. of Energy	Public Service Commission of Wisconsin	Illinois EPA
Regulated Entities and Areas	Investor-owned power utilities serving more than 100,000 customers (3)	Investor-owned power utilities	All power utilities (3 major utilities, many smaller)	All power utilities	MS4 permittees (about 440 municipalities and IDOT)
Requirement	Annual increase of 1% - 1.5% in power from renewable sources, up to 25% by 2025	30% of power from renewable sources by 2015	25% of power from renewable sources by 2025 for majors, smaller targets for minors	10% of power from renewable sources by 2015	Annual increase of 1% of rainfall on impervious surfaces managed with green infrastructure from baseline from 2014 to 2025 (incentives for more or faster implementation)
Funding	Retail utility bill surcharges	One-time charge to retail customers		Retail fees or optional green pricing	Private development budgets, Municipal taxes and storm water fees, IEPA Green Infrastructure Grants, State Revolving Fund

Comparison of RPS and potential Green Infrastructure Portfolio Standards

The purpose of both types of portfolio programs is to create a context for the planning necessary for making a major, long-term change in infrastructure, and at the same time educate and encourage a change in behavior by individuals, government units and entities that saves money and improves the quality of life in the community. The incremental nature of the programs is appealing also because it allows time for developing knowledge and experience in methodologies that have not been common in the past. This includes gradual changes to academic curricula, development of human resources with the appropriate skill sets to carry out the projects involved, and education of the community at large.

Government agencies administer both portfolio programs through a set of regulations. RPS programs are administered at the state level, primarily due to the limited number of utilities involved. In contrast, for GIPS, it is more likely that watershed, county or municipal agencies would manage the program. Since the number of regulated entities is likely to be much smaller for RPS, compared with the potential number of GIPS regulated entities where compliance takes place at the local level. However, if the GIPS utilized the existing MS4 regulatory framework, little additional bureaucracy would need to be created.

Both renewable energy and the green infrastructure programs require a change in the development of a product or service. In both cases, while it is not essential, it is certainly helpful to the success of the program for recipients of the products and services of the programs to participate and take on some responsibility through changes in behavior or other activities on their private property.

Both RPS and GIPS programs also allow for the trading of credits or payment of “fees in lieu” where it is infeasible or undesirable to carry out the changes required. On the other hand, because of the local impact of green infrastructure, the flexibility of such trading in a GIPS program would be more limited than for RPS programs.

CHAPTER V. RECOMMENDATIONS

PERFORMANCE STANDARDS

Illinois EPA should adopt, at the very least, a set of stormwater volume retention performance standards that varies according to the conditions at a particular site. Such performance standards have become the norm around the country, and are seen as the best method of reducing flooding and sewer overflows while improving water quality at the same time. In its 2008 Urban Stormwater Management report, the National Research Council recommended that "flow and related parameters like impervious cover should be considered for use as proxies for stormwater pollutant loading" because of the difficulty and expense of compliance monitoring urban stormwater for specific pollutants. A flow restriction – such as retaining the first inch or half-inch of runoff on-site by using green infrastructure practices -- is a stormwater management proxy that would work well for Illinois, since reducing the volume of stormwater discharge reduces the amount of pollution reaching our urban streams, while also reducing associated flood risks. Using a simple, clear performance standard also means that landowners have the freedom to choose a mix of different green infrastructure practices to meet the standard, based on their project design and site characteristics.

Other performance standards that should be considered include those that are currently in use in other states and in some Illinois counties, such as standards for the development of stormwater management plans, erosion and sediment controls, detention release rates, removal of Total Suspended Solids, temperature control, groundwater recharge and protection, and long-term maintenance of stormwater facilities. In all cases, flexibility is needed to accommodate variations in soils, infiltration rates, surficial geology, proximity to waterways, slopes, structures and other physical factors affecting the amount and rate of runoff discharge and its environmental impacts.

We believe it would improve the planning and preparation for the wide-spread use of green infrastructure if communities were either required or encouraged to set a long-term goal to gradually increase the amount of existing impervious surface that is subject to the performance standards using green infrastructure. This would also enable communities to develop the training and experience needed to manage urban stormwater using green infrastructure practices. The approach we are recommending uses the concept of a "portfolio standard." This process of implementing a green infrastructure portfolio standard would be similar to the one already adopted by Illinois in phasing-in a gradually larger portion of renewable energy as part of its mix (or portfolio) of energy resources, with an increasing percentage of the state's energy budget being met by renewable energy until a target percentage (25%) is reached at some target date (2025). We recommend that Illinois EPA work with county and local officials, stormwater agencies, drainage districts, soil and water conservation districts and others to initiate a process that establishes realistic annual goals for adopting green infrastructure practices statewide in a timely manner. These collaborations should additionally identify the boundaries for the portfolio standards (i.e., whether they should coincide with a HUC-12 watershed or with county or municipal boundaries) and use a percentage of effective impervious area as a potential proxy for the adoption of green infrastructure practices.

Staff and financial resources must be dedicated to program elements that create economic incentives and train county, municipal, stormwater management agency and drainage district staff in using green infrastructure practices until their use not only is accepted by county and municipal staff and within the development community but becomes the standard approach in stormwater management programs statewide. Illinois should fund staff and other resources needed to bring green infrastructure and its benefits into practice among communities.

ADMINISTRATION

The National Research Council recommends that urban stormwater should best be managed on the watershed level, rather than on the local scale. In Illinois, counties are the governmental units whose jurisdictions best correspond to watershed-scaled management, so we recommend that IEPA rely on the counties to develop appropriate rules or ordinances to locally administer the performance standards established at the state level and work directly with municipalities to promote the use of green infrastructure to meet those standards and their other MS4 program requirements. The state should also provide adequate resources to the counties to meet these responsibilities or authorize the counties to charge fees that are sufficient to cover the cost of the program. Counties also have, or can readily develop, the technical expertise necessary to train municipal staffs on how best to use green infrastructure as a component of their local urban stormwater management programs.

