U.S. House of Representatives
Committee on Transportation and Infrastructure
Washington, DC 20515

James L. Oberstar
Chairman

David Heymsfeld, Chief of Staff
Ward W. McCarragher, Chief Counsel

John L. Mica
Ranking Republican Member

James W. Coon II, Republican Chief of Staff

March 18, 2009

SUMMARY OF SUBJECT MATTER

TO: Members of the Subcommittee on Water Resources and Environment

FROM: Subcommittee on Water Resources and Environment Staff

SUBJECT: Hearing on Efforts to Address Urban Stormwater Runoff

PURPOSE OF HEARING

On Thursday, March 19, 2009, at 10:00 a.m., in Room 2167 Rayburn House Office Building, the Subcommittee on Water Resources and Environment will receive testimony from: the National Research Council; the United States Environmental Protection Agency; Dallas, Texas; Kansas City, Missouri; Milwaukee, Wisconsin; Philadelphia, Pennsylvania; Portland, Oregon; the National Association of Clean Water Agencies; the National Association of Flood and Stormwater Management Agencies; and the Natural Resources Defense Council. The purpose of this hearing is to gather information on the utility of green infrastructure and low impact development technologies and approaches in addressing urban stormwater runoff, as well as barriers towards implementing these technologies and approaches.

BACKGROUND

This memorandum summarizes stormwater, its impacts on water quality, and traditional regulatory and technological approaches for addressing stormwater discharges. It also introduces technologies and approaches that encourage stormwater infiltration and evapotranspiration – commonly known as green infrastructure or low impact development technologies or approaches. These approaches can assist in the reduction of overall volumes of stormwater in sewer systems, thereby limiting the potential for the discharge of untreated stormwater and lessening conventional infrastructure construction and maintenance costs for municipalities.

Urban Stormwater Runoff

Stormwater: From a hydrologic perspective, stormwater runoff is the water associated with a rain or snow event that flows off the surface and can be measured in a downstream river, stream, ditch, gutter, or pipe shortly after the precipitation has reached the ground.[1] From a regulatory perspective, stormwater can impair water quality and is subject to water quality regulations when it is discharged from a point source, such as a gutter, pipe, or concrete canal. Precipitation that runs as sheet flow over the ground surface directly into a water body is not regulated stormwater. Nevertheless, non-point source surface runoff can impair water quality as well.

In terms of impacts on water quality, stormwater can be characterized along at least three dimensions: volume; rate of flow; and constituents carried in it.

Urbanization and Stormwater: The creation of impervious surfaces through urbanization has significant effects on the manner in which water moves both above and below ground during and after wet weather events. Urbanization is the transformation of land use from a natural, forested, or agricultural use to suburban or urban areas. The impervious surfaces associated with urban areas include roofs, streets, and other hardened surfaces that do not allow for infiltration of precipitation into the soil. In 2002, the Pew Ocean Commission and the National Oceanic and Atmospheric Administration (NOAA) estimated that there are 25 million acres of impervious surfaces across the continental United States. This represents nearly one quarter of the 107 million acres of developed land across the nation.

Natural landscape features help to mitigate the impacts of stormwater – in terms of both flow and constituents contained within it. Trees, vegetation, and open space capture or slow-down the flow of rain and snowmelt. This facilitates the infiltration of water into the ground. Infiltrated water enters groundwater or can reconnect with nearby surface waters after seeping through the ground. Because the time lag is greater in the latter case, the flow volumes, at any one point in time, into these nearby waters are considerably lower. The U.S. Environmental Protection Agency (EPA) has found that under natural conditions the amount of rain that is converted to runoff is less than 10 percent of the rainfall volume.[2]

In 2007, the U.S. Census Bureau determined the population of the United States was growing at an annual rate of 0.9 percent. The patterns of population growth across the country are weighted towards urban and suburban areas. Therefore, the influences resulting from urban and suburban land use are growing at a faster rate than the overall population rate. In addition, the urban environment is in constant transformation. A 2004 Brookings Institute analysis found that 42 percent of urban lands will be redeveloped by 2030. Dr. Arthur Nelson, at the University of Utah, determined in a 2007 study that, by 2050, 89 million new or replaced homes and 190 billion square feet of new offices, institutions, stores, and other non-residential buildings will be constructed. In other words, two thirds of the development on the ground in 2050 will be built between 2007 and then. These figures indicate both challenges and opportunities. Increased population growth and an increased proportion of urban land use will result in greater volumes of stormwater entering the

