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March 15, 1994

National Realty Committee, which serves as Real Estate's Roundtable in Washington, believes that national policies should facilitate a healthy environment. After all, such a result is essential to Americans' quality of life and, in fact, the viability of private industry. We also believe that prudent environmental policy should be based on sound, documented scientific evidence; be cost-effective; and be measured to address issues that are significant relative to their contribution to underlying problems.

With this in mind, last year NRC and the National League of Cities asked Montgomery Watson, a noted environmental engineering firm, to assess current knowledge of the impacts of urban stormwater runoff and review the findings of studies completed for Congress, the Environmental Protection Agency (EPA) and other entities.

The Montgomery Watson study, *Defining the Urban Stormwater Runoff Problem*, concluded that the urban stormwater runoff problem has been overstated. Agriculture, erosion, wastewater overflows and leaking septic systems are the major causes of runoff-related water quality impairment, not urban stormwater runoff. In addition, the study found, the most effective strategy for stormwater management entails the use of a watershed approach that will allow local problems to be identified and prioritized. National standards, on the other hand, would result in many oversized, unnecessary and quite costly facilities. A copy of the Montgomery Watson report is enclosed for your information.

Based on the study's conclusions, we believe that national policy should:

- recognize the limited extent to which urban stormwater runoff contributes to overall water quality impairment; and
- recognize that only a small percentage of commercial (including real estate) uses justify costly regulation. (In fact, we believe EPA should identify these types of uses *before* proceeding with regulation of non-industrial commercial activities.)

As you work to reauthorize the Clean Water Act, we hope you will consider the facts documented in and the conclusions of this study. Please call if we can answer any questions or provide additional information.

Steven A. Wechsler
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MONTGOMERY WATSON

Defining The Urban Stormwater Runoff Problem

February 1994

Prepared for:

**National League of Cities
National Realty Committee**



February 3, 1994

National League of Cities
and National Realty Committee

Montgomery Watson is pleased to provide this paper on defining the urban stormwater problem. As Congress considers amendments to the 1987 Clean Water Act, the impacts of non-point source discharges must be clearly understood. This understanding is imperative to structure control strategies that will yield the greatest benefit at the least cost. This assessment includes a review of current knowledge of the impacts of urban stormwater runoff and summarizes the findings of studies completed for Congress, the U.S. Environmental Protection Agency, and other entities.

This report includes an Executive Summary with concise conclusions and recommendations of this report, a summary of studies concerning urban stormwater runoff completed in the past 15 years, a discussion of cost implications of stormwater quality controls, and brief summaries of watershed management programs that several communities have implemented.

In summary, this report found that the impacts of urban stormwater runoff need to be separated from the impacts of other non-point sources such impacts of: agricultural and industrial site runoff, erosion, and wastewater overflows and leaking septic systems. In addition, it appears that the most effective strategy for stormwater management is to use a watershed management approach that will allow local problems to be identified and prioritized. It would be extremely difficult to approach this problem with national standards due to the wide variety of watershed characteristics and storm events. National standards would result in many oversized and unnecessary facilities. Rather it would be more appropriate to develop watershed-specific programs.

If you have any questions concerning this paper, please contact us.

Very Truly Yours,

Gwendolyn M. Buchholz
Principal Engineer



February 3, 1994

National League of Cities
and National Realty Committee

Montgomery Watson is pleased to provide this paper on defining the urban stormwater problem. As Congress considers amendments to the 1987 Clean Water Act, the impacts of non-point source discharges must be clearly understood. This understanding is imperative to structure control strategies that will yield the greatest benefit at the least cost. This assessment includes a review of current knowledge of the impacts of urban stormwater runoff and summarizes the findings of studies completed for Congress, the U.S. Environmental Protection Agency, and other entities.

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Gwendolyn M. Buchholz
Principal Engineer

EXECUTIVE SUMMARY

*An Understanding of the
Extent of Urban Stormwater
Problems and Other Types of
Stormwater Pollution is
Imperative Prior to Initiating
National Urban Stormwater
Quality Programs*

PURPOSE OF THE REPORT

As Congress considers amendments to the 1987 Clean Water Act, the impacts of non-point source discharges must be clearly understood. This understanding is imperative to structure control strategies that will yield the greatest benefit at the least cost. At this time, the impacts of urban stormwater runoff are not clearly understood because the specific effects have been masked by the greater impacts of industrial, agricultural, erosion, point source discharges, and wastewater overflow discharges.

This assessment includes a review of current knowledge of the impacts of urban stormwater runoff. Reports completed by the U.S. Environmental Protection Agency (EPA) and other agencies relating to urban stormwater runoff have been summarized in an attempt to define "water quality impairment due to urban stormwater runoff". In addition, several metropolitan areas throughout the nation were contacted to determine if new stormwater quality programs initiated in response to the 1987 Clean Water Act Amendments had changed water quality.