Counties can also turn to the existing regional expertise that may be available to assist them in promoting green infrastructure practices. This expertise includes the staffs of regional stormwater management agencies, soil and water conservation districts, and drainage districts. County and regional stormwater management agencies exist in all the collar counties of northeastern Illinois, while both soil and water conservation districts (which are currently revising the Illinois Urban Manual to embrace green infrastructure) and drainage districts are also highly respected agencies in more rural areas of the state. We therefore recommend that more financial resources (through grants and stormwater management fees) also be provided to these agencies and districts to assist the counties in their stormwater management responsibilities. Counties should consider entering into intergovernmental agreements with these other agencies and districts to provide technical services, training and monitoring the use and effectiveness of green infrastructure for urban stormwater management.

APPLICABILITY

We recommend that the stormwater retention performance standard first apply to all projects and entities currently subject to a NPDES stormwater permit in Illinois, including MS4s of all sizes, industrial sites, and construction projects. Over time, applicability of the standards should be expanded to include more urban and suburbanizing areas, based on the density of impervious surfaces, rather than on population. At the watershed level, studies show that it is very difficult to maintain predevelopment stream quality when watershed development exceeds ten to 15 percent impervious cover (Schuyeler and Holland 2002). Using the percentage of impervious cover within a watershed to guide the state’s stormwater management efforts would have the dual benefits of (a) applying the standards first to those areas most significantly affecting water quality and (b) encouraging a limitation on new impervious surfaces, which will have many of the same benefits as applying the standards.

We also recommend that the standards apply to existing as well as new development, to publicly-owned as well as private property. For example, there should be a commitment by government agencies to apply the standards to manage stormwater runoff whenever public infrastructure undergoes significant maintenance, repair or replacement, or when private development is substantially improved or redeveloped. State agencies and regional governments should also set an example by using green infrastructure in their construction and maintenance activities, to help build awareness and experience with these practices. Green infrastructure retrofits are already part of the Illinois MS4 program. The state should develop guidance to ensure that green infrastructure practices are used appropriately to work most effectively in reducing pollution, erosion and sedimentation, and flood risks, while providing the ancillary benefits of improved habitat and aquifer recharge opportunities.

FUNDING GREEN INFRASTRUCTURE

Setting aside 20% of the Clean Water State Revolving Fund for a Green Project Reserve has not had any serious impact on IEPA's ability to fund traditional projects to date. We believe that in the future, with more municipalities applying for green project funding, there will be an increased interest and need for funding such projects and this need may very well exceed 20% of the annual fund. We further believe that the IEPA SRF allocation policy should recognize the enormous adverse impact of unregulated stormwater discharges on the water quality of state waters, and that the funding of stand-alone stormwater projects should have a much higher priority in the future relative to the funding of traditional wastewater projects. Assuming that IEPA takes this approach, there should be no negative consequences from a long-term policy of setting aside 20% of the SRF for a Green Project Reserve.

We also recommend that IEPA substantially increase prioritization of applications for funding the more sustainable traditional projects, as this will further enhance the effectiveness of IEPA funding investments. Increasing the sustainability or efficiency of all projects should reduce the need for yet more funding in the future, as systems are put in place that last longer and require less maintenance, repair and replacement. This is not so much an issue of being more "green" as it is developing a wiser investment strategy.

The Fiscal Year 2010 federal appropriation bill passed in October 2009 provided another round of exceptionally large water infrastructure grants to states and repeated the mandates for green infrastructure projects and grants contained in the American Recovery and Reinvestment Act of 2009 (ARRA). It is also our understanding from discussions with the U.S. Environmental Protection Agency that the current draft language in the Fiscal Year 2011 federal appropriation bill shows Congress' intent to continue these two requirements for the foreseeable future in its annual appropriations. However, to make best use of these federal funds, Illinois EPA must adopt a clear prioritization system to determine which of the municipal green infrastructure projects should receive funding first under its earmarked Green Project Reserve funds. This system should be designed to encourage applications for a wide variety of green infrastructure project all over the state.

Unlike the limited interest shown by local governments in Illinois in using ARRA's Green Project Reserve to support green infrastructure practices for urban stormwater management, states with strong education and outreach programs have received many applications for green infrastructure projects and have given out millions of dollars in grants for green infrastructure project costs. We conclude that outreach and education are critical elements of any program attempting to increase interest in, and use of, green infrastructure practices, and we therefore recommend that IEPA significantly increase the resources and effort in this portion of its program.

We would also note that historically, the SRF program has funded only about ten percent of the water infrastructure needs of the applicants. Therefore, the SRF cannot be relied on for funding a major portion of either the sorely-needed upgrades to existing conventional wastewater and stormwater infrastructure or the green projects that will be completed in the next few years to supplement that infrastructure. Instead, states, counties and municipalities should be hard at work developing additional funding sources for these projects. For example, the responsibility for stormwater management on private land should begin with the landowners, by requiring all developers to meet the performance standards described above and to encourage them to employ green infrastructure practices in their projects.

The costs of constructing and maintaining green stormwater infrastructure on private property should continue to be borne by the landowner – by the developer during construction and by the occupants after construction – the same as with conventionally-engineered stormwater infrastructure. In some instances, the responsibility for funding and maintaining stormwater management structures was provisionally allocated to property owners within ordinance language, mainly in the form of establishing Special Service Areas (SSAs) or back-up SSAs for stormwater management. This requires that an additional property tax is levied based on the Equalized Assessed Value (EAV) of a property to enable a local government to maintain and/or enforce stormwater management infrastructure. Back-up SSAs take effect when structures fail, or when a management unit (e.g., a Home Owners' Association) becomes defunct and discontinues responsibility for maintenance of stormwater management structures. This measure allows governments to charge fees to maintain infrastructure.