[1] The National Research Council notes that what constitutes 'shortly' depends on the size of the watershed and the efficiency of the drainage system. In a small and highly urban watershed, the temporal interval between rainfall and measured stormwater discharge may be very short, a matter of minutes. For large and undeveloped watersheds, the temporal lag may be multiple hours. (National Research Council. 2008. *Urban Stormwater Management in the United States*)
[2] U.S. EPA, 2003. *Protecting Water Quality from Urban Runoff.* EPA 841-F-03-003.

nation's waters. However, the redevelopment that is anticipated to occur offers opportunities to mitigate the harmful impacts of stormwater.

Stormwater runoff that is carried across impervious surfaces can impair water bodies along three dimensions: volume; rate of flow; and constituents. First, impervious surfaces do not allow infiltration to occur. Therefore, the volumes of water entering a given water body will be greater than when the land is in a natural state. Increased volume can result in localized flooding and erosion of stream banks. Second, the flow of stormwater along impervious surfaces and gutters or pipes is faster than if stormwater was running across open, undeveloped ground. When this higher rate of flow enters a water body it can result in flooding, as well as erosion, or scouring, of stream beds and banks. Third, stormwater running across an urban or suburban landscape will pick up and carry with it constituents that it encounters. These constituents are then carried into water bodies, sometimes untreated (see section below), and can result in potential water quality impairments. These constituents include: bacteria and pathogens from pet waste; metals from automobiles and roof shingles; nutrients from lawns, gardens, organic matter, trash, and atmospheric deposition[3]; oil and grease from vehicles; pesticides from lawns and gardens; sediment from construction sites and roads; chemicals from automobiles and industrial facilities and processes; and trash and debris from multiple sources.

Sewer System Types & Stormwater: Stormwater runoff, in urban areas, is usually initially captured in curbside gutters and by stormwater drains.

Most U.S. cities have separate stormwater sewer systems through which stormwater flows directly into waterways. Stormwater that travels through separate stormwater sewer systems is typically not treated before discharge into a water body. As a result, any constituents picked up by the stormwater are carried into these water bodies. The water bodies are also subject to higher volumes and rates of flow, as discussed above, in cities that use separate storm sewer systems.

However, 746 other municipalities, located in 31 states and the District of Columbia, use another sewer collection configuration, commonly referred to as combined sewer systems. These municipalities are primarily located in the northeast, the Great Lakes, the Ohio River valley, and the Pacific Northwest. In these systems, stormwater flows into the same pipes as sewage. This combined wastewater (sewage and stormwater) is intended to be treated at wastewater treatment facilities. During dry weather, or small wet weather events, the system works as intended. However, during larger wet weather events, the combined sewer systems can be overwhelmed by the large volumes of stormwater in the system. As a result, the systems are designed to discharge untreated wastewater (untreated sewage and stormwater) into nearby water bodies through outlets known as combined sewer overflows (CSOs). Whether CSO events occur (i.e., the discharge of untreated wastewater through CSO outlets), is contingent on the engineering design of a given sewer system, the topography of a city, and the amount of impervious surface present in the city. Depending on these factors, a CSO event in a given city may occur in only heavy wet weather events, in other cases during light rain events, and in others, during dry weather. The age and condition of a CSO system (for example, blockages in the sewer system) may play a role in determining whether CSO events occur.