OVERVIEW

The nature of stormwater discharges is significantly different from that of wastewater point source discharges. Congress recognized these differences by establishing a separate National Pollutant Discharge Elimination System permit process for non-point source discharges and by defining a separate standard for stormwater based on the "maximum extent practicable" management measures. The stormwater program established by Congress in 1987 incorporated a phased program intended in part to provide the information base for a more comprehensive program to be developed when Congress re-authorized the Clean Water Act.

The Urban Stormwater Runoff Problem has been Overstated. Agriculture, Erosion, Wastewater Overflows, and Leaking Septic Systems are the Major Causes of Water Quality Impairment, not Urban Stormwater Runoff

The National Urban Runoff Program (NURP) study completed in 1983 is often cited as the basis for stormwater management programs. However, the NURP study indicated that agriculture, erosion, and wastewater were the primary causes of water quality impairment due to storm events. In addition, NURP suggested that illicit connections to storm drains be eliminated and local water quality strategies should be developed.

The findings that agriculture, erosion, wastewater overflows, and leaking septic systems are the major causes of water quality impairment have been reiterated in several EPA reports. The EPA and other agencies also found that many pollutant sources attributed to "urban runoff" are not caused by discharges from residential and commercial areas. The "urban runoff" problem is frequently caused by discharges from marine vessels, shipyards, marinas, leaking septic systems, industrial sites, and erosion of stream channels and shorelines.

The need for local water quality strategies, preferably on an integrated watershed basis, has been supported by the National Research Council in a report for EPA and Congress. The findings of the National Research Council indicated that regional strategies should consider all pollutant sources and integrate policies for air, water, and land. The study also stated that local management options should reflect social goals and priorities relative to risks, costs, and benefits. The plans must be flexible to allow changes based on information collected after new management programs are implemented. This could allow agencies to eliminate non-viable programs or improve ongoing programs.

COST IMPLICATIONS

This assessment clearly indicates that expenditures for new regulatory stormwater control strategies should be limited until studies can be completed to define the effectiveness of ongoing water quality management programs and the extent of the remaining problem. Additional studies should be conducted on a watershed basis to accurately identify pollutant sources and prioritize solutions.

Costs for Treatment of Stormwater From Residential and Commercial Areas in Major Metropolitan Communities Throughout the United States Could be Over \$406 Billion for Construction and Over \$543 Billion Each Year for Operation and Maintenance

Annual Costs for Improving Stormwater Quality could be up to 500 times more Expensive than Wastewater Treatment Because of the Volume of Water and Intermittent Nature of Storms

To the extent that existing and future watershed studies identify urban runoff as a specific problem, additional measures should be employed that are appropriate for each watershed.

Cost implications of national effluent and/or treatment standards were evaluated in a recent study by the American Public Works Association of Southern California. The study identified a potential range of national costs of \$147 million to \$406 billion for construction of stormwater controls and \$1.1 billion/year to \$543 billion/year for operation and maintenance.

The costs shown in Figure 1 (located at the end of this section) are conservative estimates and may be as much as 50 percent low because the costs do not include the cost of stormwater pipelines, land and permits for the treatment facilities, and design costs.

These costs can be compared to the costs of providing municipal wastewater treatment. Since 1972, municipalities throughout the nation have spent about \$76 billion for construction (with about \$50 billion funded through federal grants). These municipalities continue to spend \$1.1 to 1.8 billion/year for operations and maintenance. It should be noted that these costs primarily remove solids and organic materials. This would be comparable to Level 4 Best Management Practices, as shown in Figure 1. The Level 5 treatment represents a treatment level significantly higher than most wastewater treatment plants provide, as shown in Figure 1. The Level 5 controls would be mandated if national stormwater discharge standards were required to meet national water quality standards.

Several agencies across the country have implemented watershed programs. These watershed programs have led to less costs than costs for complete stormwater treatment. For example, these agencies implemented what was approximately equivalent to non-structural controls, or Level 2 in the APWA study. If these agencies had implemented complete stormwater treatment to remove solids, metals and microorganisms, as described under Level 5 in the APWA study, the construction costs would be significantly higher, based on data presented in the APWA report, as shown in Figure 2.

Results of Recent Water Quality Surveys Indicate that Urban Stormwater Runoff is a Small Source of Stormwater Pollutants. Applying National End-of-Pipe Standards for Urban Stormwater Discharges Would be Extremely Costly

CONCLUSIONS

Based upon this review of studies completed over the past 15 years and discussions with stormwater quality management agencies throughout the nation, the following specific conclusions are provided.

- The urban stormwater runoff problem has been overstated.
- The urban stormwater runoff problem frequently has been described using old or over-generalized data.
- Results of recent water quality surveys indicate that urban stormwater runoff is a small source of stormwater pollutants compared to other non-point sources (less than 4 percent in some categories of receiving waters).
- Future monitoring results are needed to identify the extent of remaining urban stormwater quality problems and the cost-effectiveness of control strategies and measures.
- Applying national end-of-pipe standards for urban stormwater discharges would be extremely costly.
- Vast differences in hydrology, soils, vegetation, precipitation patterns, and land uses argues against national urban stormwater discharge standards.
- Proposed urban stormwater quality controls and national water quality standards would require urban areas to fund costly facilities to collect and treat stormwater flows while not addressing for more significant sources.