The residual runoff from such property should continue to be managed by local government. However, instead of using the general tax revenues to fund stormwater infrastructure, the state should encourage local governments to adopt stormwater management fee systems, in which rate payers are given clear information on the costs associated with such infrastructure. This should ensure that polluted runoff is not treated as an economic externality, and that landowners causing the runoff pay for the treatment and management of runoff flow and volume needed to protect our urban streams – in the same way that landowners pay for the connection fees and sewage treatment charges for pollution discharged directly into streams by publicly-owned sewage treatment plants. Green infrastructure practices should be eligible for appropriate performance credit against these stormwater fees, to encourage their adoption. If green infrastructure practices do not receive credit, land managers are less likely to utilize them because they would represent additional cost above required measures.

MAINTENANCE

Green infrastructure practices -- the same as conventional "grey" stormwater infrastructure -- require maintenance to ensure continued effectiveness over time and performance as initially designed. Where stormwater management facilities are not dedicated to a county or municipality, we recommend that communities encouraging landowners to use green infrastructure practices employ a program using restrictive covenants for maintaining all stormwater management practices on private property. These agreements should be filed in land records, so they are perpetual and subsequent owners know their responsibilities.

If a fee system established to fund stormwater management allows credits for the use of green infrastructure practices, as we recommend above, periodic performance monitoring and compliance reporting (perhaps every 3-5 years) should be included with green infrastructure measures to promote long-term reliability and performance. Such monitoring and reporting will ensure that the green infrastructure is still performing as designed in order for landowners to continue to receive their credits. The State, counties or municipalities should establish easement authority to enter properties receiving compliance credit for green infrastructure practices, and to charge responsible parties who neglect to maintain their green infrastructure features, similar to the nuisance regulations currently used to prevent neglect of conventional landscape maintenance. Based on the compliance reports, municipalities can then enter the property to undertake maintenance if the landowner is unwilling or unable to do so, and then charge the landowner or Home Owners Association for these services.

As part of our recommendation that the State encourage local governments to utilize a stormwater fee system instead of general tax revenues for stormwater management, these governments should also consider establishing stormwater utilities with budgets that are independent of wastewater and drinking water budgets. An alternative to landowner maintenance is for such a utility to be given the right and obligation to maintain all stormwater facilities, whether on private or public land, and charge the landowners for the service.

Because monitoring is so critical to maintaining stormwater facility effectiveness (and for ensuring that any landowners taking advantage of any credits against stormwater fees for using green infrastructure continue to qualify for such credits), Illinois EPA should work with county and local officials, regional stormwater management agencies, soil and water conservation districts, and drainage districts to begin to develop uniform protocols for the green infrastructure compliance monitoring and state-wide guidance for the reporting requirements.

RESEARCH NEEDS

There are substantial gaps in the peer-reviewed data on the effectiveness of many green infrastructure and low impact design strategies. For example, published data are absent for numerous types of green infrastructure, important details regarding infrastructure design and scaling are often missing from published accounts, and little information is available about the use of multiple infrastructure in combination in treatment trains or across watersheds. Filling in these data gaps is essential if we are to clarify our understanding of green infrastructure and inform policy decisions. In the meantime, however, the multiple benefits of green infrastructure that we described here have been repeatedly observed by professionals in the field, including engineers, architects, planners and developers. There is adequate information based on the experience of these experts to move forward with policies and regulations to establish a variety of stormwater performance standards and promote the use of green infrastructure to meet them.

Experience with many types of green infrastructure has shown them to be very effective, even though they have not yet been subjected to rigorous scientific analysis. Urban forestry, rain barrels and cisterns, disconnected downspouts, street sweeping, source control and education are a few additional approaches and infrastructure practices that may mitigate stormwater runoff but have little published data to support them. The first three techniques promote decentralized interception and infiltration or storage of rain before it can become runoff. Urban forestry reduces runoff volume and improves water quality through evaporation, transpiration, and infiltration of rainwater (Van Roon 2005). Street trees function similarly to bioinfiltration infrastructure when they are planted in engineered structural soils designed to improve water conduction (Bartens et al. 2009). While they are not a new technology, rain barrels and cisterns can also be used to store rainwater for non-potable uses or adapted to slowly release water and act as infiltration systems (Larson and Safferman 2008, Gilroy and McCuen 2009). Similarly, disconnecting downspouts from stormwater systems and directing the water into permeable soils can be effective at reducing runoff volume by essentially creating a decentralized network of small-scale infiltration systems (Coffman 2000). In Portland, Oregon, a program that gave homeowners a financial incentive to disconnect downspouts resulted in a decrease of 4.2 million cubic meters of runoff annually in the combined sewer system (Montalto et al. 2007).

To bolster the results shown in these case studies, more scientific data on the effectiveness of these techniques at reducing runoff volume, peak flow, and pollutant loads would be useful. Furthermore, source control methods such as street sweeping and public education have not been extensively evaluated in the literature, but show promise for pollution prevention. Studies have shown that a 15% reduction in pollutant loads can be achieved on a catchment scale by reducing nonpoint source pollution before it enters stormwater (Davis and Birch 2009). Street sweeping has been shown to reduce sediment mass by more than 55% (Tobin and Brinkman 2002). Public education regarding stormwater management has become widespread as municipalities have marked storm drains “Drains to River”. Unpublished data from Madison, Wisconsin, indicate that residents in neighborhoods where these messages have been stenciled are more likely to be aware of stormwater issues (Packer and Shepard 1999).