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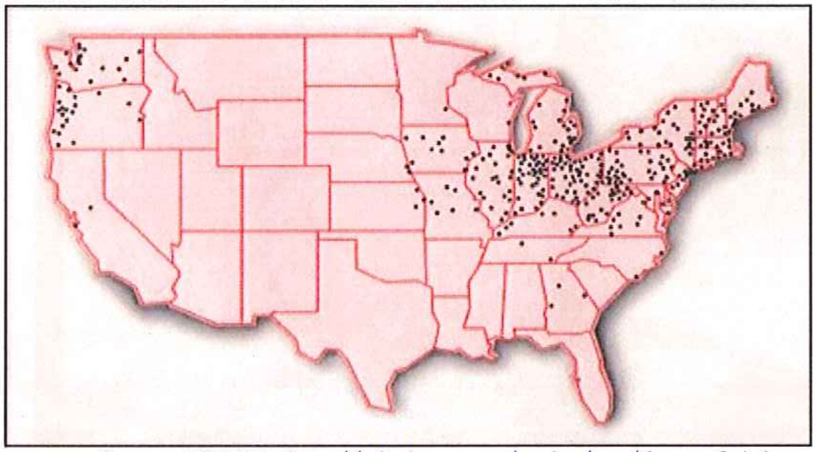
[3] Car emissions and other fuel-burning processes can produce nitrous oxides that can fall-out onto the land through atmospheric deposition.

Graphic: Approximate Locations of CSO Communities in Lower 48 States



Source: US EPA (http://cfpub.epa.gov/npdes/cso/demo.cfm) (accessed 18 March, 2009)

CSO events pose a significant environmental and public health threat as they can include bacteria and viruses.[4] As a result, cities with CSO outlets must often release public health advisories (for example, no swimming, no contact with the water, no fishing) after CSO events. In addition, the untreated sewage can contain nutrients and other oxygen-depleting constituents that can impair water bodies. EPA estimates that 850 billion gallons of untreated sewage and stormwater are discharged annually from CSO outlets.

Stormwater Impacts on U.S. Water Quality: Stormwater discharges – through both separate and combined sewer overflow discharges – have had a demonstrable impact on the nation's water quality. In some developing areas, like the Chesapeake Bay watershed, water quality impairments due to stormwater discharges are growing, relative to other sources.

According to EPA's 2004 National Water Quality Inventory, stormwater is a major source of water quality impairment, of those areas sampled for the report.[5] Urban runoff, including discharges from separate stormwater sewer systems, is responsible for:

- 9 percent of impaired rivers and streams (in terms of miles);
- 7 percent of impaired lakes, ponds, and reservoirs (in terms of acres);
- 12 percent of impaired bays and estuaries (in terms of acres).

Sewage discharges, including CSO discharges, are responsible for:

- 6 percent of impaired lakes, ponds, and reservoirs (in terms of acres);

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[4] EPA has found that the median concentration of fecal coliform in untreated CSO discharges is 215,000 colonies per 100ml, compared to less than 200 colonies per 100ml in treated wastewater. (EPA, 2004. *Report to Congress: Impacts and Control of CSOs and SSOs.* EPA-388-R-04-001).

[5] In its 2004 National Water Quality Inventory, EPA reported that the primary source of pollution of assessed Great Lakes shorelines which were impaired was contaminated sediment from historical, or legacy, toxic pollution. EPA also reported that sewage discharges, including those from CSO events, was the next leading source of impairment.

- 15 percent of impaired rivers and streams (in terms of miles);
- 32 percent of impaired bays and estuaries (in terms of acres).

In 2006, EPA reported that during 2002, 49 percent of all beach advisories and closings that had known sources of impairment were a result of stormwater runoff, and CSO and sanitary sewer overflow events.[6]

Approaches to Controlling Urban Stormwater Runoff

Regulatory: Most municipal stormwater discharges from engineered conveyances, such as gutters, pipes, or concrete canals are regulated as point sources under the Clean Water Act (CWA). As such, they require a National Pollutant Discharge Elimination System (NPDES) permit. The NPDES permitting program for separate stormwater sewer systems is the Municipal Separate Storm Sewer System (MS4) program. It includes Phase I (1990) and Phase II (1999) stormwater regulations that stipulate requirements for separate stormwater sewer systems and industrial activities, including construction. The MS4 permit system typically requires municipalities to develop a stormwater management plan, and to implement best practices. Traditional, end-of-pipe treatment technologies (that might be found at a wastewater treatment facility or with an industrial discharger) are usually not applied because of the large volumes of stormwater involved, because of the complex and decentralized nature of many municipal stormwater conveyance systems, and because of the space constraints associated with urban areas.

Municipalities that have CSO outlets are required to develop and implement short- and long-term strategies to reduce CSO overflows during wet weather events. Long-term CSO control plans must detail procedures and the infrastructure modifications necessary to minimize CSO overflows during wet weather events, and necessary to meet water quality standards. Associated with this, the CWA directs states to develop Total Maximum Daily Load (TMDL) plans for water bodies that are impaired. These should include the pollutant-load reduction measures necessary to meet water quality requirements.

