United States General Accounting Office

GAO

Report to Congressional Requesters

June 2001

# WATER QUALITY

# Better Data and Evaluation of Urban Runoff Programs Needed to Assess Effectiveness

GAO-01-679

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**Abbreviations**

| | |
|---|---|
| BMP | best management practices |
| CSO | combined sewer overflow |
| DOT | Department of Transportation |
| DPW | Department of Public Works |
| EPA | Environmental Protection Agency |
| FHWA | Federal Highway Administration |
| MCTT | Multi-Chambered Treatment Tank |
| MDE | Maryland Department of Environment |
| MS4 | Municipal Separate Storm Sewer System |
| NPDES | National Pollutant Discharge Elimination System |
| PAH | polycyclic aromatic hydrocarbons |
| PCB | polychlorinated biphenyls |
| TEA-21 | Transportation Equity Act for the 21st Century |
| TMDL | total maximum daily load |
| USGS | U.S. Geological Survey |
| WDNR | Wisconsin Department of Natural Resources |
| WPDES | Wisconsin Pollutant Discharge Elimination System |

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**United States General Accounting Office**
**Washington, D.C. 20548**

June 29, 2001

The Honorable Olympia Snowe
United States Senate

The Honorable Sherrod Brown
The Honorable Martin Meehan
The Honorable James Oberstar
The Honorable Jack Quinn
House of Representatives

Nonpoint source pollution—that is, pollution from contaminants picked up and carried into surface water by water running over land—is known to be one of the leading causes of water quality problems in the United States. Water that runs over developed areas, including paved surfaces such as roads and parking lots, before reaching a water body is known as urban runoff and is an increasingly important category of water pollution. As urban areas have expanded over the past several decades, the amount of urban runoff has also increased. Although the overall quality of the nation's waters has improved since the passage of the Clean Water Act in 1972, a significant number of water bodies still suffer from poor water quality. Because the act brought discharges from "point sources," such as industrial plants and municipal treatment plants, under control, the continuing pollution of these waters suggests that other sources, including urban runoff, are contributing to water quality problems. As a result, the Environmental Protection Agency (EPA) now classifies urban runoff as a significant cause of impairment to water quality. The Water Quality Act of 1987, which amended the Clean Water Act, required EPA, among other things, to regulate as a point source urban runoff that reaches municipal sewer systems. EPA's National Pollutant Discharge Elimination System Program for storm water requires that certain local governments take measures to control storm water runoff.

Concerned about the degradation of water quality in urban areas, you asked us to report on (1) the amount of runoff from urban areas, particularly from roads, highways, and other impervious surfaces,[1] and its effects on water quality and (2) the programs that federal regulations require local governments to develop to address urban runoff, and the costs and effectiveness of those programs. To address these issues, we reviewed federal and other studies and interviewed experts on the relationship between the amount of paved and other impervious surfaces and the amount of runoff, and on the types of materials typically contained in urban runoff. We also reviewed studies and interviewed experts on the sources of these materials and any actual or potential effects on water quality from urban runoff. We visited five urban areas and organizations that are affiliated with their watersheds[2] to obtain site-specific information about urban runoff problems, programs these areas have implemented in response to federal requirements, and the costs and effectiveness of these programs. Finally, we reviewed studies and estimates of the costs and investment requirements associated with implementing storm water management programs. Because this report focuses on local governments' actions, we did not review the portions of the National Pollutant Discharge Elimination System Storm Water Program that address industrial facilities and construction sites.

We performed our review from August 2000 through May 2001 in accordance with generally accepted government auditing standards.

## Results in Brief

The volume of urban storm water runoff increased throughout the United States in the last half of the 20th century because of the growth in impervious surfaces that resulted from the development of urban and suburban areas. According to the U.S. Department of Agriculture, between 1945 and 1997, land devoted to urban areas in the United States has increased by about 327 percent; according to EPA, paved road mileage has increased by 278 percent. Because paved surfaces are almost impervious, they allow little storm water to infiltrate the ground; therefore, the storm water runs off into creeks, rivers, and lakes. As storm water runs across these impervious surfaces and land, it picks up pollutants from these surfaces and carries them to receiving bodies of water—either directly or

[1]An impervious surface keeps water from soaking into soils.

[2]A watershed is an area of land in which all surface water drains to a common point.

through conveyances such as gutters, storm sewers, and culverts. EPA's 1998 *National Water Quality Inventory Report to Congress* showed that certain rivers, streams, lakes, and estuaries are impaired in terms of their ability to support such uses as aquatic life, swimming, and fish consumption, and concluded that urban runoff was a major source of this impairment. Studies have shown that urban runoff and the pollutants it carries can cause increases in sedimentation, water temperature, and pathogen levels and decreases in dissolved oxygen levels in bodies of water. These changes can lead to the degradation of habitat in these water bodies and a decline in diversity of aquatic life and can endanger public health. For example, metals, a pollutant typically found in urban runoff, can be toxic to aquatic organisms. Pathogens, such as bacteria from animal waste, another pollutant commonly found in urban runoff, can pose public health problems when present in waters used for recreational purposes. The magnitude and nature of these effects vary by region, depending on the type and concentration of pollutants in storm water, rainfall characteristics, land use, and other factors.

Local governments are required to address urban runoff through EPA's National Pollutant Discharge Elimination System Storm Water Program. Under permits that EPA and states issue through this program, over 1,000 local governments must meet EPA's requirements to implement storm water management programs to reduce contaminants in storm water to the "maximum extent practicable." EPA recommends that these cities use "best management practices" to reduce contaminants in storm water runoff. The most typical practices included controlling runoff through a combination of structural means, such as detention ponds, and nonstructural means, such as increasing the frequency of street sweeping and educating the public about how to prevent pollutants from reaching storm sewers. Cities also used specialized practices to address specific local runoff problems. For example, Baltimore, Maryland, has focused on reducing the level of nutrients, such as fertilizers, in its runoff because of its proximity to the Chesapeake Bay, which suffers from high nutrient levels.

Neither the overall costs of implementing the storm water program nor the program's effectiveness has been determined. EPA estimated in a 1996 report to congress that the potential need for spending on storm water runoff and overflows of sewage resulting from runoff was over $50 billion over 20 years, but the agency also believes this estimate will increase when it issues its next report in 2002. EPA's regulations require that permitted cities annually report the costs of implementing their storm water programs, along with the results of their monitoring of storm water runoff and water quality. However, in part because EPA has not established guidelines for reporting costs, these data have not been calculated or reported consistently and, therefore, are not currently useful in characterizing the program's overall cost. EPA, state, and city officials generally believe that managing storm water runoff will reduce the volume of runoff and concentrations of pollutants in the runoff, as well as improve water quality, but no systematic effort to evaluate the program's results has been started. EPA and the states have generally been unsuccessful in developing measurable program goals and in demonstrating program effectiveness through the review of water quality data reported by local governments.

We believe it is time for EPA to begin evaluating this program, which is directed at one of the nation's most significant water quality problems. Therefore, this report includes a recommendation to EPA to work with states to develop program goals, establish standards for reporting on program costs and effectiveness, and review reported water quality data to determine whether the current storm water management programs are having the intended effect of improving the quality of the nation's waters and how much the programs cost. We provided a draft of this report to EPA and the Department of Transportation (DOT). EPA generally agreed with the report and plans to take action to implement several parts of the recommendation; the agency did not comment on the other parts of the recommendation. DOT generally agreed with the report. (See the Agency Comments and Our Evaluation section of this report.)

## Background

Nonpoint source pollution can result when water, such as precipitation, runs over land surfaces and into bodies of water. Significant nonpoint sources of pollution can include paved urban areas, agricultural practices, forestry, and mining. However, in urban and suburban areas, this runoff generally enters a sewer system that can be regulated as a point source of water pollution. For example, precipitation from rain or snowmelt may run into a municipal separate storm sewer system (MS4 or storm sewer) that eventually discharges into a body of water. The precipitation may also run into a combined sewer system, which carries a combination of storm water runoff, industrial waste, and raw sewage in a single pipe to a sewage treatment facility for discharge after treatment. Lastly, the precipitation may run off of land or paved surfaces directly into nearby receiving waters.

EPA's Office of Wastewater Management, which is within the Office of Water, implements the National Pollutant Discharge Elimination System (NPDES) Program. The program was created in 1972 with the passage of the Clean Water Act. Created to control water pollution from point sources—those sources, such as a factory or wastewater treatment plant, that contribute pollutants directly into a body of water from a pipe or other conveyance—the NPDES Program did not specifically address storm water discharges. In 1987, the Congress amended the Clean Water Act with the Water Quality Act, which directed EPA to also control storm water discharges that enter MS4s—essentially requiring EPA to treat such storm water as a point source.[3] MS4s are defined as those sewers that collect and convey storm water; are owned or operated by the federal, state, or local government; and are not part of a publicly owned treatment (sewage) facility.

To regulate urban storm water runoff, EPA published regulations in 1990 that established the NPDES Storm Water Program and described permit application requirements. According to EPA, the program's objective, in part, is to preserve, protect, and improve water quality by, among other things, controlling the volume of runoff from paved surfaces and by reducing the level of runoff pollutants to the maximum extent practicable using best management practices (BMP).[4] The 1987 act also authorized EPA to implement a program that provides federal funds and technical assistance to states to develop their own nonpoint source pollution management programs. States can use the federal funds they receive for nonpoint source programs to address nonpoint sources of pollution as well as urban runoff.

Currently, EPA manages NPDES Storm Water programs in six states (Alaska, Arizona, Idaho, Massachusetts, New Hampshire, and New Mexico) and has delegated authority to the remaining 44 states to manage these programs. The storm water program is being implemented in two phases. Local governments meeting the following criteria must comply with EPA's storm water program regulations. First, Phase I of the program requires that municipalities with a population of 100,000 or more obtain a permit for their MS4 system; second, the program requires that entities obtain a

[3]Section 402(p) of the Clean Water Act.

[4]According to EPA, a best management practice is a device, practice, or method for removing, reducing, retarding, or preventing targeted storm water runoff constituents, pollutants, and contaminants from reaching receiving waters.

permit if they discharge storm water from sites with industrial activities, including construction activities that disturb 5 acres or more of land. In addition, NPDES permitting authorities may also bring other municipalities and industrial entities into the program if they deem it necessary. Municipalities that meet these conditions must submit a permit application to EPA or the governing regulatory state agency. In 1990, the regulations specifically identified 220 municipalities throughout the United States that were required to apply for a Phase I permit. According to EPA, as of April 2001, about 256 Phase 1 MS4 permits had been issued and about 17 more still needed to be issued. Because some permits cover more than one municipality, these permits cover about 1,000 medium and large municipalities nationwide.

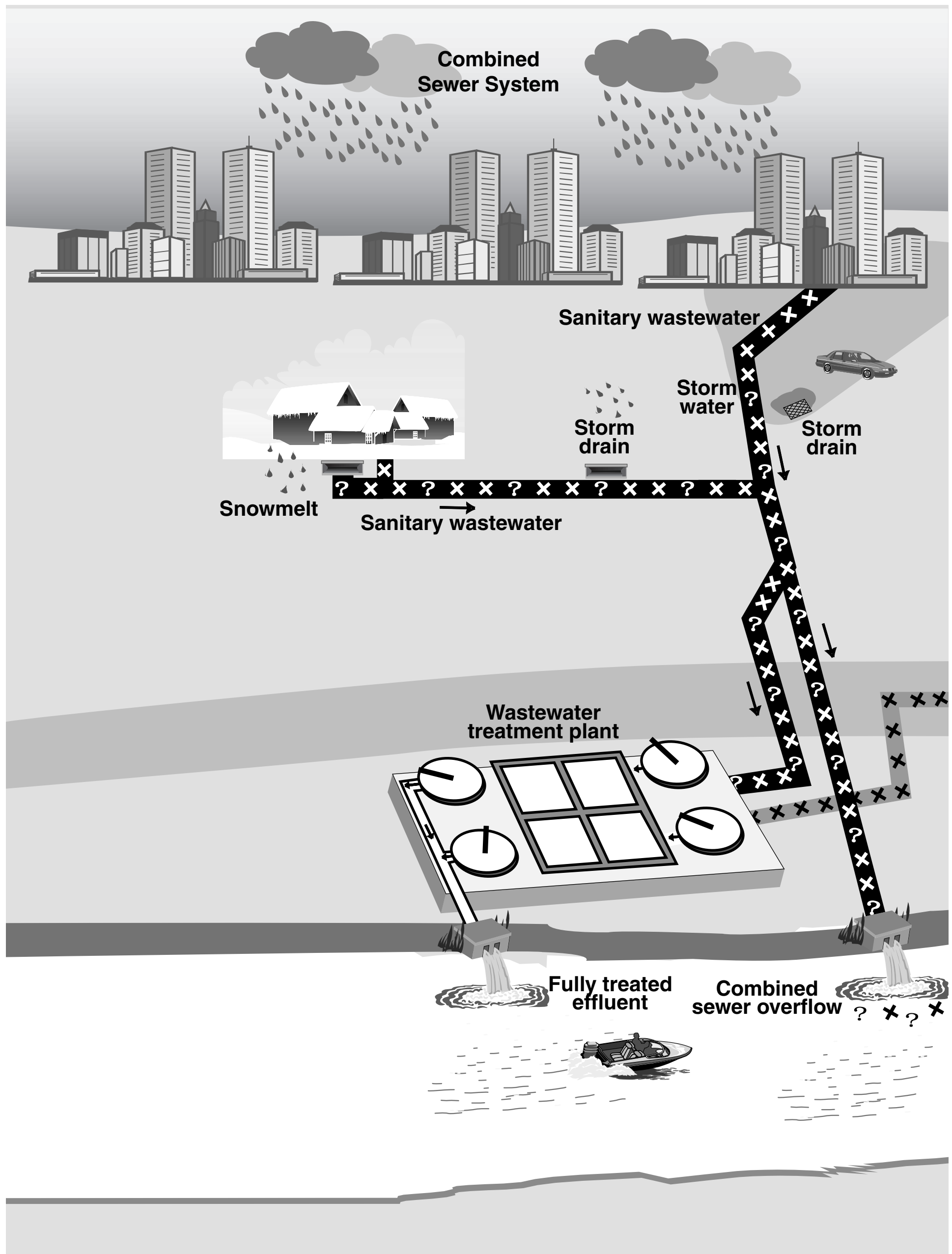
The final rule for Phase II of the program was issued in December 1999. Phase II extends Phase I efforts by requiring that a storm water discharge permit be obtained by (1) operators of all MS4s not already covered by Phase I of the program in urbanized areas[5] and (2) construction sites that disturb areas equal to or greater than 1 acre and less than 5 acres of land. As with Phase I of the program, permitting authorities may require additional small MS4s and construction sites to obtain a permit if they are a significant contributor of pollutants. Currently, EPA anticipates that about 5,000 municipalities may be subject to permitting requirements under Phase II of the storm water program. These municipalities are required to obtain permits no later than March 10, 2003.