Another area for future research is the effectiveness of combining multiple green infrastructure systems at both the site and watershed scale. At the site scale, treatment trains, systems in which runoff flows through two or more green infrastructure before flowing out into receiving water bodies, deserve serious consideration as a green infrastructure strategy. To date, limited research has been conducted to determine how combining multiple green infrastructure impacts stormwater quality. Greb (2000) found that a multi-chambered treatment train with a detention chamber, a settling chamber, and a filtration chamber reduced TSS event mean concentrations (EMC) by 98% and nitrate EMC by 32%. However, results of other studies have been mixed (Roseen et al. 2009). Effectiveness likely depends upon the infrastructure included in the treatment train, and further research is needed to determine the most effective combinations. At the watershed scale, it is not always clear whether the installation of multiple green infrastructure practices will have an additive effect on downstream water quality, flooding, or erosion risk.

An obvious large-scale stormwater management strategy is reducing impervious cover in new development. Cluster development, for example, which concentrates buildings on a small portion of a development property, and other techniques for reducing impervious cover may reduce runoff volume and improve water quality (Hood 2006). Creating compact developments by narrowing streets and concentrating buildings in small portions of catchments increases the percentage of pervious surface (Van

Roon 2005). Studying the effectiveness of these development strategies in the field is difficult because it requires paired drainage designs; however studies conducted thus far have shown that these techniques can be successful (Hood et al. 2007).

There is also a need for more consistent reporting of green infrastructure performance. For example, most sites we found in the literature have not been included in the U.S. Environmental Protection Agency's International Stormwater BMP Database. IEPA should work with county and local officials, regional stormwater management agencies, soil and water conservation districts, and drainage districts to begin to develop uniform protocols for green infrastructure compliance monitoring and state-wide guidance for the reporting requirements. Developing uniform protocols for the monitoring of green infrastructure performance and submitting the data from selected appropriate case studies to the International BMP Database will provide a larger and more consistent dataset and will assist practitioners with selecting the most appropriate green infrastructure practices for each project.

1

APPENDIX I: ENHANCING THE WILDLIFE HABITAT VALUES OF GREEN INFRASTRUCTURE

A number of green infrastructure practices can be designed to provide wildlife habitat. By carefully selecting the vegetative species used, making slight modifications in site design, or implementing maintenance practices that enhance wildlife use, some green infrastructure categories can support wildlife while also storing, improving, or infiltrating surface water.

Infiltration Areas and Buffers(or vegetative filterstrips)

Infiltration areas such as bioretention areas, swales, and infiltration basins, can be designed as discrete isolated structures or as linear features (swales). In either case, infiltration areas may need to be designed to handle concentrated flow or may be submerged for relatively short periods of time following storm events. Buffers, also referred to as vegetative filterstrips, are strips of vegetation located along streams, watercourses or wetlands. They generally are not designed for concentrated surface flow (as in swales or grass waterways) and are inundated only during natural flooding cycles. However, both of these types of green infrastructure are designed to perform the following functions: capture sediments, slow down water flow, allow water to infiltrate into the soil, sequester nutrients or pollutants attached to sediment particles or dissolved in water, allow for vegetative uptake of nutrients, and to potentially provide the substrate microbes need to break down pollutants or reduce nutrients (such as ammonia or nitrite) to other forms.

In every case, vegetation must be selected that meets the design criteria for the water quality or water quantity objective of the green infrastructure. It is possible to select vegetation that will meet the primary criteria and in addition provide valuable wildlife habitat (Macgowan and Miller 1999, Miller and McCreedy 1997). The USDA Natural Resource Conservation Service (NRCS) has developed specific management recommendations that meet water quality goals while providing beneficial habitat for target wildlife species (USDA-NRCS Fish & Wildlife Habitat Management Leaflets http://www.whmi.nrcs.usda.gov/technical/leaflet.htm). In each state, the NRCS convenes a technical committee composed of wildlife biologists and technical design experts to develop technical design, species mixes and planting standards for every approved practice that are state specific and designed to provide the best habitat for wildlife in that state (USDA-NRCS. Indiana NRCS Field Office Technical Guides http://efotg.nrcs.usda.gov/toc.aspx?CatID=4288). The Illinois Field office Technical Guide that contains these recommendations can be found at http://efotg.nrcs.usda.gov/treemenuFS.aspx . Grasses, trees, and shrubs are acceptable cover types for these practices. Use of all three cover types will enhance wildlife diversity. Filter strips and infiltration areas can be improved for wildlife by incorporating one or more of the following considerations (Macgowan and Miller, 2002).

- The grass species planted depends upon the site conditions, the grade of the slope, and the amount of sediment and contaminants in the runoff. If the slope is relatively steep and/or if the filter strip incurs a concentrated flow rate, high sediment, or contaminant load, then mixes of sod forming grasses (e.g., switchgrass or redtop) planted at high densities may be necessary. Planting fescue should be avoided when possible. If fescue must be planted, a low endophyte fescue (eg. Johnstone, Fawn, Kenhy, Forager vars.) should be used. Fescue endophyte is a fungus that grows between the cells of a tall fescue plant. High endophyte fescue (eg. Ky31 var.) has been found to reduce litter sizes in some species such as rabbits.

- If concentrated flow or high sediment conditions are not present (or concentrated flow areas are being expanded with additional width), then the above grass mixtures can be planted at lower densities or a grass/legume combination (such as clover, annual lespedeza or partridge pea), or native warm-season bunch grass mixtures (Macgowan 2001) suited to the soil and site conditions can be selected. Grasses are an excellent source of cover for many wildlife species, however, bunch grasses (grasses that do not form a sod) provide spaces for wildlife to move through making them particularly valuable for winter and brood cover.