Existing Programs for Source Controls Should be Continued and Watershed Management Programs Should be Implemented to Evaluate Identify and Address Water Quality Problems

RECOMMENDATIONS

A watershed evaluation approach would identify the most significant stormwater pollutant sources, including pollutant discharges from industrial sites, agricultural areas, and leaking septic systems. Therefore, based upon the findings presented in this paper, the following recommendations are presented.

- Continue and expand the use of initial "good-housekeeping" and public education measures that are currently being implemented by most metropolitan areas.
- Continue the Stormwater National Pollutant Discharge Elimination System permit programs for industrial and hazardous waste sites.
- Limit the scope of measures for urban runoff in a watershed to primarily non-structured measures until non-point source problems are understood.
- Develop and initiate a watershed approach applicable to all pollution sources to identify and address water quality problems.
- Develop watershed water quality plans that address water quality constraints, opportunities, and priorities within the framework of the unique physical and economic situation each watershed.

By identifying the specific sources of stormwater quality impairment, pollution control efforts can be targeted and made more effective. This approach would save billions of potentially unnecessary construction dollars and annual operation and maintenance dollars that are needed for other programs and services.

LEVELS OF BEST MANAGEMENT PRACTICES

LEVEL 1



NON-STRUCTURAL SOURCE CONTROLS

- Prevent Illicit Discharges
- Increased Street & Sidewalk Sweeping
- Clean Storm Drains

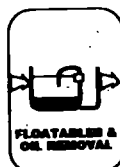
LEVEL 2



MINOR STRUCTURAL SOURCE CONTROLS

- Diversion Channel
- Grass Swales
- Improve Natural Channels to Reduce Erosion
- Plant Vegetation on Exposed Soils

LEVEL 3



FLOATABLES AND OIL REMOVAL

- Parking Lot Oil/Grease Separators
- Parking Lot and Rooftop Runoff Storage and Separators

LEVEL 4



SOLIDS REMOVAL

- Detention Basin
- Primary Clarifiers
- Swirl Concentrators
- Screens
- Wetlands

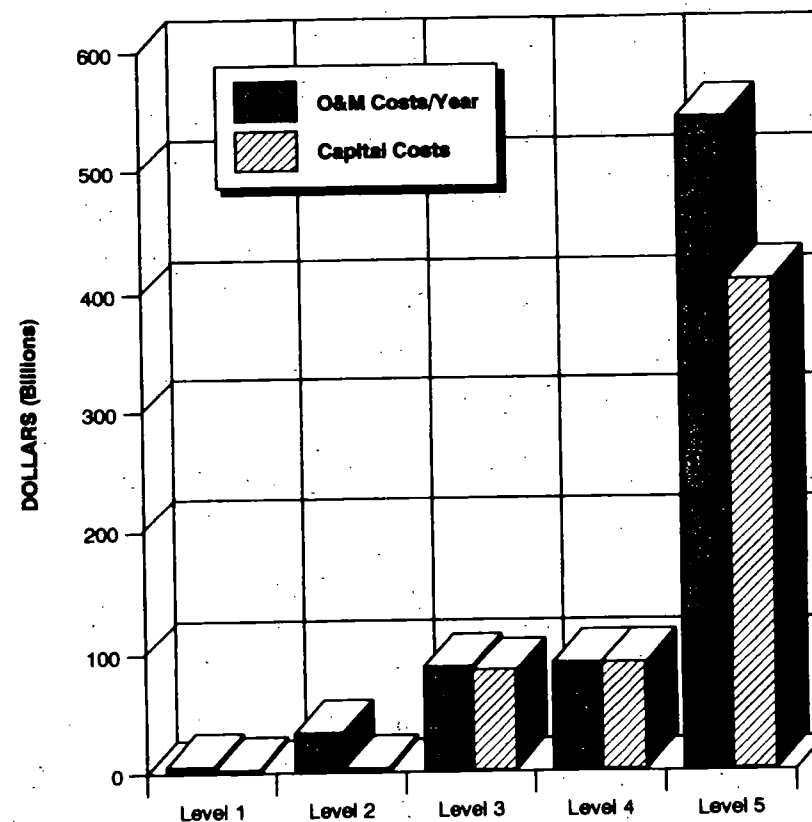
LEVEL 5



METALS REMOVAL

- Detention Basins and Wetlands
- Primary Clarifiers and Lime Precipitation

ESTIMATED NATIONAL COSTS TO IMPLEMENT BEST MANAGEMENT PRACTICES ALTERNATIVES (IN BILLION DOLLARS)