[5]The Bureau of the Census generally defines an urbanized area as a land area comprising one or more places—central place(s)—and the adjacent densely settled surrounding area—urban fringe—that together have a residential population of at least 50,000 and an overall population density of at least 1,000 per square mile.

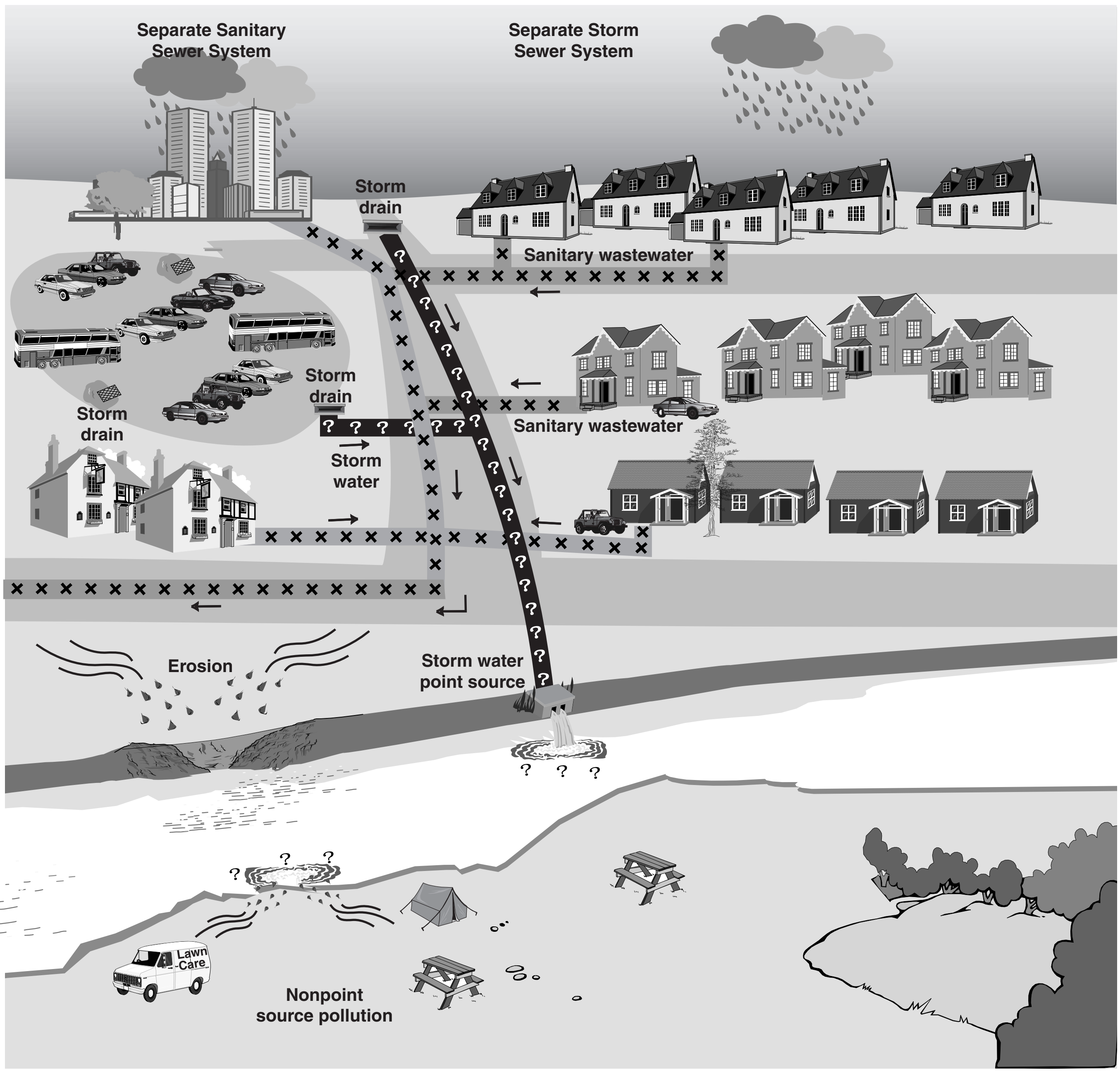
EPA also regulates combined sewer overflows (CSO) that can be caused by urban storm water runoff. Combined sewer systems, in which storm water enters pipes already carrying sewage, may overflow when rain or snowmelt entering the system exceeds the system's flow capacity. In the CSO that results, the mixture of untreated sewage and runoff bypasses the water treatment facility and is diverted directly into receiving waters. (See fig. 1 for an illustration of combined and separate sewer systems.) These combined systems generally serve the older parts of approximately 900 cities in the United States. Pipes carrying sewage and storm water separately generally serve newer parts of cities. EPA's 1994 CSO policy requires communities with combined sewer systems to take immediate and long-term actions to address CSO problems. The policy contains provisions for developing appropriate, site-specific NPDES permit requirements for all combined sewer systems that overflow because of wet-weather events. The Wet Weather Water Quality Act of 2000 requires that any permit, order, or decree issued for a CSO conform to the 1994 policy. Under this act, EPA is also required to submit a report to the Congress by September 2001 on the status of the program.[6]

[6]Sanitary sewer overflows, which are illegal under the Clean Water Act, can also result from rainfall. A sanitary sewer overflow may occur when rainwater or snowmelt leaks into sanitary sewage pipes, thereby exceeding the pipes' capacity and causing them to overflow. This discharge of raw sewage from municipal sanitary sewer systems can release untreated sewage into places such as streams, basements, and streets. EPA proposed regulations to require municipalities to reduce the number of overflows. However, these regulations have been withdrawn for further review.

Figure 1:  Urban Runoff Flows in Different Types of Sewer Systems




× Sanitary sewage/wastewater
? Storm water runoff with potential contaminants




Source: GAO illustration based on EPA data.

The Total Maximum Daily Load (TMDL) Program, established under the Clean Water Act, is intended to address water bodies that do not meet water quality standards because of pollutant loadings from point and nonpoint sources. Currently, it is unclear how and when this program will affect EPA's and states' issuance of storm water permits. A TMDL is a calculation of the maximum amount of a pollutant that a body of water can receive and still meet the water quality standard set by the state. Under EPA's regulations, the state is to allocate this "pollutant load" among the point and nonpoint pollutant sources that flow into the water body and then take steps to ensure that no source exceeds its assigned load. In 1996, EPA issued a policy that outlined an interim approach to including water quality standards in storm water permits. The policy promoted the use of BMPs in the first 5-year term permits, followed by a tailoring of BMPs in the second round of permits as necessary to comply with water quality standards. Until recently, few TMDLs had been established, and citizen organizations sued EPA for its lack of action. EPA issued a new set of regulations for the TMDL Program in 2000, but the Congress prevented EPA from spending money to implement the rule in 2000 and 2001. It is possible that establishing a TMDL for a body of water could result in the application of a numeric effluent limit to outfalls[7] that release storm water into that body of water. Some city officials we spoke with generally felt that numeric effluent limits would significantly increase the cost of managing storm water.

## Volume of Urban Runoff Increases With the Expansion of Urban Development and Can Affect Water Quality

Since World War II, urban runoff has increased throughout the United States. This increase is directly related to growth in the amount of impervious surfaces due to urban and suburban development and the construction of roads, highways, and other impervious surfaces. Coinciding with this growth in impervious surfaces has been a reduction in wetlands and in the amount of storm water that infiltrates the ground to recharge aquifers. Moreover, the loss of vegetation due to development and related runoff can cause major erosion. Ultimately, much of this runoff is channeled into gutters, storm drains, and paved channels, and vegetation and sediment removed with the runoff may end up in receiving waters. EPA has identified urban storm water runoff as one of the leading sources of pollution to the nation's rivers, streams, lakes, and estuaries. Runoff from impervious surfaces picks up potentially harmful pollutants and

[7] An outfall is an outlet, such as a pipe, that allows storm water to flow into a river, lake, or other body of water.

carries them into receiving waters. Studies have shown that urban runoff and the pollutants it carries can negatively affect water quality, aquatic life, and public health.

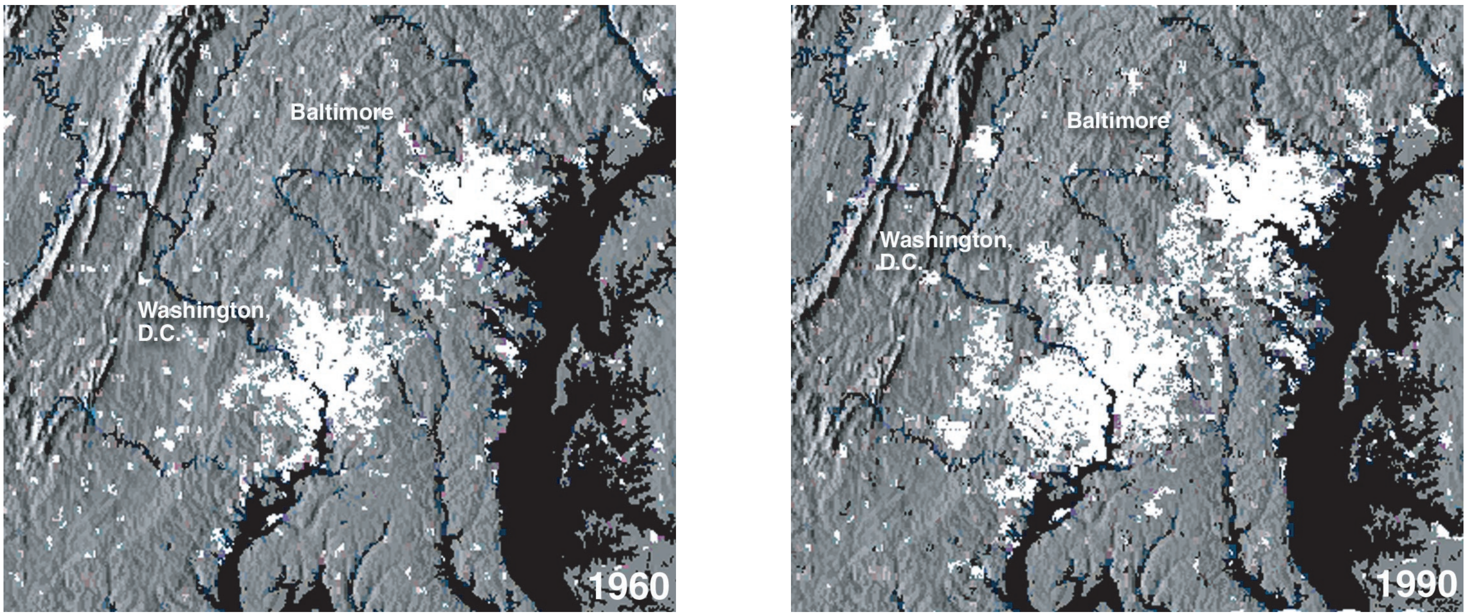
## Paved Surfaces Have Increased With Urban and Suburban Expansion and Growth in Automobile Use

According to the U.S. Department of Agriculture, between 1945 and 1997, urban land area increased by almost 327 percent, from 15 million acres to about 64 million acres in the contiguous 48 states. From 1992 through 1997, the annual rate of development averaged about 1 million acres per year. The land developed between 1945 and 1997 came primarily from forestland and pasture and range.[8] For example, according to the Bureau of the Census, between 1960 and 1990, the amount of land used for urban purposes in Baltimore, Maryland, and Washington, D.C., grew by about 170 percent and 177 percent, respectively. As a result, urbanization, with its accompanying expansion of impervious surfaces like sidewalks, roofs, parking lots, and roads, has significantly increased the nation's total developed land and paved surface area.[9] Figure 2 demonstrates the growth in the urbanized areas of Baltimore and Washington, D.C., over the last half of the 20th century.