- Adding forbs (non-woody plants other than grass, i.e., wildflowers and legumes) (Macgowan and Miller 2002 Table 2, page 11 and Table 3, page 12) to grass plantings will enhance its value to most wildlife species. Forbs provide a source of food and structure that attracts insects.

- When not restricted by local or regulated drain regulations, the addition of shrub species provide escape cover for many species and provides valuable nesting habitats for shrubland bird species, many of which are declining in the central hardwood region (Dettmers 2003, Hunter et. al 2001, and Herkert 1995). Shrub species suited to soil type provide food and nesting habitat for wildlife (Macgowan and Miller 2002 Table 4, pages 13-16). Placing one row of shrubs closest to the stream helps stabilize the stream bank while providing a setback for the first row of trees. This may be concern along watercourses with heavy scour erosion. In these situations, trees that are set back from the stream edge are less likely to fall into the stream in later years; however, they are still close enough to provide shade to the stream. Designing plantings with irregular edges will increase the edge and interspersion for many early successional and shrub dependent species (Thompson and Dessecker 1997).

- Select tree species that provide food and/or cover for wildlife (Macgowan 2003, Macgowan and Miller 2002 Table 5, pages 17-22). For example, many native tree species adapted to soil conditions along streams are excellent wildlife trees. A tree planting containing many species provides a diversity of food and structure. Thus, it becomes more valuable for wildlife than a planting that only contains one or two tree species. Planting a variety of tree species also minimizes the chance of incurring a high mortality rate due to micro site variability and potential diseases that might inflict the stand.

- Native plants species adapted to the site conditions should always be used when possible (Macgowan and Miller 2002 Tables 1-6, pages 10-23) to benefit wildlife. A mixture of plant species and habitat types such as grassland, old-field/brushland, and forestland provide escape, nesting, and foraging cover for a wide variety of wildlife species. Plants should be selected that meet the basic requirements of the priority wildlife species for a given planting or area.

Making minor alterations in width, shape, and landscape placement can greatly improve the value to wildlife.

- The minimum width of the filter strip depends upon the percent slope of the drainage area above the filter strip. However to benefit wildlife, filter strips should be designed as wide as possible. The old adage of bigger is better applies here. Many wildlife species utilize filter strips for nesting, cover, and travel ways. Filter strips need to be wide enough to allow nesting animals a chance to hide from mammalian predators that travel the edges of these areas. Filter strips 66 feet wide or greater on each side of the waterway provide good cover for wildlife, while meeting the setback requirement on the atrizine label and program requirements of NRCS programs – (USDA-NRCS 2008. Conservation Practice Standard 393 –Filter Strip http://efotg.nrcs.usda.gov/references/public/IN/Filter_Strip.pdf)

Making minor alterations in vegetation management or maintenance will also improve the habitat value for wildlife.

- Minimize or eliminate disturbance (mowing, machine traffic, grazing, etc.) during the nesting season (prior to August 15). Repeated mowing during the growing season prior to establishment is necessary for establishment of cool season grasses and control of weeds. Once established, mow the grassed waterway in a 2 to 3 year rotation so that only 1/2 to 1/3 of it is mowed in a given year. This will maintain the integrity of the waterway while providing some winter cover and early-spring nesting habitat for wildlife. Mow cool-season grass no shorter than 6 inches and native warm-season grass no shorter than 10 inches. (Macgowan and Miller 2002)

Constructed Wetlands

Wetland benefits and values include storm water storage, ground water recharge, nutrient recycling, sediment filtering, and wildlife habitat. The appearance, character and function of wetlands vary depending on the depth of the water, length of flooding and characteristics of the surrounding land. The different types of wetlands provide a unique array of habitats for many species of wildlife (Miller 1990, Mitsch and Gosselink 1986).

Constructed wetlands can be designed to enhance one or all of these values. One concern with constructed wetlands is that if they are designed to accumulate pollutants that can be harmful to wildlife, then they should be managed to discourage wildlife from using the affected areas. A classic example is the Kesterson National Wildlife refuge in California that received drainage water from agricultural areas to fill their wetlands used by migrating waterfowl. Selenium leaching from the farmland built up in the wetlands and began causing deformities in ducklings raised there. Consequently, the wetlands were drained and or managed to discourage waterfowl form using them (Ohlendorf et. al 1986, Popkin 1986).

Since that time, a systems approach has been used in wetland restoration and creation when wildlife habitat is a goal. Sediment traps, wetland treatment cells, and other bioremediation structures are often designed to receive polluted runoff at the beginning of the system (or at the top of the watershed) (Miller et. al 2000). These structures are designed to remove the pollutants harmful to wildlife and are designed to receive regular maintenance. Often redundant systems are built so one is performing while another is undergoing renovation (Reaves et. al 1994). Structures designed for this purpose are not designed to contain vegetation or structural characteristics that would be attractive to waterfowl and other aquatic wildlife. However, when wildlife habitat is a goal, additional wetlands are built or restored downstream of these initial structures. In these wetlands, nutrients and pollutants not harmful to wildlife (such as N and phosphates) can be removed while producing productive wildlife habitat. This systems approach also mimics the way natural wetlands are located and perform in a watershed (Van Der Valk, 1989).