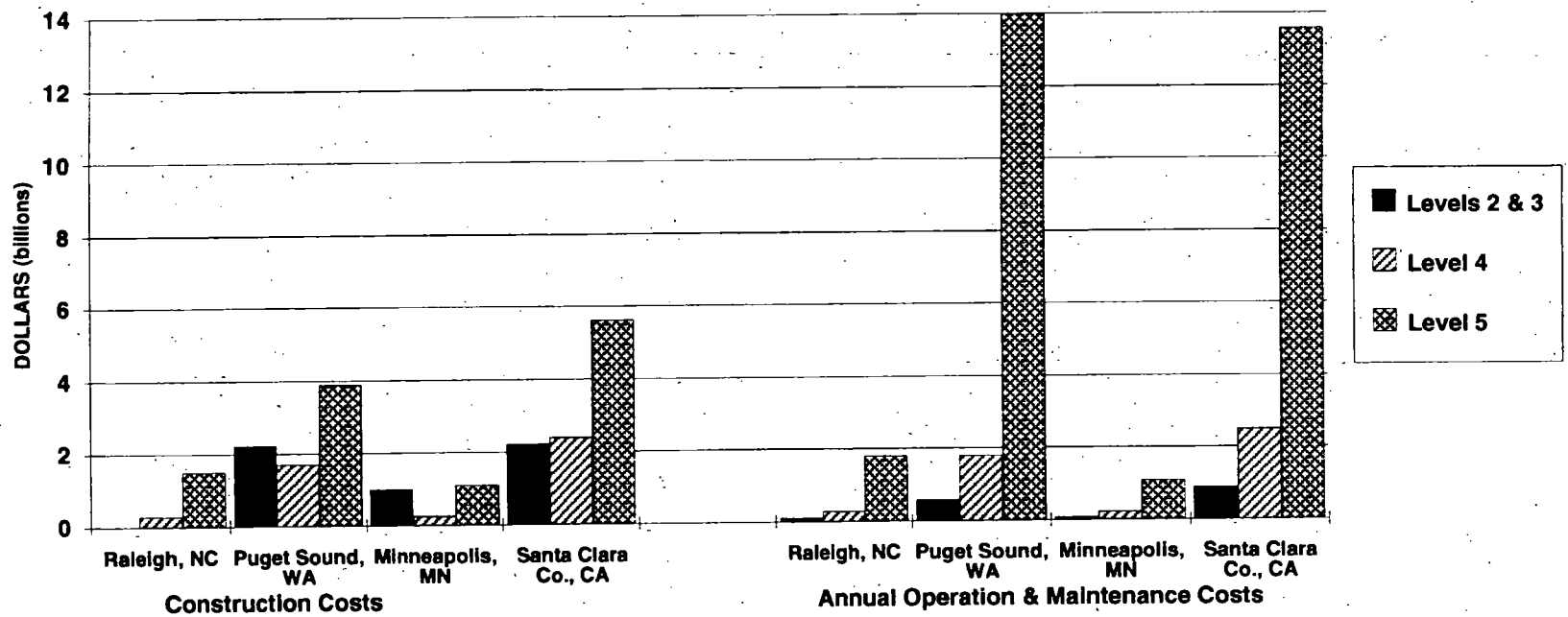


Source: APWA 1992
ENR 4900

Note: Costs do not include pipelines, land, permits, or design costs.
Therefore costs could increase by 20 to 50 percent.

FIGURE 1

FIGURE 2
ESTIMATED COSTS TO IMPLEMENT BEST MANAGEMENT PRACTICES
ALTERNATIVES IN SELECTED COMMUNITIES
 (Source: APWA 1992)





MONTGOMERY WATSON

Defining The Urban Stormwater Runoff Problem

February 1994

Prepared for:

**National League of Cities
National Realty Committee**

Montgomery Watson is an employee-owned environmental engineering firm with over 2300 employees in 65 offices worldwide. In the 45 offices in the United States, Montgomery Watson specializes in water and wastewater planning and design projects conducted for federal, state, and local agencies. Many of these projects have included assessments of receiving waters to identify sources of pollution and development of plans to reduce or eliminate pollutant discharges.

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DEFINING THE URBAN STORMWATER RUNOFF PROBLEM

*An Understanding of the
Extent of Urban Stormwater
Problems and Other Types of
Stormwater Pollution is
Imperative Prior to Initiating
National Urban Stormwater
Quality Programs*

PURPOSE OF THE REPORT

Various reports completed since the early 1960s by the U.S. Environmental Protection Agency (EPA) and other agencies have indicated that urban stormwater runoff may impair receiving water quality. However, these reports have not been able to identify the degree of impairment, the extent of the problem, or the costs and benefits of the solution.