[8] *Agricultural Resources and Environmental Indicators, 2000,* U.S. Department of Agriculture, Economic Research Service, Resource Economics Division.

[9] *Our Built and Natural Environments, A Technical Review of the Interaction Between Land Use, Transportation and Environmental Quality,* U.S. Environmental Protection Agency (EPA 231-R-00-005, Nov. 2000).

Figure 2: Increase in Urbanized Land in Selected Cities, 1960-90

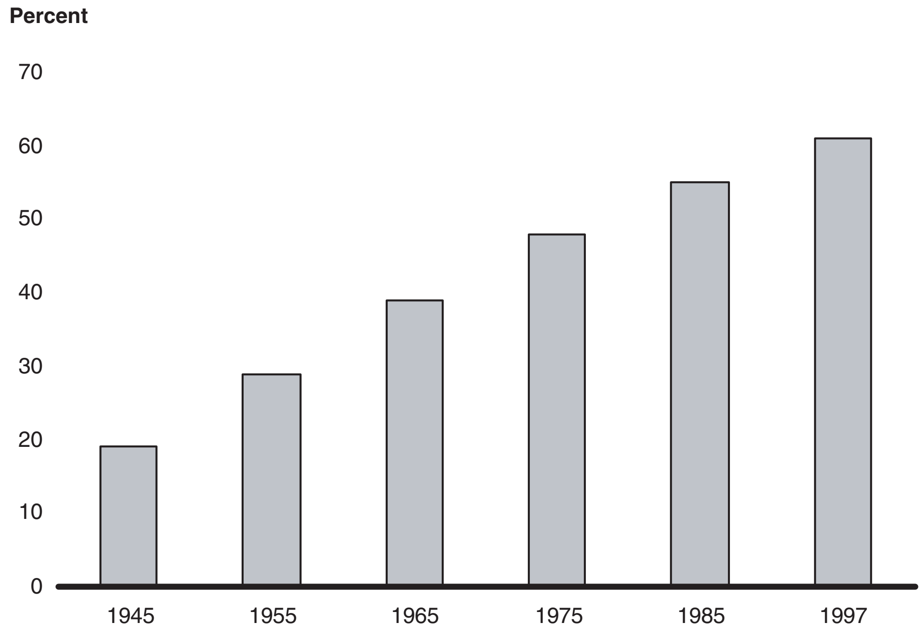



Source: U.S. Geological Survey.

The increase in paved surfaces has been spurred not only by urban and suburban development, but also by a steady increase in the use of automobiles, the primary mode of daily transportation for most Americans. Roads also play an important role in the economy of the United States, since trucks carry about 75 percent of the value of all goods shipped. According to EPA, paved road mileage in the United States increased by 278 percent from 1945 to 1997. In 1945, 19 percent of the public roads in the country were paved; by 1997, that percentage had increased to 61. (See fig. 3.) According to a 1999 study, motor-vehicle infrastructure, such as roads and parking lots, accounts for close to half of the land area in U.S. urban cities.[10]

[10] *Stormwater Strategies, Community Responses to Runoff Pollution,* Natural Resources Defense Council (May 1999).

Figure 3:  Percentage of Paved Public Road Miles, 1945-97




Source:  EPA.

## Increase in Impervious Surfaces Leads to Increased Runoff

The increase in impervious surfaces over the past several decades has led to an increase in storm water runoff.  In part, this has occurred because highways and other developments have reduced the amount of wetlands and other undeveloped land.  Wetlands mitigate the effects of storm water runoff by acting as a natural form of flood control, facilitating sediment replenishment, and improving water quality by removing excess nutrients and other chemical contaminants before the contaminants can affect receiving waters.  According to a 2000 EPA report,[11] of the 12 states that listed wetland losses, six reported that they had significant losses due to highway construction, and 10 reported that they had significant losses due to residential growth and development.  However, the effect of road building on wetland loss has been reduced in recent years.  According to a Federal Highway Administration (FHWA) official, since 1996, wetlands have been replaced and restored under the Federal-Aid Highway Program

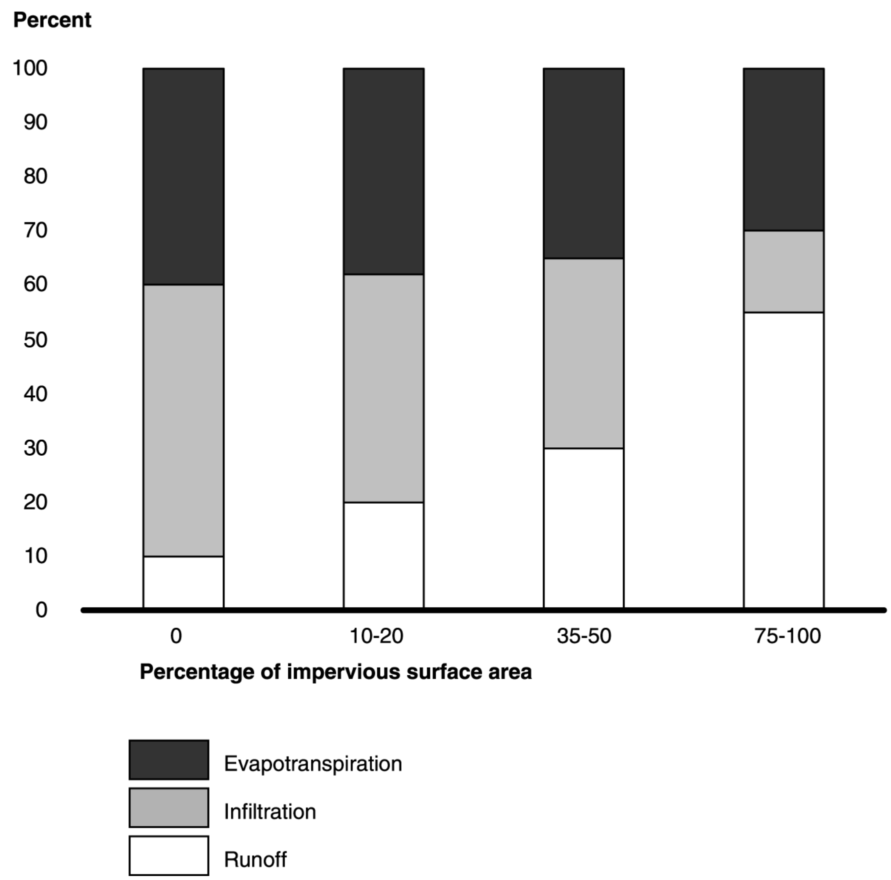
[11]See footnote 9.

at an average rate of 2.7 acres for every acre lost to highway building. Other undeveloped land with vegetation also performs some of the roles that wetlands play in managing runoff, although to a lesser extent.

Furthermore, as impervious surfaces increase, less storm water is able to infiltrate through the soil to groundwater. Impervious areas allow only a very small amount of initial infiltration compared with unpaved areas whose infiltration capacity varies, depending on the soil type. Figure 4 demonstrates EPA's estimates of the impact of impervious surfaces on the percentages of storm water that runs off, infiltrates the ground, and is lost through evapotranspiration.[12] When natural ground cover is present over an entire site, normally 10 percent of precipitation runs off the land into nearby creeks, rivers, and lakes. In contrast, when a site is 75- to 100-percent impervious, 55 percent of the precipitation runs off into these receiving waters. However, according to an FHWA official, the runoff rates can be reduced if developers take mitigating actions to develop and implement BMPs to control flooding or runoff.

[12]Evapotranspiration represents water loss from evaporation and the absorption and eventual release into the atmosphere of water that plants and trees have collected. The extent to which evapotranspiration occurs is dependent primarily on the solar energy available to vaporize the water. As a result, the effect of evapotranspiration varies greatly across the country.

**Figure 4: Impact of Impervious Surfaces on the Amount of Storm Water That Runs Off, Infiltrates, and Evapotranspires**




Source: EPA.

The decrease in storm water infiltration that accompanies urbanization also reduces the amount of water that is available to recharge groundwater supplies. For this reason, reduced infiltration may lead to problems with the water table in certain urban areas. For example, a Massachusetts Department of Environmental Protection official noted that a low recharge rate affects water quality because it can result in a loss of wetlands and adversely affect aquatic habitat as water-table levels fall during dry weather.[13] In addition, officials from the Charles River Watershed Association in Massachusetts are concerned that the lack of infiltration might cause some communities to run short of drinking water in the next 20 years.

## Urban Runoff Has the Potential to Impair Water Quality and Disrupt Biological Integrity

Urban runoff can adversely affect the quality of the nation's waters, and urban storm water runoff has been identified as one of the leading sources of pollution to rivers, streams, lakes, and estuaries.[14] Section 305(b) of the Clean Water Act requires states and other jurisdictions to report on the quality of their waters to EPA every 2 years. The 1998 *National Water Quality Inventory Report to Congress* showed that 35 percent of assessed river and stream miles, 45 percent of assessed lake acres, and 44 percent of assessed estuarine square miles were impaired in terms of their ability to support uses such as aquatic life, swimming, and fish consumption.[15] The report identified urban storm water runoff as one of the leading sources of impairment to the assessed waters.

[13]Dry weather is defined as a period when rainfall measuring at least 0.10 of an inch has not occurred for 72 hours.

[14]Other leading sources of pollution include agricultural runoff, municipal point sources, hydrologic modifications, and atmospheric deposition.

[15]Information contained in the 1998 report reflects only those waters assessed by states and other jurisdictions and cannot be used to characterize nationwide water quality. Furthermore, water quality standards among states are not identical, and the monitoring design used to collect data differed among states.

Studies have shown that as the percentage of impervious cover increases within a watershed, biodiversity also declines. Research conducted by the Center for Watershed Protection found that, generally speaking, when a watershed has 10 percent or less impervious cover, the associated stream can be categorized as sensitive.[16] Sensitive streams are characterized as having high fish diversity and good water quality. Once the percentage of impervious cover exceeds 25 to 30 percent of the watershed, however, streams tend to become nonsupporting. Nonsupporting streams are highly unstable, have poor diversity of fish and aquatic life, and have poor water quality. For example, one study evaluated the relationship between the extent of impervious cover in watersheds to the number and diversity of fish populations in 47 small streams in southeastern Wisconsin between the 1970s and 1990s.[17] The results revealed that the number of fish species per site was highly variable for drainage areas that had less than 10-percent imperviousness. In contrast, sites that had greater than 10-percent imperviousness had consistently low numbers of fish species.

Other studies have associated urban runoff with basic changes in the receiving body of water. Runoff can carry sediment into surface water, and this sediment can carry contaminants, harm aquatic plants, and smother organisms. Runoff can also be warmed by the impervious surfaces it flows across. When sufficient amounts of warmed runoff enter a water body, the water temperature can rise. Less oxygen is then available for aquatic organisms because water holds less oxygen as it becomes warmer. These combined factors lead to the degradation of aquatic habitat. According to EPA, the common effects of these types of pollution on aquatic life include a decline in biodiversity and an increase in invasive species.

An increase in the volume of storm water runoff also increases the likelihood of erosion, which allows for transport of eroded sediment downstream into receiving waters. For example, during a site visit, we observed extensive erosion along the Gingerville Creek Subbasin in Anne Arundel County, Maryland, that was caused by urban runoff channeled into the creek. Figure 5 depicts the eroded banks and channel of this creek.

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[16]"The Importance of Imperviousness," *Watershed Protection Techniques*, v.1:3, Fall, 1994. The article reviews 18 studies on the relationship between urbanization and stream quality.

[17]L. Wang and others, "Watershed Urbanization and Changes in Fish Communities in Southeastern Wisconsin Streams," *Journal of the American Water Resources Association,* Oct. 2000, Vol. 36, No. 5.

Figure 5: Damage Caused by Storm Water Runoff From Urbanized Areas in the Gingerville Creek Subbasin

Source: Anne Arundel County, Maryland, Department of Public Works.