Plant selection

Suitable environments for both aerobic and anaerobic microorganisms are present in the wetland and carry out the biological processes necessary to remove or transform pollutants such as nitrates, phosphates, ammonia, manganese, sulfur, and carbon carried by the water. Microbes (microscopic organisms) provide most of the treatment. Plants in the wetland remove nutrients and improve aesthetics, but their primary function is to provide a surface area for the growth of microbial films. More plant stems in the water column translate into more microbes cleaning the water. System design and operation should be aimed at enhancing features that improve these characteristics of the wetland system (Miller et. al 2003). Plants that have wildlife value and are suited to the wetland physical and chemical conditions should by favored and encouraged through planting or proper management (Lembi, 2003)

Sizing

Local or state regulations often mandate that constructed wetlands be sized for a 25 year, 24-hour storm event. However, there is flexibility in how a specific system will comply with this requirement. Individual components of the constructed wetland system can be sized to accommodate this level of water flow. If wetland cells are sized to retain open lot runoff from an extreme storm event, there will be insufficient water during the dry parts of the year to maintain plants and microbial populations beneficial to wildlife. If the wetland system dries, microbes will be lost. When water is returned to the system, treatment will be greatly reduced because of the lack of microbes. A significant amount of time will pass before these organisms are reestablished. This problem can be overcome by placing a structure with water storage capacity upstream of the wetland system, an arrangement that allows gravity to do the work of moving additional water through the system as needed. Upstream storage capacity also allows for wastewater to be captured during wet times of the year, typically winter and spring when a wetland system will not provide a high level of treatment. Wastewater can be held and released during warmer and drier parts of the year when wetland treatment will be at its peak. Captured precipitation can also be used as dilution water, reducing the possibility of overloading the system with a sudden pulse of wastewater with a high concentration of contaminants. Upfront storage capacity of both contaminated and fresh water allows greater control of water levels and water quality in the constructed wetland system throughout the year and can therefore enhance wildlife habitat value and use. (Miller et. al 2003).

System size is important in determining how well the wetland functions. A wetland should be sized to accommodate the normal expected flow, including rainfall, but should be conservative in treating contamination levels in the wastewater. For example, BOD (Biochemical Oxygen Demand) should be below 50 pounds per day per acre and nitrogen levels should be below 400 ppm (parts per million) for incoming wastewater, and preferably below 200 ppm. Samples of typical wastewater that will be treated by the constructed wetland should be analyzed to determine the expected levels of ammonia, nitrates, phosphates, and BOD. This will provide a more accurate basis for sizing the treatment system rather than relying on typical published values. Wetland cells should be sized to allow for 7 to 14 days retention time, meaning it will take 7 to 14 days for water to move from the inlet to outlet of the system. The quality of water exiting the system is dependent on the quality of water coming in and the length of time the water is retained (Miller et. al 2003).

Enhancements for Wildlife Habitat

The best rule to follow when designing a wetland with wildlife habitat management objectives as a priority, is more diversity equals more wildlife (Macgowan and Miller 2002 . Therefore, increasing the size, the diversity of water depths, and the number of plant species maximizes its value for wildlife. Cole et al. (1996) recommended the following design considerations:

• Install water control structures. They can be used to more accurately control water levels, and to allow for draw-downs to control or enhance wetland vegetation.

• Larger wetlands generally support more diverse plant and wildlife communities. Wetlands ranging in size from 0.5 to 5.0 acres can be expected to support a reasonably diverse wildlife community.

• Irregular shapes promote more structural diversity in and around the wetland basin. Coves, peninsulas, islands, and rough shorelines provide more habitat types.

• Gentle slopes (1:10) result in exposed mudflats and a diversity of emergent plants. These areas are used by many bird, amphibian, and reptile species. Plan for a high diversity of slopes with a higher percentage of gentle slopes.

• Providing variety of depths results in a diversity of plant communities, and subsequently, wildlife. Emergent plants favor depths less than 18 inches and are favorite habitats of dabbling ducks, herons, and frogs. Submergent and floating plants prefer water depths 18 to 48 inches. Depths greater than 6 feet provide permanent water. However, wildlife tends to be much more diverse and abundant in wetlands that are dominated by shallow (<3 feet) water.

Detention/Retention Areas

Detention basins can provide wildlife habitat benefits as one of the multiobjective uses for detention areas (Chuanqi 2009). Detention areas are designed to detain water in a manmade pond to reduce peak flow and allow pollutants to settle. One concern with detention areas is that if they are designed to accumulate pollutants that can be harmful to wildlife, then they should be managed to discourage wildlife from using the affected areas (fencing, wildlife deflecting devices, preventing attractive vegetation from establishing, covering the open water areas, designing systems with no surface flow, systems that drain within a few days of storm events; see the discussion of the Kesterson National Wildlife refuge above).

A treatment train approach can be used for detention/retention areas when wildlife habitat is a goal. Sediment traps, wetland treatment cells, and other bioremediation structures can be designed to receive polluted runoff at the beginning of the system. These structures are designed to remove the pollutants harmful to wildlife and also to receive regular maintenance. Often redundant systems are built so one is performing while another is undergoing renovation. Structures designed for this purpose are not designed to contain vegetation or structural characteristics that would be attractive to waterfowl and other aquatic wildlife. Additional retention areas containing open water and aquatic habitats can be built or restored downstream of these initial structures. In these areas, nutrients and pollutants not harmful to wildlife (such as N and phosphates) can be removed while producing productive wildlife habitat.

When contaminant loads that would deem an area unacceptable as wildlife habitat are not present, detention areas that retain water for extended periods of time can be designed to contain the structural components and vegetative structure of natural aquatic habitats. Different types of wetlands attract different communities of wildlife. Therefore, aquatic habitat design should reflect habitat requirements of desired species, or suites of species. For example, if you would like to manage for waterfowl, then a wetland with a 50/50 mix of open water and aquatic emergent plants is ideal.

The water depth for dabbling ducks (mallards, teal, wood duck, etc.) should not exceed 18 inches and should include depths <12inches. Generally, aquatic emergent plants grow in shallow areas less than 18inches in depth. They are important because these plants provide food and cover for many species of wildlife such as waterfowl, reptiles, amphibians, and the invertebrates they depend on for food (Macgowan and Miller 2002). Detention areas retaining water for extended periods can be designed in a terrace fashion creating shelves at 18 inch depths or less around the basin at different pool gradients. This results in flat bands of vegetation submerged vegetation required by wildlife. Such a design also provides a shallow shelf along deeper pools allowing a margin of safety when human access is allowed.