As Congress considers amendments to the 1987 Clean Water Act, the impacts of non-point source discharges need to be clearly understood. This understanding is imperative to structure control strategies that will direct limited resources to valid needs. At this time, the impacts of urban stormwater runoff are not clearly understood because the specific effects have been masked by the greater impacts of industrial, agricultural, erosion, point source discharges, and combined sewer systems (CSOs) discharges. Most studies indicate that urban runoff causes less than 10 percent of the total non-point source pollution problem.

The purpose of this paper is to assess the current level of knowledge of and the current regulatory and legislative approach to addressing the impacts of urban stormwater runoff. To meet that objective, this paper provides a summary of reports by the EPA and other agencies relating to urban stormwater runoff that were prepared in an effort to define "water quality impairment due to urban stormwater runoff". In preparing this report, several metropolitan areas throughout the nation were contacted to determine if new stormwater quality programs initiated in response to the 1987 Clean Water Act Amendments had changed water quality.

OVERVIEW

Overall, EPA and other agency reports have found that the most significant contributor to stormwater pollution is agriculture, and that many pollutant sources attributed to "urban runoff" are not caused by discharges from residential and commercial areas. The "urban runoff" is usually caused by discharges from marine vessels, shipyards, marinas, leaking septic systems, industrial sites, and erosion of stream channels and shorelines.

Results of Recent Water Quality Surveys Indicate that Urban Stormwater Runoff is a Small Source of Stormwater Pollutants. Applying National End-of-Pipe Standards for Urban Stormwater Discharges Would be Extremely Costly

Specific Water Quality Control Plans Can be Developed for Agricultural Runoff and Sediment Source Controls, Industrial Site Runoff and Discharge Source Controls, Sanitary Sewer and Leaking Septic System Overflows, and the Remaining Urban Stormwater Runoff Flows

Proposed programs for "urban stormwater runoff" will not reduce the major causes of stormwater pollution and may not be necessary after concurrent water quality programs are completed.

CONCLUSIONS

Based upon this review of existing studies and discussions with stormwater quality management agencies throughout the nation, specific conclusions are as follows.

- **The urban stormwater runoff problem has been overstated.** Reported urban stormwater runoff problems frequently include problems due to erosion, leaking septic systems, CSOs, and industrial site runoff. These problems have been recognized and are regulated under different portions of the Clean Water Act. The proposed urban stormwater programs would only treat pollutant sources and flows from residential and commercial areas rather than more significant sources of non-point source pollutants.
- **The urban stormwater runoff problem frequently has been described using old or over-generalized data.** Therefore, impacts due to stormwater runoff and the beneficial effects of measures employed over the past several years cannot be specifically defined.
- **Results of recent water quality surveys indicate that urban stormwater runoff is a small source of stormwater pollutants compared to other non-point sources (less than 4 percent in some categories of receiving waters).** Rather, the most significant sources of stormwater water quality problems are:
 - Agricultural Activities
 - Non-point Natural Sources
 - Wastewater Sewer Overflows
 - Municipal and Industrial Point Sources
 - Illicit Discharges
 - Erosion from Disturbed Soils

A Watershed Management Approach Will Address the Most Significant Pollutant Sources, Thereby Reducing the Amount of Stormwater Flows that Require Treatment, Prioritize Solutions, and Lead to Solutions that are Funded Equitably by the Pollutant Sources

- **Future monitoring results are needed to identify the extent of remaining urban stormwater quality problems and the cost-effectiveness of control strategies and measures.** The programs to reduce the other types of stormwater runoff pollution (noted above) were only recently implemented and will probably reduce the overall water quality problem. There is a need to evaluate the effectiveness of current urban runoff programs before considering additional regulatory measures.
- **Applying national end-of-pipe standards for urban stormwater discharges would be extremely costly.** The costs and potential disruption associated with trying to capture and treat stormwater from existing urban areas are so great as to necessitate careful and thorough analysis of the nature and degree of the problem areas and potential alternative solutions.
- **Vast differences in hydrology, soils, vegetation, precipitation patterns, and land uses argue against national urban stormwater standards.** Any attempt to define guidance at the national level for stormwater treatment requirements or "best management practices" will either be very general and therefore, not useful; or too specific as to result in impossible solutions that are not cost-effective.
- **Proposed urban stormwater quality controls and national water quality standards would require urban areas to fund costly facility to collect and treat most of the stormwater flows while not addressing for more significant sources.** However, these types of controls will be extremely costly and will not eliminate the majority of stormwater pollutants.

***Programs for Source Controls
Should be Continued and
Watershed Management
Programs Should be
Implemented to Identify and
Address Water Quality
Problems***

RECOMMENDATIONS

Based upon the inconclusive nature of stormwater runoff studies, it is important that stormwater control strategies are based upon additional studies that define the specific impacts on ongoing water quality management programs and the extent of the remaining problem. Additional studies should be conducted on a watershed basis to accurately identify primary pollutant sources and to prioritize solutions.

A watershed evaluation would identify the most significant stormwater pollutant sources, including pollutant discharges from industrial sites, agricultural areas, and leaking septic systems. Therefore, based upon the findings presented in this paper, the following recommendations are presented.