## Contaminants in Urban Runoff Can Affect Aquatic Life and Human Health

There have been several efforts to characterize the chemicals and other constituents in urban runoff. The Nationwide Urban Runoff Program, conducted by EPA between 1978 and 1983, examined the characteristics of urban runoff. Another federal effort to characterize urban runoff is an ongoing joint project of the U.S. Geological Survey (USGS) and the FHWA to evaluate guidelines for highway runoff. As table 1 indicates, these studies and others have shown that the principal contaminants found in urban runoff include nutrients, solids, pathogens, metals, hydrocarbons, organics, salt, and trash. Water flowing over various surfaces, such as streets, parking lots, construction sites, industrial facilities, rooftops, and lawns, carries these pollutants to receiving waters. The contaminants have the potential to impair water quality, degrade aquatic ecosystems, and pose health risks to swimmers.

**Table 1: Storm Water Pollutants in Urban Runoff, Including Sources and Potential Impacts**

| Contaminant | Source | Potential impact |
|---|---|---|
| **Nutrients** | | |
| Nitrogen, phosphorous | Animal waste, fertilizers, failing septic systems, atmospheric deposition,[a] CSOs | Nutrient enrichment can cause an excessive growth of algae. Nuisance levels of algae are associated with dissolved oxygen deficiencies leading to fish kills, loss of submerged aquatic vegetation that serves as a habitat for aquatic organisms, and loss of natural biodiversity. |
| **Solids** | | |
| Sediment | Construction sites, other disturbed and/or nonvegetated lands, eroding banks, road sanding | Sediment can cause infection and disease among fish, scour submerged aquatic vegetation, prevent sunlight from reaching aquatic plants, and bury bottom-dwelling aquatic organisms. |
| **Pathogens** | | |
| Bacteria, viruses | Animal waste, failing septic systems, illicit connections and discharges to storm sewer system, CSOs | Pathogens entering waters used for recreational purposes can pose human health risks. |
| **Metals** | | |
| Lead, cadmium, copper, zinc, mercury, chromium, aluminum, and others | Industrial processes, normal wear of automobile brake linings and tires, automobile emissions, automobile fluid leaks, metal roofs | Metals can cause acute or chronic toxicity for aquatic organisms. |
| **Hydrocarbons** | | |
| Oil and grease, polycyclic aromatic hydrocarbons | Industrial processes, automobile wear, automobile emissions, automobile fluid leaks, waste oil | Hydrocarbons have the potential to be acutely toxic for aquatic organisms and several are suspected carcinogens. |
| **Organics** | | |
| Pesticides, polychlorinated biphenyls (PCB), synthetic chemicals | Pesticides (herbicides, insecticides, fungicides, rodenticides, etc.), industrial processes | Low concentrations of some organics have the potential to bioaccumulate in the food chain. |

(Continued From Previous Page)

| Contaminant | Source | Potential impact |
|---|---|---|
| **Salt** | | |
| Sodium Chlorides | Road salting and uncovered salt storage | Salt can damage roadside vegetation, transport high levels of chlorides to receiving waters, and degrade aquatic ecosystems. Chloride can be harmful to some species of fish. |
| **Trash** | | |
| | Street refuse and improperly discarded waste material | Trash impairs water quality by inhibiting the growth of aquatic vegetation and conveys nutrients, toxic substances, and other pollutants to aquatic ecosystems. |

[a]Atmospheric deposition occurs when pollutants in the air fall on land or water.

Sources: Massachusetts Department of Environmental Protection Stormwater Policy; EPA reports and guidance, including *Preliminary Data Summary of Urban Storm Water Best Management Practices, Combined Sewer Overflow Control Policy, Innovative Urban Wet-Weather Flow Management Systems*, and the 1998 *National Water Quality Inventory Report to Congress*; the California Regional Water Quality Control Board; the Natural Resources Defense Council's *Stormwater Strategies: Community Responses to Runoff Pollution*; "Accretion of Pollutants in Roadway Snow Exposed to Urban Traffic and Winter Storm Maintenance Activities - Part I," Draft;[18] and USGS' National Water Quality Assessment Program.

[18]J.J. Sansalone and D.W. Glenn, "Accretion of Pollutants in Roadway Snow Exposed to Urban Traffic and Winter Storm Maintenance Activities –Part I," DRAFT.

In our visits to cities with Phase I permits and their watersheds, we identified specific instances in which these contaminants had affected water quality. The Chesapeake Bay, for example, has been polluted with the nutrients nitrogen and phosphorus and with excess sediment caused, in part, by urban runoff. The excess nutrients cause algae blooms that block sunlight from reaching bay grasses—which are a source of food, shelter, and nursery grounds for many aquatic species. In an effort to control nutrient pollution in the Chesapeake Bay, the Executive Council of the Chesapeake Bay Program[19] established a goal to reduce the nitrogen and phosphorus entering the Chesapeake Bay by 40 percent, including through control of runoff from urban areas. In addition, an assessment of the status of chemical contaminant effects on living resources in the bay's tidal rivers found "hot spots" of contaminated sediment. As a result, the Baltimore Harbor and the Patapsco River in Maryland; the Anacostia River in Washington, D.C.; and the Elizabeth River in Virginia were designated as "regions of concern." Urban storm water runoff is a significant source of contaminants in the three regions. The Chesapeake Executive Council has committed to reduce by 30 percent the chemicals of concern in the regions of concern by 2010 through pollution prevention measures and other voluntary means.[20]

Pathogens such as bacteria and viruses, which are often present in urban runoff, can pose public health problems. For example, the Santa Monica Bay Restoration Project conducted a study to identify adverse health effects of untreated urban runoff by surveying over 13,000 swimmers at three bay beaches. [21] The study established a positive association between an increased risk of illness and swimming near flowing storm-drain outlets. Table 2 explains health outcome measures at various distances from storm drains. For example, the study found a 1-in-14 chance of fever for swimmers in front of the drain versus a 1-in-22 chance at 400 or more yards away.

[19]The Chesapeake Executive Council includes the governors of Maryland, Pennsylvania, and Virginia; the Administrator of the U.S. Environmental Protection Agency; the mayor of the District of Columbia; and the chair of the Chesapeake Bay Commission.

[20]Chesapeake Bay Program Office, *Toxics 2000 Strategy: A Chesapeake Bay Watershed Strategy for Chemical Contaminant Reduction, Prevention, and Assessment,* Dec. 2000.

[21]R.W. Haile and others, "The Health Effects of Swimming in Ocean Water Contaminated by Storm Drain Runoff," *Epidemiology,* July 1999, Vol. 10, No. 4.

**Table 2: Comparative Health Outcomes for Swimming in Front of Drains Versus 400 or More Yards Away**

| Health outcomes | 0 yards | 400 or more yards |
|---|---|---|
| Fever | 1:14 | 1:22 |
| Chills | 1:26 | 1:42 |
| Ear discharge | 1:68 | 1:143 |
| Coughing with phlegm | 1:20 | 1:33 |
| Significant respiratory disease (fever and nasal congestion, fever and sore throat, and cough with phlegm) | 1:12 | 1:22 |

Note: This table includes the statistically significant health outcomes.

Source: GAO analysis of data from "The Health Effects of Swimming in Ocean Water Contaminated by Storm Drain Runoff," *Epidemiology*, July 1999, Vol. 10, No. 4.

Metals and polycyclic aromatic hydrocarbons (PAH) in urban runoff can present a threat to aquatic life. Studies have found the following:

- Storm water runoff from an urban area proved to be toxic to sea urchin fertilization in the Santa Monica Bay, and dissolved zinc and copper were determined to be contributors to this toxicity. [22]
- Brown bullheads (a bottom-dwelling catfish) in the Anacostia River developed tumors that were believed to be caused by PAHs associated in part with urban runoff.[23]
- High PAH and heavy metal concentrations were found in crayfish tissue samples from several urban streams in Milwaukee. The study associated these contaminants with storm water runoff.[24]

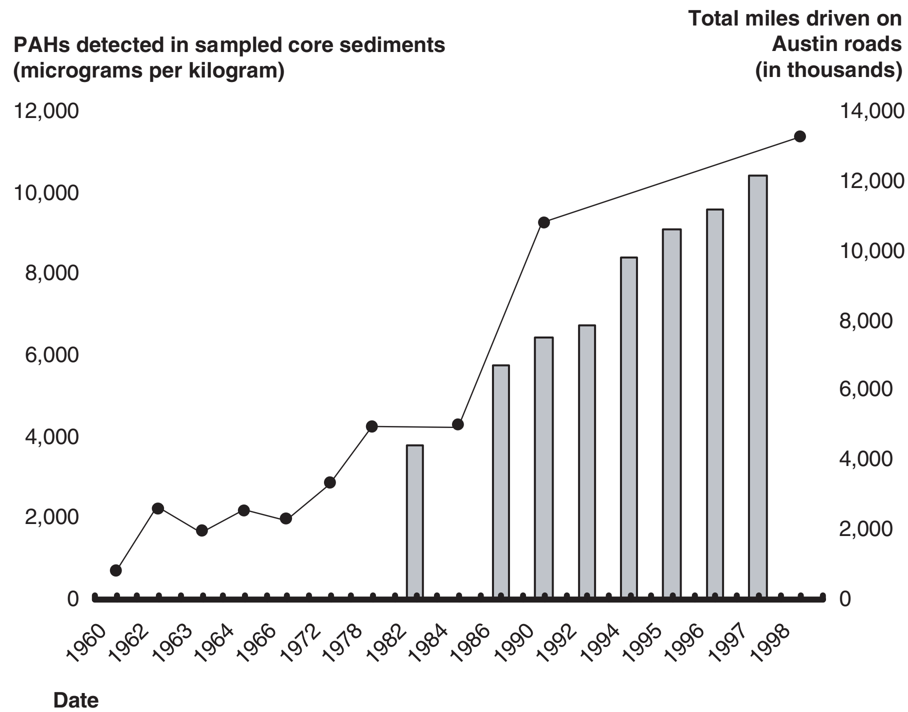
[22]Southern California Coastal Water Research Project, *Study of the Impact of Stormwater Discharge on Santa Monica Bay –Executive Summary,* Nov. 1, 1999.

[23]Chesapeake Bay Program Office.

[24]J.P. Masterson and R.T. Bannerman, "Impacts of Stormwater Runoff on Urban Streams in Milwaukee County, Wisconsin," *National Symposium on Water Quality, American Water Resources Association,* Nov. 1994.

In addition, USGS tracked trends in the concentrations of PAHs found in sediment in 10 lakes and reservoirs in six metropolitan areas over the last several decades. This study found that PAH concentrations in developed watersheds are increasing and that these increases may be linked to the amount of urban development and vehicle traffic in urban and suburban areas.[25] For example, from 1982 to 1996, PAH concentrations in the sediment core in Town Lake (Austin, Texas) and total miles driven in greater Austin both increased by about 2.5 times. Figure 6 illustrates this correlation.

**Figure 6: Comparison of Town Lake PAHs and Traffic Trends**




Note: According to USGS, irregularities in the date pattern are due to intervals at which sediment samples were collected.

Source: USGS National Water Quality Assessment Reconstructed Trends Program.

[25] P. Van Metre, B. Mahler, and E. Furlong, "Urban Sprawl Leaves Its PAH Signature," *Environmental Science and Technology,* Vol. 34, No. 19, 2000.

Although the studies we reviewed show that certain contaminants are likely to be present in urban runoff, factors such as land development practices, climate conditions, atmospheric deposition, and traffic characteristics all can affect the characteristics of runoff from a particular area. Therefore, given the diffuse nature of many storm water discharges and the variability of other contributing factors, characterizing the concentrations of pollutants contained in storm water runoff has been challenging. Recent USGS reports also suggest that improvements are needed in the methods used to analyze sediment and metals in runoff.[26]

## Local Governments Take Actions to Manage Urban Storm Water Runoff, but Information Is Limited on the Cost and Effectiveness of These Actions

To comply with federal and state storm water management for Phase I permitting requirements, permitted municipalities must create and implement storm water management programs. The three primary activities used in these programs include efforts to characterize storm water runoff; BMPs aimed at reducing pollutants in storm water runoff to the maximum extent practicable; and reporting program activities, monitoring results, and costs of implementing the program. Some BMPs are structural—meaning that they are designed to trap and detain runoff until constituents settle or are filtered out. Other BMPs are nonstructural—meaning that they are designed to prevent contaminants from entering storm water through actions like street sweeping and inspections. Many permitted municipalities use specialized BMPs tailored to address particular runoff problems in their locations. Over 1,000 cities are undertaking these efforts under the NPDES Storm Water Program, but information on the overall costs of managing urban runoff and the effectiveness of the actions taken is limited. EPA's attempts to forecast costs have not encompassed the entire program or are out of date. In addition, the permitted municipal agencies we visited estimated their annual storm water management costs and reported them to state agencies or EPA, but the approaches they used to calculate these estimates varied considerably, making it difficult to draw any conclusions. Although EPA and state agencies believe that the program will be effective in improving water quality, EPA has not made a systematic effort to evaluate the program. Without such an effort, EPA cannot tell what effect the program is having on water quality nationally.