Deep-water areas provide habitat for diving ducks and many fish species. They are important to migrating (waterfowl, water birds) and overwintering (fish) wildlife. Predators of mosquitoes require deeper water refuges (usually > 8 feet that won't dry out easily (Knipp et. al 2008). Many birds, frogs, fish, and insects (dragonflies, damselflies, water striders, backswimmers, and diving beetles), all natural enemies of mosquitoes, inhabit wetlands having these characteristics ((Ladd and Frankenberger 2003).

Managing wetlands for fish populations is not compatible for all management goals. For example, fish management is compatible with waterfowl management, but not for amphibian species since fish are one of their primary predators (Macgowan and Miller 2002). Upland areas of dry detention or extended dry detention basins can be managed for wildlife using the upland habitat principles described above (Iowa Stormwater Management Manual, version 2 2008).

APPENDIX II: SUCCESSFUL GREEN INFRASTRUCTURE PROJECTS IN NORTHEASTERN ILLINOIS

Despite the many perceived barriers to green infrastructure, numerous successful projects have been implemented throughout northeastern Illinois. The following are a few of these projects and by no means is meant to describe all of the completed projects.

The Morton Arboretum[57] in Lisle, Illinois undertook a number of projects in 2004, one of which included the installation of permeable paving blocks in the visitor's parking lot (see Figure 9). The parking lot was installed to improve the water quality of stormwater runoff. The project has been an overwhelming success and has become an attraction at the Arboretum. The parking lot also utilizes bioswales to further provide water quality benefits. Arboretum staff have said that minimal maintenance has been required on the parking lot since installation and they have not observed decreased performance from the permeable pavers over the past five years.

Figure 9: Morton Arboretum Visitors' Parking Lot[58]

The Ryerson Woods Welcome Center[59] in Riverwoods, Illinois is a Lake County Forest Preserve District Building that utilizes green building techniques. The site design incorporates the use of rain gardens, porous asphalt and rainwater harvesting. This site has become an educational demonstration site where people can learn about the techniques being used. There are cutouts within the interior of the building for visitors to see the rainwater harvesting system and how it would be used as a water source for the fire sprinkler system. Collected water is also used to water the native plantings during dry periods. The building also incorporates recycled and recyclable materials, natural temperature control and natural lighting. See Figure 10.

[57] http://www.mortonarb.org/sustainable-practices/environmental-parking.html
[58] http://www.mortonarb.org/sustainable-practices/environmental-parking.html
[59] http://www.lcfpd.org/ryerson_woods_center/index.cfm?fuseaction=home.green_building_strategies

Figure 10: Ryerson Woods Welcome Center[60]

The Villa Park Police Station,[61] in the Village of Villa Park, was a redevelopment site that incorporates the use of a green roof, porous pavement and bioretention swales (see Figure 10). This site was able to take detention credit for the void space in the gravel layer below the parking lot because it is a small site (less than 1 acre). This project also had a monitoring component which will be able to provide the Village and the site designer's important information on the long term performance of the green infrastructure on site. The site was modeled and designed to reduce the 100-year, 24-hour storm event from 4.4 cfs in existing conditions to 0.07 cfs in proposed conditions.

Figure 10: Villa Park Police Station Green Roof[62]

[60] Presentation by Nan Buckardt at Chicago Metropolitan Agency for Planning, Water 2050 Summit, 3/22/2010
[61] Presentation given by Tom Price at IAFSM Conference and email correspondence dated 2/19/2010 from Tom Price
[62] http://www.dupageco.org/dec/generic.cfm?doc_id=4286

Elmhurst College in Elmhurst, Illinois recently built a new residence hall, West Hall[63] which incorporates the use of underground rainwater cisterns, permeable paver parking lot and bioswales with native plantings[64] (Figure 12). The college has made a commitment to green infrastructure and sustainability. West Hall also incorporates a number of sustainable practices such as lighting features, water efficient fixtures and use of local materials for construction. The project received support from the Illinois Department of Commerce and Economic Opportunity and DuPage County Stormwater Management Division. The College views the project as a success and has observed student interest in the building.

Figure 12: Elmhurst College West Hall Permeable Paver Parking Lot and Bioswales[65]

Lake County, Illinois recently completed construction of the New Lake County Central Permit Facility (Figure 13) that now acts as a one-stop shop for customers needing building permits within Lake County.[66] The building incorporates a number of BMPs and green infrastructure and was partially funded by an Environmental Protection Agency Section 319 Grant. The site contains three rain gardens, bioinfiltration swales (4,830 square feet), vegetated swales (26.831 square feet) and two wetland detention basins. The rain gardens are estimated to reduce runoff and pollution by 55-90%.