- Continue and expand initial "good-housekeeping" and public education measures that are currently being implemented by most metropolitan areas.
- Continue to implement the Stormwater National Pollutant Discharge Elimination System permit programs for industrial and hazardous waste sites.
- Limit the scope of measures for urban runoff in a watershed until non-point source problems are understood.
- Develop and initiate a watershed approach applicable to all pollution sources and address water quality problems.
- Develop watershed water quality plans that address water quality constraints, opportunities, and priorities within the framework of the unique physical and economic situation in each watershed.

Recent Studies Indicate that NURP Mass Loading Projections may be Overstated. If Stormwater Quality Regulations are Based on Overstated Projections, Municipalities Could Construct Unnecessary or Oversized Treatment Facilities

By identifying the specific sources of stormwater quality impairment in specific watersheds, pollution control efforts can be prioritized and targeted. This approach would save billions of unnecessary construction dollars and annual operation and maintenance dollars that are needed for other programs and services.

LEGISLATIVE BACKGROUND

The 1972 Clean Water Act prohibited pollutant discharges to navigable waters from point sources unless the discharges were authorized by a National Pollutant Discharge Elimination System (NPDES) permit. This program focused on reducing municipal and industrial point-source pollutant discharges.

As the control measures for point sources were implemented, the need to address non-point pollution sources was considered. Non-point source water quality management studies and the National Urban Runoff Program (NURP) studies were initiated in the 1970s in an effort to quantify the overall problem. Limited amounts of sampling were used to develop unit mass loading rates (such as 1,000 lbs/acre of a pollutant). Results of the NURP studies were used to develop stormwater plans to reduce pollutant discharges. The results of the NURP studies also have been considered in the development of wet weather effluent requirements.

Recent water quality studies indicate that pollutant mass loadings projected by NURP studies were overstated. These studies also identified a great variability in loadings and impacts throughout the country. Therefore, the management plans and/or the effluent regulations may be inappropriate and result in excessive spending for construction and operation of future urban stormwater treatment facilities.

In 1987, amendments to the Clean Water Act were adopted. Some of the amendments defined stormwater discharges that are required to have a NPDES permit, prohibited non-stormwater discharges to storm sewers (including dry weather discharges from industrial sites) unless a NPDES permit is issued, and required controls to reduce the discharge of pollutants to the "maximum extent practicable" management measures. This term was included because Congress recognized that stormwater controls must be based upon local conditions. This finding was consistent with 1992 findings of the Ninth Circuit Federal Appellate Court (Court). The Court determined that Congress did not mandate a minimum standards approach or specify that EPA develop minimal performance requirements. The Court also determined that Congress could have written a statute requiring stricter standards, but Congress adopted a statute that allowed local interpretations.

To correctly interpret "maximum extent practicable", EPA must have a thorough knowledge of local water quality problems, and determine the real cost/benefit of required controls for each community or watershed.

DEFINING THE URBAN STORMWATER RUNOFF WATER QUALITY PROBLEM

The Urban Stormwater Runoff Problem has been Overstated. Agriculture, Erosion, Wastewater Overflows, and Leaking Septic Systems are the Major Causes of Water Quality Impairment, not Commercial and Residential Runoff

It is difficult to segregate the impacts of urban stormwater runoff from the impacts of other discharges. First, urban stormwater runoff is discharged into receiving water bodies that also contain discharges from industrial sites, combined sewer (stormwater and sanitary sewer) overflows (CSOs), point-source municipal wastewater treatment plants, and irrigation runoff. Second, the receiving waters frequently include pollution from upstream sources, such as mines, erosion of disturbed soils, and agricultural lands. The impacts of the other pollution sources are usually greater than the impacts of urban stormwater runoff from residential and commercial areas, and therefore, mask the impacts of specific sources.

Studies did not Identify a Specific Correlation between Stormwater Runoff from Separate Storm Sewers and Significant Receiving Water Quality Problems

Recent Studies also Indicate that Urban Stormwater Runoff did not Appear to Cause Large Scale or Immediate Water Quality Problems Based on Water Quality Monitoring During and Following Storm Events

Initial Stormwater Runoff Studies

Concerns about potential pollution from urban stormwater runoff were raised almost 30 years ago by the U.S. Public Health Service. These concerns have been evaluated many times by the Urban Water Resources Research Committee of the American Society of Civil Engineers, the Council on Environmental Quality, the U.S. Environmental Protection Agency, and other organizations and agencies.

The first non-point sources investigations identified a correlation between discharges from CSOs and water quality problems in the receiving waters. These problems were primarily due to the sanitary sewer flows in the CSO discharges which are regulated under separate portions of the Clean Water Act.