[26]The USGS reports indicate that certain methods used to analyze sediment and metals samples can be unreliable. For example, sample collection and processing methods can have an effect on measured concentrations of metals.

## Municipalities Comply With Federal and State Requirements Through Monitoring, Best Management Practices, and Reporting

The NPDES Storm Water Program requires municipalities operating under a Phase I MS4 permit to characterize and monitor storm water runoff, implement BMPs to reduce pollutants to the maximum extent practicable, and report costs and monitoring results to the permitting authorities. Because of these requirements, local governments have generally shifted the focus of their storm water management from water quantity control or flood management to water quality concerns.

Besides following the basic federal requirements, municipalities must follow any additional regulations developed by states that have been delegated the authority to manage the NPDES Storm Water Program. For example, Wisconsin's Department of Natural Resources broadened the requirements for determining which municipalities must get permits. The state requires local governments with storm sewer systems in priority watersheds (based on the significance of storm water runoff as a pollutant source) that serve a populace of 50,000 or more[27] to obtain a permit with requirements similar to those for a Phase I permit. Wisconsin's Department of Natural Resources also requires municipalities that are located in one of the state's five Great Lakes Areas of Concern[28] to obtain a state permit. Furthermore, in line with specific criteria in Wisconsin's Administrative Code, the state requires other municipalities to obtain a permit if the municipality is found to significantly contribute storm water pollutants to waters of the state. These various requirements increased the number of municipalities that must get permits from the two under federal requirements to over 70 under the states' requirements.

The local governments we reviewed were undertaking three primary activities when applying for permits and implementing their storm water management programs. Specifically, these activities were (1) characterizing storm water runoff; (2) developing BMPs to reduce discharges of pollutants to the maximum extent practicable; and (3) reporting program activities, monitoring results, and reporting program costs.

First, to characterize runoff, applicants are to provide quantitative data that describe the volume and quality of discharges from municipal storm

[27]For example, we visited West Allis, Wisconsin, which has a permit even though its population is under 100,000.

[28]Areas of concern have persistent water quality problems, which impair beneficial uses.

sewers. For example, cities must map all storm sewer outfalls—an undertaking that one group representing cities described as significant. After the permit application is approved, additional monitoring is required throughout the life of the permit to facilitate the design of effective storm water management programs and to document the nature of the storm water. The local governments we visited were all monitoring for a variety of purposes, including characterizing runoff from different types of land use in order to target their BMPs, testing the effectiveness of a particular BMP, or establishing a baseline for their storm water quality evaluations.

Second, the storm water management programs that local governments develop focus on implementing BMPs. While active treatment, such as sending storm water through a treatment facility, is a possible BMP, the cities we visited were generally not using active treatment. EPA's February 2000 report[29] on the Phase I program described the program as based on the "use of low-cost, common-sense solutions." The five cities we visited were generally using similar types of structural and nonstructural BMPs, as follows:

- Structural BMPs are designed to separate contaminants from storm water. For example, detention ponds temporarily hold storm water runoff to allow solids and other constituents in the runoff to settle before the water is released at a predetermined rate into receiving waters. In addition, catch-basin inserts, placed in a storm drain, catch trash and other debris, and particle separators, placed beneath the surface of an impervious area such as a parking lot, separate oils from runoff and allow sediment and debris to settle. Structural devices such as these require regular maintenance to function properly and remain effective.
- Nonstructural BMPs are primarily designed to minimize the contaminants that enter storm water. These nonstructural BMPs include
  - "good housekeeping" practices by the local government, such as oil collection and recycling, spill response, household and hazardous waste collection, pesticide controls, flood control management, and street sweeping;

[29] *Report to Congress on the Phase I Storm Water Regulations*, U.S. Environmental Protection Agency, February 2000. This report includes information on the program for local governments, industries, and construction sites.

- public education programs, such as storm-drain stenciling, to remind the public that trash, motor oil, and other pollutants thrown into storm drains end up in nearby receiving waters;[30]
- new ordinances to control pollution sources, such as prohibiting the disposal of lawn clippings in storm drains and requiring pet owners to clean up after their pets;[31]
- requirements that developers comply with storm water regulations and incorporate erosion and sediment controls at all new development sites;
- requirements that runoff from properties owned or activities sponsored by the municipality be properly controlled; and
- efforts to identify and eliminate illicit connections and illegal discharges to the storm sewer systems, such as those from pipes carrying sewage.

We found that the NPDES Program's requirements allowed local governments to tailor their storm water management efforts to prioritize local concerns, such as a particular type of contaminant, a particular climatic condition, or a particular body of water. Some cities also developed specialized BMPs to address these concerns. The following information highlights specific storm water-related concerns in the five cities we visited and the specialized BMPs these municipalities have developed to address these particular concerns. (See apps. I to V for additional information on these cities' storm water management programs.)

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[30]Other public education programs we observed included in-school education programs, partnerships with grassroots organizations concerned with water quality issues, and the identification of commercial businesses and industries to educate owners on methods to control storm water runoff.

[31]According to Worcester, Massachusetts' April 2000 *City of Worcester DPW Stormwater Management Program Annual Report*, the city has proposed ordinances that prohibit the disposal of lawn clippings and other yard waste in catch basins and that require pet owners to clean up after their pets. As of April 2001, neither ordinance had been implemented.

- In **Baltimore, Maryland**, excessive levels of nutrients, particularly phosphorus and nitrogen, are among the city's major water quality concerns because of the city's participation in the Chesapeake Bay Program. Baltimore City agreed to assist the state in reaching the Chesapeake Bay Program's goal to reduce nutrients discharged to the bay by 40 percent by the year 2000. According to a Chesapeake Bay Program Office representative,[32] as of March 2001, the program has not met this goal but expects to reach it within the next several years.
- In **Boston, Massachusetts**, the Boston Water and Sewer Commission, which holds the permit for Boston's storm sewer system, is concerned about runoff from roadways, especially runoff containing salt and sand used in the winter months and dissolved metals (copper and zinc) from automobiles. In September 2000, the commission began a 3-year program to develop and implement a citywide catch-basin inspection, cleaning, and preventive maintenance program. The program will also include the development of a database and map that can be linked to the commission's Geographic Information System.
- **Los Angeles County, California**, is responding to a TMDL for trash in the Los Angeles River Watershed that will require the county, over a 10-year period, to eliminate trash in runoff. The county is testing a variety of devices that remove trash from runoff and specialized catch-basin devices that are designed to prevent trash from ever reaching the storm sewers.
- **Milwaukee, Wisconsin**, changed its monitoring and public education activities in its recent permit to test the effectiveness of a BMP targeting public education efforts to a specific community. The new permit also requires a monitoring program aimed at the community, its associated watershed, and city employees who work in the area.
- **Worcester, Massachusetts**, had a significant problem with illicit connections to its storm sewers and with flow in these sewers during dry weather. Worcester's Department of Public Works (DPW) screened 71 of its storm water outfalls and determined that 32 of them had drainage areas that carried both sanitary sewage and storm drainage in separate conduits through common manholes. DPW has retrofitted over 65 percent of the manholes to prevent sewage from mixing with storm water.

[32]The Chesapeake Bay Program Office, U.S. EPA Region III, was founded in 1983 with the formation of the Chesapeake Bay Program. The program is a voluntary regional partnership that leads and directs restoration of the Chesapeake Bay. Members of the Chesapeake Bay Program include Maryland, Pennsylvania, Virginia, the District of Columbia, the Chesapeake Bay Commission (a tristate legislative body), EPA, and participating citizen advisory groups.

Third, local governments participating in the Phase I program are required to report annually to EPA or the state regulatory agency on their storm water programs. These reports are to include a status report on the program; a summary of data, including monitoring results collected during the reporting year; information on annual expenditures on the program and a budget for the coming year; and a description of any water quality improvements or degradation.

## Information on the Costs of Addressing Storm Water Runoff Is Limited

Good information about the cost of implementing federal storm water requirements is limited. EPA conducted a survey to estimate the nation's future water infrastructure needs over a 20-year period—from 1996 to 2016. In its 1996 report,[33] EPA estimated that states would require over $50 billion to meet their current (as of 1996) water infrastructure needs. The estimate consists of storm water management needs (at $7.4 billion) and CSO needs (at $44.7 billion).[34] EPA noted, however, that estimated storm water management needs are likely too low and could increase following an analysis of data collected to prepare the agency's 2000 clean water needs survey—to be released in 2002. According to EPA, many cities have implemented the Phase I program since EPA reported to the Congress in 1996, and municipalities should now be better able to provide documented cost data. As a result, EPA will need to rely less on modeled storm water needs than it did in the 1996 needs survey. EPA did not project the costs and benefits of the program when it was initiated; therefore, no initial cost estimates are available. When EPA promulgated the Phase I program regulations in 1990, the agency decided that the storm water program did not meet the requirements for preparing a benefit/cost analysis.

[33] *1996 Clean Water Needs Survey Report to Congress*, U.S. Environmental Protection Agency (Sept. 1997). EPA's estimate represents the estimated capital costs for water quality projects eligible for state revolving fund support.

[34] EPA also estimates that $81.9 billion of its 20-year water infrastructure needs cost can be attributed to sanitary sewer overflows. These overflows may occur when rainwater or snowmelt leaks into sanitary sewage pipes, exceeding the pipes' capacity and causing them to overflow. This overflow can release untreated sewage from municipal sanitary sewer systems into streams, basements, and streets.

The costs to local governments of complying with the Phase I program have generally been portrayed as high. However, because of inconsistencies in cost accounting and reporting practices, we could not determine the cost of the program to several of the cities we visited. Although municipalities are required to provide information on the expenditures that they anticipate will be needed to implement their storm water management programs for each fiscal year covered by the permit, EPA has not issued any cost reporting guidelines. Consequently, while the reported fiscal year 1999 total cost to manage and treat storm water runoff across the five municipalities in our review ranged from less than $1 million (Milwaukee) to $135 million (Los Angeles County),[35] these numbers are not comparable because the municipalities did not have consistent cost accounting and reporting practices and did not fully express storm water management costs.[36] For example, some cities reported only the costs of activities that were funded by the city department that held the permit. Significant activities funded by other city departments were not reported, even if they were important components of the storm water program. Officials in the Milwaukee Department of Infrastructure Services and the Boston Water and Sewer Commission told us that other city departments perform and fund activities such as street sweeping and flood control. The costs of these activities are not reported as storm water program costs because the activities serve other purposes besides preventing storm water pollution.

In addition, according to some city officials, these activities were in place before the permit was issued and, therefore, cannot be characterized solely as storm water costs. The cost of street sweeping can be significant—for fiscal year 1999, Baltimore City and Worcester, which did include street-sweeping costs in their storm water program's cost estimate, stated that their street-sweeping expenses totaled about $9.5 million and $1.2 million, respectively. Similarly, Milwaukee did not report the cost of a significant project related to storm water runoff because it was mostly funded by the state of Wisconsin.

[35]Los Angeles County's cost was projected by the municipal permit holder and represents the cost of the 85 cities covered by the permit.

[36]We were unable to obtain comprehensive information on the total cost to the Boston Water and Sewer Commission of managing storm water, so their fiscal year 1999 costs could not be included in this range.

An EPA official told us that the agency had not yet made a national effort to analyze the information that Phase I permittees submitted on the costs of their storm water programs. This official cited the inconsistent formats of the annual reports as a reason that the information was not readily available at the national level and also indicated that adequate staff are not available to analyze the data. In addition, other EPA officials informed us that the Office of Wastewater Management must divide its resources among a number of issues that will challenge the agency's water program over the next decade.

Several officials in the cities we visited said that their annual costs are likely to increase. A number of factors could affect the costs. For example, a Baltimore City official explained that the anticipated, future program costs depend on several factors, including (1) requirements in watershed-management plans currently being developed, (2) pollution-reduction goals the city will be required to achieve, (3) requirements of the state regulatory agency in future permits, and (4) requirements the city may have to meet if TMDLs or numeric effluent limits are incorporated into NPDES storm water permits. Other city officials also expressed concern about the extent to which TMDLs could affect their future costs. These city officials are concerned that when and if TMDLs are established, their future storm water permits may require that storm water runoff meet specific water quality standards. For example, Los Angeles County's trash TMDL could potentially drive the county's storm water management costs upward, and the county expects additional TMDLs to be imposed. On the other hand, Worcester officials estimated that their future storm water costs would be about the same as they were at the time of our review—about $4.5 million per year.

In a separate analysis, EPA estimated in 1999 that it will cost Phase II municipalities about $848 million to $981 million per year (in 1998 dollars) to manage storm water runoff. Because Phase II permits have not been issued as of May 2001, we did not gather any cost information on them from these cities.

## Funding for Managing Storm Water Runoff Is Available From Local and Federal Sources

The five cities we visited had not generally obtained federal funds for their storm water management efforts. They used local sources, including general revenues, bonds, revenue from specifically created storm water utilities, state grants, and inspection and permit fees.