[63] http://public.elmhurst.edu/news/ecscene/31102584.html
[64] http://www.theconservationfoundation.org/BMPSeminar2010/site%20230%20Elmhurst%20College.pdf
[65] http://www.theconservationfoundation.org/BMPSeminar2010/site%20230%20Elmhurst%20College.pdf
[66] http://www.lakecountyil.gov/centralpermitfacility/default.htm

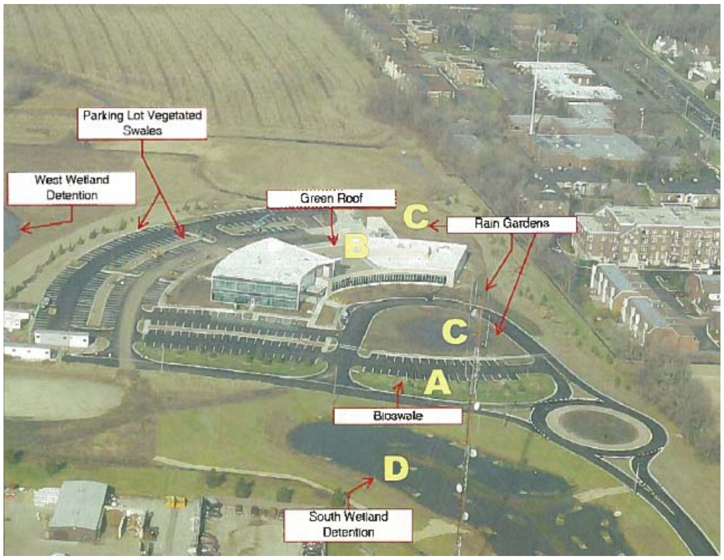


Figure 13: Lake County Central Permit Facility[67]

The City of Chicago developed the Green Alley Program in 2006 (Figure 14). The program retrofits existing alleys that have existing flooding issues. The specific design of each Green Alley is somewhat flexible to address the unique needs of the project but typically incorporates permeable pavements, open bottom catch basins, recycled materials and other green techniques[68]. The City has developed The Chicago Green Alley Handbook with design details and describes the benefits of the different components[69].

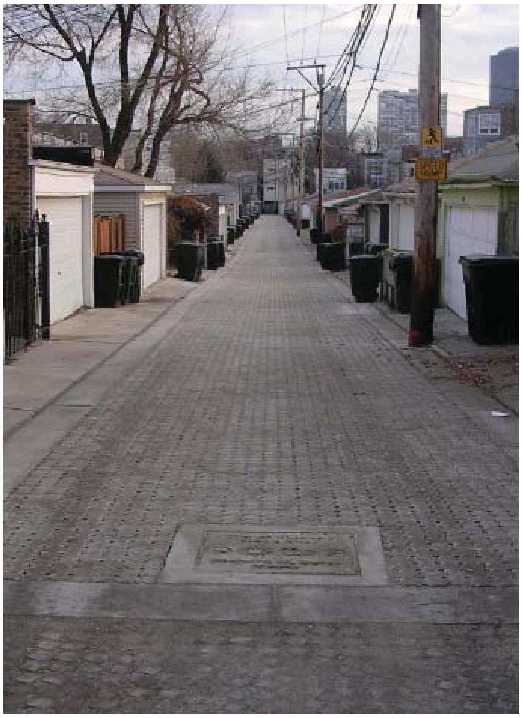


Figure 14: An Example of Chicago's Green Alley Program[70]

[67] Handout provided by Lake County at the Lake County Stormwater Management Commission Technical Advisory Meeting on 5/21/2010

[68] http://www.cityofchicago.org/city/en/depts/cdot/provdrs/alley/svcs/green_alleys.html

[69] http://www.cityofchicago.org/content/dam/city/depts/cdot/Green_Alley_Handbook_2010.pdf

[70] http://www.cityofchicago.org/content/dam/city/depts/cdot/Green_Alley_Handbook_2010.pdf

APPENDIX III: ACKNOWLEDGMENTS

A large number of individuals provided information to us about state and local urban stormwater management programs using green infrastructure.   The state contacts we interviewed are listed in Chapter IV, under each state program description. Those who provided us with information about local programs in Illinois are: **Andrew Billing**, Consultant to City of Chicago, Department of Buildings, Stormwater Management, Mackie Consultants ; **Tony Charlton**, Director, DuPage County Stormwater Management; **Greg Chismark**, Executive Vice President, Wills Burke Kelsey Associates, Consultant for Kendall County; **Joanna Colletti**, Permit Engineer, Lake County Stormwater Management Commission; **Jerry Dudgeon**, Director, Kendall County Planning, Building and Zoning; **Maureen Durkin**, Principal Civil Engineer, Engineering Department, Metropolitan Water Reclamation District of Greater Chicago; **Dan Feltman**, Development Coordinator, City of Aurora-Engineering Division; **Howard Hamilton**, President of Robert E. Hamilton Consulting Engineers; **Timothy Harbaugh**, Director, Kane County Department of Environmental and Building Management; **Clayton Heffer**, Stormwater Permitting Manager, DuPage County Stormwater Management; **Jim Kleinwachter**, Land Protection Specialist, The Conservation Foundation; **Erik Morimoto**, Assistant City Engineer, City of Crystal Lake; **John Murray**, Senior Civil Engineer, Metropolitan Water Reclamation District of Greater Chicago; **Derek O'Sullivan**, Assistant Director Will County Stormwater Management Planning Committee; **Stephane Phifer**, Director of Planning and Zoning, City of Aurora; **Mark Phipps**, Chief Stormwater Engineer, McHenry County Department of Planning and Development; **Tom Price**, Director of Water Resources Engineering, Conservation Design Forum; **Joseph Rakoczy**, Supervising Civil Engineer, Metropolitan Water Reclamation District of Greater Chicago; **Victor Ramirez**, Director of Engineering and Building/City Engineer, City of Crystal Lake ;**Michelle Rentzsch**, Director of Planning & Economic Development, City of Crystal Lake; **William Sheriff**, Assistant Director of Engineering, Metropolitan Water Reclamation District of Greater Chicago; **Robert Swanson**, Water Quality Specialist, DuPage County Stormwater Management; **Michael D. Warner**, Executive Director, Lake County Stormwater Management Commission; **Josh Wheeler**, City Engineer, City of North Chicago; **John Wills**, President, Wills Burke Kelsey Associates, Consultant to DuPage County; **Kurt Woolford**, Chief Engineer, Lake County Stormwater Management Commission .

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