Importantly, the investigations did not identify a specific correlation between urban stormwater runoff from separate storm sewers and significant water quality problems in the receiving waters (EPA 1983). These conclusions also were corroborated by the Office of Research and Development (ORD) which investigated urban stormwater runoff from 250 communities. The results of the ORD study indicated that receiving water quality was highly variable throughout the nation and that there was no correlation between urban stormwater runoff flows and water quality problems as defined by dissolved oxygen concentrations.

Recent Stormwater Runoff Studies

The EPA and state water quality agencies have completed additional studies in the past 10 years to define urban stormwater runoff water quality impairment. The studies have indicated that sediment and nutrients are the most significant pollutants, and that agricultural activities were the source of most pollutants during storm periods (EPA 1977, EPA 1992, EPA 1983, EPA 1993, Mancinini 1987, WPCF 1990).

Observed Wet Weather Fish Kills were Frequently Related to Pesticides, Herbicides, Spilled Oil, and Wastewater Overflows, not Urban Stormwater Runoff

The NURP Studies Identified the Most Significant Impairments to the Nation's Waterbodies as Erosion of River Banks, Phosphorous from Fertilizers and Other Chemical Applications Upstream of Lakes, and Bacteria due to Wastewater Overflows and Leaking Septic Systems in Estuaries and Coastal Waters

Most of the studies by EPA and other groups also indicated that urban stormwater runoff did not appear to cause large scale or immediate water quality problems based on water quality monitoring during and following storm events (Hearrey et al 1984, Mancinini 1987, EPA 1977, EPA 1983, Hvitred et al 1986). The findings of the many studies indicated that the impacts of stormwater discharges varied widely and were mostly affected by upstream pollution sources and the assimilation capacity of specific receiving waters (EPA 1983).

Recent studies have indicated that fish kills that occurred during wet weather periods generally were not directly related to urban stormwater runoff. Rather, the fish kills were frequently related to upstream runoff that contained pesticides, herbicides, spilled oil, and wastewater overflows from leaking septic systems and sanitary sewer overflows (Hearrey et al 1984).

These studies also found that many of the wet weather water quality problems in lakes were caused by eutrophication due to pollutants from leaking septic systems, sediments and fertilizers from agricultural sites, chemical spills, wastewater overflows, and wastewater treatment plant effluent that did not comply with NPDES permits. Many of these sources had been eliminated years before the water quality problems were observed. However, the pollutants had remained in the sediments of the lakes and the problems continued. Therefore, the remaining urban stormwater runoff from residential and commercial areas could be falsely identified as the source of pollutants that were causing water quality problems (Hearrey et al 1984).

National Urban Runoff Program Studies

The National Urban Runoff Program (NURP) studies were initiated to provide information and develop methods that could be used for stormwater quality plans throughout the nation. The program developed stormwater quality plans for 28 communities. The communities were selected to include a wide range of conditions in order that the results could be extrapolated to other communities.

Many of the Proposed Urban Stormwater Regulations are Focused on Constituents in the Stormwater which have not been Shown to Significantly Impact Surface Waters

The selected communities did not include CSO systems. However, stormwater from several of the selected communities was discharged into receiving waters that contained CSO discharges from adjacent communities. The NURP studies also were designed to determine impacts of urban stormwater runoff on receiving waters. Significantly, only two of the 28 studies included consistent monitoring of the receiving waters.

The conclusions of the NURP studies were presented in Results of the Nationwide Urban Runoff Program Final Report in 1983 (EPA 1983). The NURP studies found that flows and quality of urban stormwater runoff varied significantly not only between sites, but also within the same storm event at the same site. Therefore, it was difficult to develop consistent findings that could be used throughout the nation. By comparing, findings of all the studies, several overall conclusions regarding major impacts to different types of receiving waters can be developed, as summarized below.

- **Rivers and Streams:** Most significant impacts resulting in habitat changes are caused by high stormwater flows and associated erosion. Significant impacts do not appear to be caused by stormwater quality.
- **Lakes:** Most significant impacts are due to phosphorous, possibly from fertilizer in irrigation runoff.
- **Estuaries, Embayments, and Wetlands:** Most significant impacts can be attributed to bacteria associated with leaking septic systems, sanitary sewer connections to storm drains, and sanitary sewer overflows.

The NURP studies found that the most significant impacts to receiving waters were due to erosion, agricultural or fertilizer sources of phosphorous, and sanitary sewage. These are not constituents that are currently the focus of many proposed urban stormwater regulations. Instead, many of the proposed urban stormwater regulations are focused on constituents in the stormwater which have not been shown to significantly impact receiving waters.

EPA has Recently Implemented Several NURP Study Recommendations, Including Elimination of Illicit Connections Between Sanitary Sewers and Storm Drains and Control of Industrial Site Stormwater Runoff

Recent Water Quality Surveys have indicated that Sediment, Pesticides, and Nutrients from Non-Urban Activities Impair More Waterbodies Than Urban Stormwater Runoff

Other conclusions of the NURP studies are summarized in Table 1 (included at the end of this report).