While several sections of the Clean Water Act provide funding that can be used for municipal storm water control, relatively few federal funds have been directed to these types of projects. The most significant source of funds is the state revolving loan funds administered by states.[37] These revolving loan funds provide loans for eligible storm water control projects. In some cases, nonpoint source projects may also qualify for funding when storm water permits are not required or issued. However, municipal storm water management is generally a low priority in these programs. Specifically, in the year 2000, revolving fund loans were made in the "storm sewers" category in the amount of $38.76 million for 44 different projects. These funds represented less than 1 percent of the amounts loaned from these revolving funds that year. Activities eligible for revolving fund loans include constructing BMPs to control runoff, but support for ongoing operations and maintenance is not eligible. Revolving fund loans can also be used for eligible CSO control projects. In 2000, Clean Water State Revolving Fund Program loans were made in the "CSO Correction" category of a national EPA database in the amount of $411.3 million for 69 different projects and could have been used for CSO or sanitary sewer overflow projects. This amount represented about 9 percent of the funds loaned in 2000.

According to EPA, the agency also issues grants to universities and other research institutions to help implement the storm water program. Some of these grants provide training and guidance to Phase I permittees on watershed protection and the proper selection of BMPs.

Other sources of funding may be available to local governments beginning in 2002. In December 2000, the Congress authorized programs for fiscal years 2002 through 2004 to provide grants to local governments for (1) pilot projects for managing municipal CSOs, sanitary sewer overflows, and storm water discharges on a watershed basis and for testing BMPs and (2) controlling pollutants from MS4s to demonstrate and determine cost-effective, innovative technologies for reducing pollutants from storm water discharge. EPA's proposed budget does not request funds for these programs. In addition, the Congress authorized programs for fiscal years 2002 and 2003 to provide grants to local governments for planning, designing, and constructing treatment works to intercept, transport,

[37]Under the Clean Water State Revolving Fund Program, the federal government provides grants to capitalize states' funds. States provide loans to local governments for wastewater projects.

control, or treat municipal CSOs and sanitary sewer overflows. EPA's proposed budget requested $450 million for this program.

## EPA, States, and Local Governments Believe the NPDES Storm Water Program Is Effective, but It Has Not Been Evaluated

EPA, state, and municipal officials generally believe that the NPDES Storm Water Program will improve water quality. These officials believe that the program will result in more bodies of water that meet water quality standards, improved aesthetic conditions, reduced risk from bacterial contamination, and improvements attributable to the discovery and management of pollutants in storm water that otherwise would have gone unnoticed. EPA attempted to put a dollar value on these benefits in its benefit/cost analysis prepared for the Phase II storm water regulations, estimating that such benefits could range from $672 million to $1.1 billion per year (in 1998 dollars).[38]

However, little information is currently available on the benefits of the storm water program or its general effectiveness. There is no doubt that it will take time for the results of the Phase I program to be demonstrated. As EPA notes in its February 2000 report to the Congress, pollution control efforts under water quality management programs produce long-term changes, and the agency expects water quality improvements attributable to the Phase I program to become evident in the future, as the program matures. In this report, EPA concluded that the program has improved storm water management at the local level, improved water quality, and decreased pollutant loads in storm water. However, EPA relied on a survey of only nine Phase I cities in making these conclusions and, therefore, also reported that the agency could not provide national estimates on water quality protection and improvements generated by Phase I of the program. To evaluate the entire program, EPA would have to establish goals for the program that are based on its mission; obtain information about the program's results; compare the results with the goals; and make changes to the program, if warranted, to get closer to achieving the agency's goals.

EPA and the states also have not taken advantage of information that is available to evaluate the program. Each city we visited was regularly monitoring its storm water to establish baseline information on pollutant levels and was reporting this information to EPA or the regulatory state agency each year. Although cities with Phase I permits are required to report on their storm water monitoring results and changes in water

[38]Using another method, EPA estimated the benefits at $1.6 billion per year.

quality, overall, EPA and the states have not successfully developed measurable goals for the program or demonstrated its effectiveness through the review of municipal reports. An EPA official said that some states had requested funding to analyze program data because they did not have the resources to do so, and that EPA had provided the funding in a few cases. EPA also has not established any guidelines for how these data should be reported. Therefore, the reports may be as variable as the cost information we obtained in our five site visits.

EPA has not yet taken any of these data-analysis steps because, according to EPA officials, other program challenges within the Office of Wastewater Management compete with storm water management efforts for priority. For example, EPA officials stressed that available resources within the office must address other significant wet-weather pollution problems, such as CSOs and sanitary sewer overflows, and nonpoint source pollution problems, such as agricultural practices, forestry, and mining. One agency official noted that the highest priority is addressing needs that the agency and local governments have identified for improving wastewater infrastructure, such as sewage treatment facilities. The program also has relatively few staff assigned—about five in the headquarters office and about 10 in the regional offices—for the municipal, industrial, and construction portions of the program. In a program plan recently prepared for the storm water program, EPA estimated that nine to 10 staff would be needed in EPA headquarters to evaluate the program and implement other program requirements.

EPA officials described two efforts that may be the first steps in developing better information about the program. First, EPA intends to issue a grant to the University of Alabama in June 2001 to evaluate monitoring data submitted by a sample of municipalities with Phase I permits. This effort will (1) determine the different types of monitoring being conducted by Phase I municipalities, (2) assess water quality in and around permitted municipalities and determine any correlation between program implementation and impacts on water quality, and (3) recommend approaches for improving the effectiveness of municipal storm water monitoring programs. EPA expects the results of this study in 2003. Second, an EPA official stated that the agency would like to establish a system for analyzing program findings, incorporating necessary changes that are based on these findings, and evaluating the program's effectiveness. The agency plans to implement a pilot project in 2001 in the agency's Atlanta Region IV office for analyzing data reported in annual reports and developing key indicators for the program. If this project is successful and resources are available, the project could be expanded.

## Conclusions

EPA regards urban runoff as a significant threat to water quality across the nation and considers it to be one of the most significant reasons that water quality standards are not being met nationwide. Prompted by the Congress, EPA has responded with a variety of programs, including the NPDES Storm Water Program, which requires more than 1,000 local governments to implement storm water management programs. Those municipalities that are currently involved in Phase I of the program have been attempting to reduce pollutants in storm water runoff for several years. It is time to begin evaluating these efforts. However, EPA has not established measurable goals for this program. In addition, the agency has not attempted to evaluate the effectiveness of this program in reducing storm water pollution or to determine its cost. The agency attributes this problem to inconsistent data reporting from permitted municipalities, insufficient staff resources, and other competing priorities within the Office of Wastewater Management. Although Phase I municipalities report monitoring and cost data to EPA or state regulatory agencies annually, these agencies have not reviewed this information to determine whether it can be of use in determining the program's overall effectiveness or cost. Our analysis shows that the reported cost information will be difficult to analyze unless EPA and its state partners set guidelines designed to elicit more standardized reporting. Better data on costs and program effectiveness are needed—especially in light of the Phase II program that will involve thousands more municipalities in 2003. EPA's planned research grant to the University of Alabama and its pilot project in the agency's Region IV to analyze data from annual reports and develop baseline indicators is a step in the right direction and could point the way for a more comprehensive approach.

## Recommendation

To determine the extent to which activities undertaken through the NPDES Storm Water Program are reducing pollutants in urban runoff and improving water quality, and the costs of this program to local governments, we recommend that the Administrator, EPA, direct the Assistant Administrator for the Office of Water to

- establish measurable goals for the program;

- establish guidelines for obtaining consistent and reliable data from local governments with Phase I permits, including data on the effects of the program and the costs to these governments;
- review the data submitted by these permittees to determine whether program goals are being met and to identify the costs of the program; and
- assess whether the agency has allocated sufficient resources to oversee and monitor the program.

## Agency Comments and Our Evaluation

We provided a draft of this report to EPA and DOT for their review and comment. EPA generally agreed with the report and with the recommendation, although it did not explicitly comment on all parts of it. (EPA's comments appear in app. VI.) In response to our recommendation that EPA set measurable goals for the storm water program, EPA stated that under the second phase of the program, local governments will establish their own goals. Although this is an important activity, EPA will have difficulty evaluating the program's effectiveness at a national level without setting goals that reflect the program's mission of improving water quality. The agency (1) agreed that it should establish guidelines for obtaining consistent and reliable data from local governments about their programs and (2) plans to award grants to two universities for reviews of monitoring data reported by local governments. EPA did not comment on whether local governments should report on the costs of their programs. EPA also agreed that it and its state partners should review data reported by local governments to determine whether the program's goals are being met. In April 2001, EPA officials told us that the agency planned to undertake a project in the Region IV (Atlanta) office to evaluate the methods local governments are using to control storm water. EPA's letter indicates that the agency now plans to implement this project in three regional offices and 10 states. EPA did not comment on the part of our recommendation that the agency review the level of resources devoted to overseeing and monitoring the program. EPA also provided technical comments that we incorporated where appropriate.

DOT generally agreed with the draft report and provided technical comments that we incorporated where appropriate. In particular, DOT suggested that we revise several references in the draft report to paved surface area and its relationship to increases in urban runoff, to emphasize that impervious surfaces, of which paved surfaces are a significant subset, cause increases in runoff. We revised the language in these places.

As agreed with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days after the date of this report.  At that time, we will send copies of this report to the Administrator, Environmental Protection Agency, and the Secretary of Transportation.  We will make copies available to others on request.  If you or your staff have any questions about this report, please call me at (202) 512-2834.  Key contributors to this report are listed in appendix VII.

Peter F. Guerrero
Director, Physical Infrastructure Issues

# The Storm Water Program in Baltimore City, Maryland

Baltimore City's municipal separate storm sewer system (MS4) is regulated by the Maryland Department of Environment (MDE) and, according to a city official, services the entire city. The city is currently implementing its second, 5-year National Pollutant Discharge Elimination System (NPDES) permit, issued on February 8, 1999. Before obtaining the first NPDES storm water permit in 1993, Baltimore City addressed the adverse affects of storm water runoff by implementing Maryland's Storm Water Management Program and Erosion and Sediment Control Program. According to the 2000 census, Baltimore City's population is about 651,000.

## Urban Runoff Problems in Baltimore City

Baltimore City's urban runoff discharges to four major areas—Gwynns Falls, Jones Falls, Herring Run, and the Patapsco River—and then ultimately to the Chesapeake Bay. In 1990, the Environmental Protection Agency's (EPA) 319(a) report[1] implicated urban runoff as the main source of pollution in these waters. Moreover, Baltimore City was one of the areas studied in EPA's Nationwide Urban Runoff Program in the 1980s. This study reported that urban runoff contributed over 60 percent of the total nitrogen, phosphorus, and organic carbon; over 70 percent of the chemical oxygen demand; and over 80 percent of the total suspended solids, lead, and zinc in local water bodies.

An MDE official told us that nutrients, zinc, and suspended solids are among the constituents most commonly found in urban runoff, but the quantitative contribution to water quality impairment in the state's waters was not known. Also, in 1996, the Chesapeake Executive Council designated the Baltimore Harbor as one of three toxic regions of concern in the Chesapeake Bay. The harbor suffers from sediment contaminated by banned substances (such as the termiticide chlordane) and contaminants currently being released (such as metals and organics). Furthermore, according to the Chesapeake Bay Program Office, data collected from Phase I permittees indicate that storm water runoff can be a significant source of metals and organics in the harbor.

A Baltimore City official told us that some portions of Maryland's waters are impaired because of unacceptable levels of nutrients, metals,

[1]Section 319(a) of the Clean Water Act requires, among other things, that states identify and report to EPA the navigable waters that cannot reasonably be expected to maintain water quality standards (e.g., established water body uses) without additional action to control nonpoint source pollution.

suspended sediments, and chlordane. Moreover, this official noted that the state does not consider data that municipalities collect under their NPDES storm water permits during the 303(d) listing process. Therefore, he believes that streams in Maryland are much more impaired than indicated by the listing process.

## Baltimore City's Use of Best Management Practices

Like other NPDES storm water permit holders, Baltimore City uses a variety of best management practices (BMP) to reduce the amount of pollutants in runoff to the maximum extent practicable. These BMPs include detention ponds, shallow marshes (which use the biological and naturally occurring chemical processes in water and plants to remove pollutants), sand filter devices, public education programs, and the identification of illicit discharges to the MS4 system. Furthermore, Baltimore City participates in Maryland's effort to reduce nutrient levels in the Chesapeake Bay. Refer to the section of this report describing local government efforts to manage storm water for details concerning this nutrient-reduction goal. One other BMP includes the following:

- Baltimore City has incorporated the *2000 Maryland Storm Water Design Manual's* management policies, principles, methods, and practices into its current NPDES storm water discharge permit. The purpose of the design manual is to (1) protect the waters of the state from the adverse effects of urban storm water runoff; (2) provide design guidance on the most effective structural and nonstructural BMPs for development sites; and (3) improve the quality of BMPs that are constructed in the state, with particular attention to their performance, longevity, safety, ease of maintenance, community acceptance, and environmental benefit.