Traditional Infrastructure Methods for Combined Sewer Stormwater Control: The two primary, traditional approaches for addressing CSO discharges involve separating combined sewers (into lines separated and dedicated for sewage and stormwater, respectively) and building deep storage tunnels. Both are very expensive approaches. EPA's 2004 Clean Water Needs Survey estimated that $54.8 billion would be required in capital investment for CSO controls. In its 2004 report to Congress on *Impacts and Controls of CSOs and SSOs*, EPA reported expenditure information from 48 communities that had installed new infrastructure and technologies to control CSO events. These communities spent approximately $6 billion in total, ranging from $134,000 to $2.2 billion per community.

Separating combined sewers involves disconnecting stormwater inlets from the combined sewer system and directing them to a newly installed separate storm sewer system. While this

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[6] 43 percent of all beach closings or advisories were a result of pollution with unknown sources. If these unknown closings and advisories are included, stormwater, CSO events, and sanitary sewer overflow events account for 28 percent of all closings and advisories.

approach eliminates untreated sewage entering water bodies through CSO discharge events, it does increase the total volume of untreated stormwater entering water bodies.

Deep storage tunnels are very large underground storage tunnels that are designed to store the large volumes of combined sewer wastewater that occur during wet weather events. As the wet weather event subsides, wastewater can be slowly released from the tunnel back into the sewer system, ultimately ending at the waste water treatment facility. Deep tunnels, if designed and operated correctly, can significantly reduce CSO discharges. However, constructing deep tunnels is very expensive and can take many years. The table below illustrates examples of cities that have either constructed, or are constructing deep storage tunnels, as well as associated costs.

City	Project Duration	Expected Completion Date	Storage Capacity (gallons)	Cost
Chicago, Illinois	40+ years	2019	18 billion	$3.4 billion
Milwaukee, Wisconsin (Phase 1)	17 years	1994	405 million	$2.3 billion
Milwaukee, Wisconsin (Phase 2)	8 years	2005	88 million	$130 million
Portland, Oregon	20 years	2011	123 million	$1.4 billion
Washington, DC	20 years (after construction begins)	(20 years after construction begins)	193.5 million (proposed)	$1.9 billion (projected)

Green Infrastructure and Stormwater Control: A 'green infrastructure,' or low impact development (LID), approach for stormwater mitigation is premised on the notion that the volume of stormwater should be reduced before entering into stormwater and/or sewage conveyance systems. Green infrastructure approaches for stormwater mitigation provide more opportunities for infiltration or evapotranspiration to occur in a developed landscape – thereby lessening the amount of runoff. Green infrastructure approaches are a proactive response to the problem of impervious surfaces by addressing runoff at the source, as opposed to a reactive response to large volumes of stormwater within the stormwater system.

Green infrastructure can take a variety of forms. Central to all technologies and approaches is the use of the natural environment to manage stormwater naturally by capturing and retaining water, infiltrating runoff, and trapping and filtering constituent pollutants. Examples of green infrastructure include:

- Green Roofs: Outfitting buildings with soil and vegetation on the roof can nullify the impervious nature of most roofs. Instead of immediately washing off a building's roof and into the stormwater system, precipitation is absorbed into the soil where it is absorbed by the vegetation or released slowly into the stormwater system. Precipitation is also evapotranspirated from the vegetation back into the atmosphere;

- Permeable Pavement: Road or alleys can be designed and constructed with materials that allow for increased infiltration of water into the ground;

- Curb Cut-outs: Curb cut-outs are constructed gaps in street curbs that allow for some of the stormwater making its way along street gutters to enter into median strips where it can infiltrate into the ground;

- Rain Swales and Gardens: Rain swales and rain gardens are designed ditches or depressions that contain stormwater during wet weather events. These can hold larger volumes of stormwater than traditional street gutters, slow down the flow of stormwater, and promote infiltration;

- Increased Tree Cover: Planting street trees can reduce stormwater runoff because urban tree canopies intercept rainfall before it hits an impervious surface below (a sidewalk or road). This lessens the volume and rate of flow of stormwater entering the stormwater conveyance system. Trees with mature canopies can absorb the first half-inch of rainfall. Researchers at the University of California-Davis have estimated that for every 1,000 deciduous trees in California's Central Valley, stormwater runoff is reduced by one million gallons;

- Green Space and Buffer Zones: Urban parks and the expansion of green space provide more opportunities for infiltration to occur. This reduces the volume and flow of stormwater entering into the sewer system. Planting vegetation by urban and suburban water bodies can also help to slow stormwater runoff, and capture constituent pollutants contained within the stormwater.