## Costs Associated With Managing Storm Water

We were not able to obtain comprehensive information on the total cost to Baltimore City of managing storm water. Therefore, we do not present that information here.

## Funding Sources

Baltimore City funds its storm water management control efforts with city water and sewer user fees and with state funds.

# The Storm Water Program in Boston, Massachusetts

The Boston Water and Sewer Commission received a NPDES storm water permit in October 1999. The commission is a separate entity from the city of Boston and, therefore, does not manage some storm water controls that are common in Phase I permits, such as street sweeping, winter deicing, and many of the urban runoff controls required for new developments. Boston has combined sewer systems as well as separate sanitary sewers and storm drains. The commission maintains 206 storm water outfalls and serves approximately 33 percent of the city through its separate MS4 system. In addition to the resident population of about 589,000, this system also almost daily serves 340,000 commuting workers; 70,000 shoppers, tourists, and business people; and 75,000 commuting students. The commission's sanitary and combined flows are transported to the Massachusetts Water Resources Authority at Deer Island. The commission is also the permittee for EPA's Combined Sewer Overflow Program.

## Urban Runoff Problems in Boston

The commission considers the identification and elimination of illegal sanitary sewer connections as the most effective means of improving water quality and protecting public health. It is also concerned with the washoff of animal wastes from residential and open land, which is another major contributor to the impairment of water quality because it can cause an increase in coliform levels in the storm water discharges to the receiving waters.

The commission has contracted for various studies to determine the impact of storm water runoff. The following two studies identified sources of bacterial contamination and characterized the quality of storm water discharged from different types of land uses. The studies included metering storm water flows, collecting and analyzing the storm water and receiving water quality samples, and identifying and remediating illegal sewer connections. Observations from the studies include the following:

- A 1996 study determined that pet waste, rather than sanitary sewage, was a key contributor of bacteria to the storm drain system that had possibly led to beach closings in the area.
- A 1998 study identified several illegal connections to the storm drain system. Furthermore, the study showed that deicing and sanding efforts resulted in levels of sodium, chloride, total dissolved solids, and cyanide that exceeded EPA's acute (high dose) toxicity levels.

## Boston's Use of Best Management Practices

To meet the NPDES permit's requirements, the commission, like other permittees, continued BMPs, such as identifying illegal connections, and implemented new BMPs aimed at preventing the discharge of pollutants to storm drains and receiving waters. Refer to the section of this report describing local government efforts to manage storm water for details describing the commission's citywide catch-basin inspection cleaning and preventative maintenance program. Other efforts include the following:

- The commission has placed particle separators, which remove oil, grease, and sediments from storm water flows, throughout the city. The commission requires particle separators to be installed by developers on all newly constructed storm drains that serve outdoor parking areas. Fuel-dispensing areas not covered by a canopy or other type of roof enclosure must also have a particle separator.
- The commission requires developers to consider on-site retention of storm water for all new projects, wherever feasible. On-site retention aids in controlling the rate, volume, and quality of storm water discharged to the commission's storm drainage system.

## Costs Associated With Managing Storm Water

We were not able to obtain comprehensive information on the total cost to the commission of managing storm water because the commission does not separate the cost of its storm water program from the cost of its sewer operations. Therefore, we do not present that information here.

## Funding Sources

The commission funds its storm water management control efforts primarily with city water and sewer user fees and bond proceeds.

# The Storm Water Program in Los Angeles County, California

Under the NPDES Storm Water Program, the Los Angeles Regional Water Quality Control Board issues 5-year permits to Los Angeles County for its municipal storm water program. The Los Angeles County permit, issued in July 1996, is the county's second storm water permit. This permit includes Los Angeles County as the principal permittee and 85 cities as permittees. According to the 2000 census, Los Angeles County's population is about 9.5 million.

## Urban Runoff Problems in Los Angeles County

The effects of urban runoff on the ocean are of particular concern in southern California. Contaminated sediments, impaired natural resources, and potential human illness could threaten the county's tourism economy, estimated to be about $2 billion a year.

The following three studies have shown that urban runoff can pose health risks to swimmers near storm drains and contribute toxic metals to receiving water sediments:

- The Santa Monica Bay Restoration Project conducted a study to assess the possible adverse health effects of swimming in waters contaminated by urban runoff.[1] This study revealed that there is an increased risk of illness associated with swimming near flowing storm drain outlets and an increased risk of illness associated with swimming in areas with high concentrations of bacteria indicators. Furthermore, illnesses were reported more frequently on days when the samples were positive for enteric viruses. Refer to the section of this report describing the effects of runoff on aquatic life and human health for more details.
- The Southern California Coastal Water Research Project coordinated a study that assessed microbiological water quality and found that the majority of shoreline waters exceeded water quality standards during wet-weather conditions. Furthermore, the ocean waters near storm water outlets demonstrated the worst water quality regardless of the weather.[2]
- The Southern California Coastal Water Research Project also compared the runoff from an urban area and a nonurban area in the Santa Monica

[1] R.W. Haile and others, "The Health Effects of Swimming in Ocean Water Contaminated by Storm Drain Runoff," *Epidemiology,* July 1999, Vol. 10, No. 4.

[2] Southern California Coastal Water Research Project, *Southern California Bight 1998 Regional Monitoring Program, Volume 3: Storm Event Shoreline Microbiology,* 2000.

Bay Watershed.[3] The results of the study indicated that storm water plumes extended up to several miles offshore and persisted for a few days. Furthermore, the runoff from the urban area proved to be toxic to sea urchin fertilization, and dissolved zinc and copper were determined to be contributors to the toxicity. The study also found that in urban areas, sediments offshore generally had higher concentrations of contaminants such as lead and zinc.

## Los Angeles County's Use of Best Management Practices

As in the other sites we visited, the county is managing its runoff through the use of conventional BMPs. These BMPs include the elimination of illicit connections and discharges to the storm sewer system, construction control measures, routine inspections, staff training, pollution prevention plans for public vehicle maintenance and material storage facilities, sweeping and cleaning public parking facilities, street sweeping, catch-basin cleaning, and public education.

The Los Angeles Regional Water Quality Control Board recently adopted a Total Maximum Daily Load (TMDL) Program to reduce trash loads to the Los Angeles River. As a result, the county is exploring a number of trash reduction BMPs, which are discussed in the section of this report describing local government efforts to manage storm water.

## Costs Associated With Managing Storm Water

Table 3 indicates that the county and the other permittees have allocated significant funding for storm water management activities over the years. For example, for fiscal year 1999,[4] projected funding for storm water management activities for the county and the other permittees amounted to over $134 million.[5] The largest projections for both went toward public agency activities. For example, during fiscal year 1999, the principal permittee and the permittees together projected almost 67 percent of storm water management funds to public agency activities. The activities in this

[3]Southern California Coastal Water Research Project, *Study of the Impact of Stormwater Discharge on Santa Monica Bay –Executive Summary,* Nov. 1, 1999.

[4]The county's fiscal year begins July 1 and ends June 30.

[5]According to an official with the Los Angeles Regional Water Quality Control Board, this figure may also include activities that are outside the scope of the permit.

program include staff training, inspections of construction projects, street sweeping, and catch-basin cleaning.

**Table 3: Summary of Fiscal Resources Projected for Los Angeles County and Its Co-permittees, Fiscal Years 1997-99**

(Dollars in thousands)[a]

| | Fiscal year 1997 | | Fiscal year 1998 | | Fiscal year 1999 | |
|---|---|---|---|---|---|---|
| **Activity** | **County** | **Others[b]** | **County** | **Others[b]** | **County** | **Others** |
| Program Management | $2,225 | $6,195 | $1,856 | $4,874 | $1,466 | $6,187 |
| Illicit Connection, Illicit Discharge Program | 1,620 | 3,515 | 1,017 | 3,075 | 764 | 2,901 |
| Development planning and construction | 784 | 6,208 | 1,300 | 3,769 | 1,452 | 5,743 |
| Public agency activities | 38,544 | 40,915 | 40,256 | 31,992 | 43,316 | 46,657 |
| Public information and participation | 2,840 | 5,538 | 4,360 | 3,856 | 4,629 | 6,177 |
| Monitoring | 2,018 | 619 | 1,768 | 729 | 1,598 | 737 |
| Other | 187 | 13,991 | 490 | 8,656 | 1,318 | 11,834 |
| **Total** | **$48,218** | **$76,981** | **$51,048** | **$56,950** | **$54,543** | **$80,237** |

[a]Totals may not add up because of rounding.

[b]Does not include 17 permittees for fiscal year 1998 and 13 permittees for fiscal year 1997 for the following reasons: The permittee operated on a different budget cycle, the final document was not available at the time of the annual report, or the information submitted by the permittee was not complete.

Source: GAO's analysis of cost data provided by the Los Angeles County Department of Public Works.

As shown in table 3, the county maintains primary responsibility for monitoring activities, having projected over $2 million for storm water monitoring activities in fiscal year 1997, almost $2 million in fiscal year 1998, and over $1.5 million in fiscal year 1999. Conversely, the permittees' projected funding levels for monitoring activities amounted to only $619,000 in fiscal year 1997, $729,000 in fiscal year 1998, and $737,000 in fiscal year 1999. According to an official with the Los Angeles Regional Water Quality Control Board, the County has consistently maintained primary responsibility for monitoring activities required under the permit.

## Funding Sources

The primary source of funds for the county's storm water program is flood control assessments collected throughout the district. Although the county has not applied for any state revolving funds, it has applied for and received approval for federal funds through the Transportation Equity Act for the 21st Century (TEA-21) for a pilot study of an engineering device that would remove trash from storm water. Additionally, the county has received partial funding through Proposition A of the Safe Neighborhood Parks of 1992 and 1996[6] for two Vortex Separation Systems—a Continuous Deflective Separation unit and a Stormceptor unit. Additionally, the county received grant money from the Metropolitan Transit Authority, which partially funded catch-basin screens, a Continuous Deflective Separation unit, and 120 catch-basin inserts.[7]

[6]The Los Angeles County Regional Park and Open Spaces District (a district within the Parks Department) received this funding from Proposition A and, in turn, made grants to the Los Angeles County Department of Public Works for the BMP devices.

[7]The Metropolitan Transit Authority receives TEA-21 funds from the California Department of Transportation.

# The Storm Water Program in Milwaukee, Wisconsin

The Wisconsin Department of Natural Resources (WDNR) has the authority to regulate the discharge of storm water from municipalities, construction sites, and industries under Natural Resources Code 216. This rule identifies Wisconsin municipalities that are required to obtain a storm water discharge permit under the Wisconsin Pollutant Discharge Elimination System (WPDES). Milwaukee completed its application process in 1994, and WDNR issued a WPDES permit to the city in October 1994. This was the first municipal storm water permit issued to a municipality in EPA's Region 5 covering the midwest. In July 2000, WDNR reissued Milwaukee's storm water permit. According to the 2000 census, Milwaukee's population is about 597,000.

## Urban Runoff Problems in Milwaukee

Milwaukee has a combined sewer system as well as a separate sanitary sewer system. The Milwaukee Metropolitan Sewerage District implemented a rehabilitation program that cost over $2 billion to reduce the number of combined sewer overflow (CSO) events each year. The rehabilitation program involved the construction of deep tunnels to store untreated wastewater and rainwater for later treatment at a wastewater treatment plant. Since 1996, the deep tunnels have significantly reduced the number of overflow events from an average of 50 to 60 per year before the construction to an average of two per year afterwards.

Urban runoff has been identified as a leading source of pollution to the Milwaukee River basin's streams, lakes, and wetlands and the Milwaukee River estuary. To address pollution from urban runoff, WDNR issues storm water permits to municipalities with MS4s serving areas with populations of 100,000 or more, municipalities in Great Lakes "areas of concern" where water quality has been identified as a serious problem, municipalities with populations of 50,000 or more that are located in priority watershed planning areas, and designated municipalities that contribute to the violation of a water-quality standard or are significant contributors of pollutants to state waters.

## Milwaukee's Use of Best Management Practices

In addition to BMPs such as the elimination of illicit connections and discharges to the storm sewer system, the reduction of pollutants in storm water runoff from construction sites, public education, catch-basin cleaning, street sweeping, and the use of detention basins, Milwaukee has explored the use of innovative BMPs. Refer to the section of this report describing local government efforts to manage storm water for more details about an educational campaign directed at a specific watershed. Additional BMPs include the following:

- An innovative storm water control device was installed in a parking lot at a heavily used municipal public works yard that was found to discharge significant amounts of storm water pollutants. Termed the Multi-Chambered Treatment Tank (MCTT), this device is suitable for areas with limited space, cleans up polluted runoff close to its source, removes pollutants that are not susceptible to other treatment methods, and is hidden from view. The MCTT consists of a catch basin, a settling chamber, and a filter. Although the results of the monitoring studies have revealed that the device has a positive effect on water quality, officials with the Department of Public Works explained that it is cost-prohibitive and suitable only for sites with limited space.
- The permittee has also been working with WDNR, the Department of Transportation, the U.S. Geological Survey, and a neighborhood association in a joint effort to develop a storm water monitoring assessment program consisting of two innovative storm water treatment devices. One device removes grit, contaminated sediments, heavy metals, and oily floating pollutants from surface runoff. The other device removes a broad range of pollutants from runoff, such as bacteria, heavy metals, nutrients, petroleum hydrocarbons, and suspended solids. The devices are to be installed along a new reach of the Milwaukee Riverwalk through the third ward of Milwaukee.

## Costs Associated With Managing Storm Water

Reliable data on the total cost to manage storm water in Milwaukee were not available and cannot be presented here because certain activities are not reported as program costs in the city's annual report. These activities include street sweeping; leaf collection; catch-basin and inlet cleaning; maintenance of public boulevards, parks, and public green spaces; and the recycling of waste oil and antifreeze. Therefore, the program costs reflected in the annual report do not take into account many of the nonstructural BMPs employed by the city nor do the totals include activities funded through grants. The storm water management activities that were included in the city's 2000 budget request were estimated to cost $460,000.

## Funding Sources

Milwaukee's storm water program is primarily funded through the city's sewer maintenance fund. Unlike the general revenue account, which is based on property taxes, the sewer maintenance fund is based on water consumption. The city has also received supplemental funding from the Wisconsin Nonpoint Source Water Pollution Abatement Program in the form of WDNR grants. The city has received over $1 million since 1991 for a wide variety of storm water management activities.

# The Storm Water Program in Worcester, Massachusetts

Worcester's Department of Public Works (DPW) received a NPDES permit on November 1, 1998. The Sewer Operations Division, within the DPW, is directly responsible for operating and maintaining the city's separate storm sewer system, along with the sanitary and combined sewer system. Since 1993, the Sewer Operations Division has had a full-time storm water coordinator, reflecting Worcester's increased emphasis on meeting NPDES program requirements. Worcester has a population of about 173,000. Its water system covers an extensive area, including 371 miles of sanitary sewers, 340 miles of storm sewers, 56 miles of combined sewers, 27,000 manholes, over 14,000 catch basins, and 263 outfalls. Worcester's separate storm drain systems consist of 93 main drainage areas covering approximately 6,680 acres.

## Urban Runoff Problems in Worcester

The constituents that are typically found in urban runoff in Worcester are the same as those normally found in urban runoff in older cities. Because virtually all of the paved surfaces in the Worcester area are devoted to the city's transportation infrastructure, the constituents generated include automobile-related petroleum products, such as total petroleum hydrocarbons, oil and grease, along with total suspended solids. Also, coliform, silt, and sediment have been identified in the city's runoff.

## Worcester's Use of Best Management Practices

Like other permittees, the DPW has implemented BMPs under the major areas of education outreach, pollution prevention and source controls, storm-drainage system maintenance, regulatory efforts, and storm-drainage system infrastructure. Additionally, to reduce storm water pollution, the DPW has retrofitted a number of twin manholes in the city as discussed below. BMPs that are specific to Worcester include the following:

- The DPW implemented a demonstration project to determine the effectiveness of an oil and grit separator installed on a street drain. The drain is a major surface sewer main that services approximately 226 acres of heavily urbanized area with a typical mix of residential, commercial, and industrial use. The drain discharges into Lake Quinsigamond, which is a large lake used for recreational purposes such as swimming and boating. In its April 2000 annual plan submitted to EPA, the DPW noted that because of drought conditions, it currently did not have sufficient sampling data to determine the effectiveness of the project.

- The DPW has embarked on a comprehensive program to minimize the possibility that sewage and storm water will be mixed in its twin invert manholes. Since the program began, the DPW has installed hold-down devices on over 1,680 of the approximately 2,580 twin invert manholes in the city. The DPW expects to continue the program until all of the manholes have been retrofitted.
- The DPW is also working closely with the Massachusetts Department of Environmental Protection in its ongoing tracking efforts to ensure that industries in Worcester are doing their part to reduce storm water pollution.
- To improve its storm-drainage infrastructure, the city has established a voluntary plan to reduce the number of unpaved private roads. The dirt from these roads, especially after rain storms, causes sediment to build up in the drainage system. The DPW has developed a plan to pave the streets at a lower grade than would be necessary to meet the legal requirements for a public street. Under this plan, residents would not have to pay the additional betterment taxes that are now required to cover the costs of sediment removal and less sediment would be transported in runoff.

## Costs Associated With Managing Storm Water

Since 1993, the DPW has allocated significant funding from the water and sewer utility fees it collects for controlling the effects of runoff, especially through catch-basin cleaning, street sweeping, and correcting illegal connections. For example, its fiscal year 1993 budget for storm water programs included about $1.6 million for specific programs and another $1 million for capital improvement programs, such as inflow/infiltration and flood control. The DPW also spent $500,000 to develop and submit its permit application. Furthermore, as shown in table 4, Worcester made extensive capital expenditures during fiscal years 1994 through 1999 on pertinent storm water projects to improve the quality of storm water runoff emanating from the city's storm water sewer system.

Table 4: City of Worcester's Capital Expenditures for Storm Water Management

(Dollars in thousands)

| | Fiscal year | | | | | |
|---|---|---|---|---|---|---|
| **Activity** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** |
| Sewer construction | $0 | $500 | $500 | $300 | $300 | $300 |
| Infiltration control | 0 | 400 | 400 | 100 | 100 | 100 |
| Pump station rehabilitation | 200 | 200 | 200 | 200 | 200 | 200 |
| Sewer rehabilitation | 300 | 750 | 300 | 750 | 750 | 1,500 |
| Landfill closeout | 150 | 1,200 | 200 | 500 | 0 | 0 |
| Belmont Drainage project | 0 | 100 | 600 | 100 | 0 | 0 |
| Beaver Brook Culvert project | 0 | 500 | 100 | 100 | 300 | 100 |
| Surface drain control | 40 | 150 | 200 | 200 | 200 | 200 |
| Geographic Information System | 0 | 0 | 0 | 125 | 125 | 125 |
| Other | 0 | 70 | 10 | 0 | 0 | 0 |
| **Total** | **$690** | **$3,870** | **$2,510** | **$2,375** | **$1,975** | **$2,525** |

Note: The Belmont Drainage project involved enlarging the drain to eliminate surcharging and siltation and moving the outfall to eliminate stagnation. The Beaver Brook Culvert project involved repairing the culvert and conducting a study that included a detailed hydraulic analysis of the drainage basin.

Source: Worcester Department of Public Works.

Furthermore, during fiscal year 1999, the DPW spent approximately another $2.1 million to operate and maintain storm water activities. Key expenditures included about $1.2 million for street sweeping, about $617,000 for catch-basin maintenance, $52,000 for root control, and another $48,000 for street paving. Also included was $40,000 per year for sampling five outfalls around the city three times per year as required by the permit. According to a DPW official, in previous fiscal years, the DPW funded the same or similar operation and maintenance activities to help control storm water runoff. As a result, the costs since 1994 were similar to those for 1999, except for annual adjustments for inflation. Therefore, the annual operation and maintenance expenditures ranged from about $1.7 million for 1994 to about $2.1 million for 1999.

According to a DPW official, the department expects to spend from $3 million to $4.5 million annually over the next several years on storm water-related activities. The amount of the cost increase will depend on whether EPA asks the city to increase its spending.

## Funding Sources

The DPW funds its storm water management controls effort from the water and sewer user fees it assesses to homes and businesses.

# Comments From the Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN 14 2001

OFFICE OF WATER

Mr. Peter F. Guerrero
Director, Physical Infrastructure Issues
United States General Accounting Office
Washington, DC 20548

Dear Mr. Guerrero:

Thank you for the opportunity to review your draft report entitled "Better Data and Evaluation of Urban Runoff Needed to Assess Effectiveness." We appreciate the difficulty that assimilating and interpreting such information on an extremely complex subject must have presented. Your report provides a fair and balanced depiction of the Agency's efforts, with the assistance of our State and local partners, to implement a national urban storm water runoff control program.

As the report correctly acknowledges, the Environmental Protection Agency (EPA) believes that urban runoff is a significant threat to water quality and is actively working to control the discharge of pollutants in storm water runoff. EPA's urban storm water control program has been a very successful undertaking to date and we are taking steps to address several of the recommendations identified in the report.

One of the challenges of controlling urban storm water runoff is to be able to address a wide array of complex environmental issues, even within the boundaries of one municipality. EPA's urban storm water program is developed with the understanding that a "one size fits all" approach will not work. For example, existing municipal separate storm sewer system (MS4) permits are tailored to suit the needs of each individual municipality. In fact, the municipalities select the majority of the measures that will be implemented to control storm water runoff. Similarly, EPA's Phase II regulatory framework for small MS4s requires the municipality to identify appropriate BMPs to control runoff and establish measurable goals against which program effectiveness will be measured. These BMPs and measurable goals then become the enforceable permit conditions for that municipality. EPA expects that approximately 5,000 small MS4s will each have a unique set of measurable goals that will define expectations of a successful storm water control program.

While EPA has developed a sound regulatory basis for urban storm water control, competing initiatives have limited our ability to invest sufficient resources to fully evaluate the effectiveness of the program and the associated implementation costs. We believe that the flexibility afforded MS4 permittees provides some assurance that permit requirements do not become onerous or unjustified. Additionally, with the MS4 permits reissued every five years,

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EPA expects that dialogue between MS4s and permitting authorities will better focus on those activities found to be most beneficial.

Over the next year, we will address challenges relating to evaluating the effectiveness of municipal storm water programs. Consistent with the first recommendation, EPA will evaluate storm water monitoring data that has been collected since program inception. Two grantees (UCLA and the University of Alabama) will review monitoring data that has been submitted as part of routine discharge monitoring reports and annual reports. EPA expects these efforts will evaluate the correlation between storm water discharges and trends in water quality impairment. Another anticipated finding from these grants is a compilation of the range of monitoring activities required of municipalities in storm water permits and the identification of the monitoring that appears to be most effective in demonstrating program results.

To meet another challenge, we are evaluating MS4 permit requirements and annual reports to identify the types of storm water control activities in place and the environmental and programmatic results of these activities. Initially, this effort will evaluate MS4s in at least three EPA Regions and 10 states to gather information on the range of methods employed by permitted MS4s to control storm water discharges. Through this effort, EPA expects to determine whether program goals are being met and establish meaningful indicators of program performance. Should this effort prove useful, EPA will expand the evaluation to a national effort that will evaluate MS4 permits and annual reports in all affected EPA Regions and states. In either case, results of this effort will be disseminated nationally to ensure that findings are incorporated into other MS4 programs, as appropriate.

Enclosed are additional comments on terminology and regulatory citations provided in the report. Again, we appreciate the opportunity to review and comment on the draft report. If you have any questions about these comments or would like to discuss urban storm water runoff issues, please contact me or call Jeff Lape, Acting Director of the Water Permits Division, at (202) 564-9545.

Sincerely,

Michael Cook

Michael B. Cook
Director
Office of Wastewater Management

Enclosure

Enclosure

Below are several additional comments for your consideration that address terminology and regulatory citations provided in the report:

- The term "nonpoint source" throughout the report, when referring to storm water runoff, is somewhat misleading in that the federal definition of "point source" includes many of the types of storm water discharges discussed in the draft report as "nonpoint source pollution." We recommend clarifying that EPA's NPDES storm water permits regulate point source discharges that includes storm water runoff from small, medium, and large municipal separate storm sewer systems. In fact, to avoid confusion between point sources and nonpoint sources in an NPDES context, we recommend that you consider using the term "wet weather discharges" when referring to storm water runoff.

- The third sentence in the first full paragraph on page 3 states that "EPA requires cities to use 'best management practices' to reduce contamination in storm water runoff." We recommend that you change the word "requires" to "recommends." While best management practices are common for reducing storm water contamination, EPA regulations allow MS4s to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques, and system, design, and engineering methods, and such other provisions which are appropriate.

- The last sentence in the second full paragraph on page 3 states that "managing storm water runoff will reduce runoff and improve water quality." We recommend changing this sentence to indicate that "managing storm water runoff will reduce the volume and concentration of pollutants in runoff and improve water quality.

- The last sentence of the same paragraph indicates that "Neither EPA nor states have developed measurable program goals or reviewed municipal reports on the results of storm water programs to determined whether the reports provide information that could demonstrate the program's effectiveness." A similar statement is made in the first full paragraph on page 31. We recommend that these two sentences be revised to indicate that "EPA and states have generally been unsuccessful in developing measurable program goals and in demonstrating program effectiveness through the review of municipal reports." EPA and some states have attempted to determine program effectiveness through the review of municipal reports but, to date, these efforts have been unsuccessful in making this determination.

# GAO Contacts and Staff Acknowledgments

## GAO Contacts

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## Staff Acknowledgments

In addition to those named above, Jennifer Clayborne, Richard LaMore, Sally Coburn, Elizabeth McNally, Charles Bausell, and Timothy Guinane made key contributions to this report.

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