The cost-effectiveness and technical feasibility of incorporating these green infrastructure, or low impact development, approaches can vary. However, in particular circumstances, the incorporation of green infrastructure technologies may offer advantages to municipalities. These approaches reduce the volume of stormwater in the system. Improved infiltration can also help to remove pollutants that had been carried in the stormwater. Green infrastructure approaches can also provide a municipality with site-specific solutions. The nature of the technologies and approaches result in decentralized solutions, as opposed to a traditional, centralized stormwater infrastructure approach, like deep storage tunnels. Decentralized mitigation options, like green infrastructure, can provide city planners with options that may work in constrained urban spaces.

Green infrastructure approaches can also be used in the context of reducing stormwater runoff from highways. For example, in 2008, the California Department of Transportation began installing best management practice technologies along thousands of miles of highways in Los Angeles and Ventura Counties.[7] This is expected to keep more than six million pounds of pollution out of area waters every year.

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[7] Examples of best management practice technologies used by the California Department of Transportation include infiltration basins and trenches (technologies that encourage infiltration), biofiltration swales and strips (technologies that slow the flow of stormwater and capture pollutants using vegetation, and also encourage infiltration), and sand filters (two-chambered stormwater treatment practices; the first chamber is for settling, and the second is a filter bed filled with sand or another filtering media).

Green infrastructure approaches can also offer a number of non-stormwater related ancillary benefits. Some technologies, like green roofs, can help to mitigate urban heat island effects. The placement of vegetation on a roof can help to insulate the building – thereby lowering heating and cooling costs. This can result in significant savings for building managers. The vegetation can also result in significantly cooler temperatures at the top of buildings. Increased vegetation can also help to filter air pollutants. Finally, green infrastructure can yield aesthetic improvements that can increase property values, as well as, in some forms, provide additional recreational space.

The experiences of those cities that have experimented with these approaches have shown that these technologies can be cost-competitive with conventional, 'hard' infrastructure approaches for controlling stormwater. Studies in Maryland and Illinois have shown that new residential developments that use green infrastructure technologies saved $3,500 to $4,500 per lot (quarter- to half-acre lots), compared to new developments with conventional stormwater controls. In addition to lowering these immediate costs, these developments discharged less stormwater. Retrofitting existing buildings and communities with green infrastructure can be expensive, however. For example, adding a green roof to an existing building can be very expensive because structural changes may be necessary. However, taking into account heat savings and insulation that could accrue from the application of this technology can make it more cost attractive.

WITNESSES

Panel I

The Honorable Tom Leppert
Mayor of Dallas, Texas

The Honorable Mark Funkhouser
Mayor of Kansas City, Missouri

The Honorable Tom Barrett
Mayor of Milwaukee, Wisconsin

Panel II

Mr. Mike Shapiro
Acting Assistant Administrator, Office of Water
United States Environmental Protection Agency
Washington, D.C.

Dr. Robert Traver
Professor, Civil and Environmental Engineering
Villanova University
Villanova, Pennsylvania

Testifying on behalf of the National Research Council

Mr. Howard Neukrug, P.E.
Director, Office of Watersheds
Philadelphia Water Department
Philadelphia, Pennsylvania

Testifying on behalf of the National Association for Clean Water Agencies

Mr. Timothy Richards, P.E.
NAFSMA Director and Stormwater Committee Chair
Deputy City Engineer
City of Charlotte, North Carolina

Testifying on behalf of the National Association for Flood and Stormwater Management Agencies

Ms. Mary Wahl
Director, Office of Watersheds
Portland Bureau of Environmental Services
Portland, Oregon

Ms. Nancy Stoner
Co-Director, Clean Water Program
Natural Resources Defense Council
Washington, D.C.