The NURP studies acknowledged the limitations of the study program due to its scope and schedule. Therefore, the final report included recommendations for stormwater management and for further study to better define the impacts of urban stormwater runoff. These recommendations are listed in Table 2 (included at the end of this report).

Since the completion of the NURP studies, EPA has initiated programs to implement several of the recommendations. These programs have been recently implemented and include elimination of illicit connections between sanitary sewers and storm drains and control of stormwater runoff from industrial sites.

The results of the recent discharge elimination programs and the resolution of outstanding issues identified by the NURP studies should be considered prior to establishing control strategies for urban and other non-point sources.

1992 EPA Water Quality Surveys

Each year water quality surveys are conducted by EPA or by the states which have received authorization from EPA to manage local water quality. The survey results are used to assess water quality problems and allocate federal funds to mitigate the worst water quality problems.

The most recent report completed by EPA to assess the water quality problems due to non-point pollution was summarized in Managing Nonpoint Source Pollution in 1992 (EPA 1992a). The primary findings are summarized below.

- Wildlife habitat and recreation are the "beneficial uses" most impacted by non-point pollution.
- Agricultural activities are the primary sources of non-point pollution, including sediments, nutrient, and pesticides.

Due to the Need to Aggregate Data, Highly Disparate Activities Associated with "Urban Runoff" including Discharges from Industrial Sites, Vessels, Marinas, Shipyards, and Leaking Septic Systems, and Diversions of Water Supplies were aggregated together

For the 1992 National Water Quality Survey of Nonpoint Source Pollution, Only 40 States Reported on Rivers, 18 States Reported on Lakes, 3 States Reported on Wetlands, and 18 States Reported on Coastal and Estuarine Waters

- Siltation due to sediments and eutrophication due to nutrients are the most significant non-point pollutants. These pollutants are generally from non-urban areas.

This study and other reports have indicated that pollution due to point source discharges significantly reduced over the past 20 years (EPA 1992, NRDC 1993, CWMCUA 1993). Pollution from CSOs and other non-point sources also has decreased.

For the 1992 non-point source study, the states submitted data for each receiving waterbody, including waterbody type, degree of impairment to beneficial uses, designated beneficial uses, type of monitoring, sources of pollution (ie, urban runoff), and pollutant type.

Due to the wide variety of water quality problems that occur throughout the nation, many of the responses from the states were aggregated into nine categories, one of which is called "urban runoff". However, each category included many types of pollution sources. The term "urban runoff" included stormwater runoff from industrial sites, wastewater overflows, shipyards, and marinas, as well as runoff from commercial and residential neighborhoods. In addition, due to a lack of standard methods to identify water quality impairment and pollution sources, urban runoff problems in one state included impairment due to leaking septic systems and diversion of water for local water supplies.

The information presented in the EPA report addressed four types of waterbodies: rivers and streams, lakes, wetlands, and coastal waters and estuaries. Information presented in the report is presented below in accordance with these categories.

- **Rivers and Streams:** Only 40 states reported any findings. All 40 reporting states indicated that waters were impaired. The impaired waters represented only 11.8 percent of all rivers and streams in the nation and 16 percent of all rivers and streams in the reporting states.

The Limited Data Set Does Not Provide a Balanced Definition of the Problem

Agriculture was the primary pollutant source impacting nation's rivers (41 percent of all pollutant sources). *Urban runoff (including all categories such as shipyards and leaking septic systems) represented about 4 percent of all pollutant categories.*

- **Lakes:** About 20 percent of all lakes in the nation (excluding the Great Lakes, the Great Salt Lake, and lakes in Alaska) were considered impaired. All of the impaired lakes were located in 18 states. The primary source of pollutants is agriculture (23 percent of all pollutant sources). *Urban runoff caused only 6 percent of the impairment.*
- **Wetlands:** Only three states reported impaired wetlands: California, Delaware, and Iowa. Because of the absence of other data, EPA could not extrapolate the information to a nationwide conclusion. For California and Iowa (the only states that reported pollution sources), 81 percent of the impairment was caused by agricultural runoff. *Only 4 percent was caused by urban runoff sources.*
- **Coastal Waters and Estuaries:** Only five states reported data for coastal waters and thirteen states reported data for estuaries. The EPA report indicated that most of the impairment was due to fuel and oil spills from leaking tanks, hydrologic modification due to erosion, and construction in estuaries. *Urban runoff (including discharges from vessels, marinas, shipyards, and industrial sites) only impacted about 10 percent of the area.*

Based on the reporting states with wide variations in data sources and interpretations, only 4 to 10 percent of the water quality impacts resulted from urban runoff.

California Survey. Because of the diverse nature of the pollutants and types of impairment, the California survey used in the EPA reports appears to present over-generalized conclusions. The over-generalizations are primarily caused by the need to aggregate data and the lack of standard reporting methods.

Most of the Pollutant Sources Categorized in the California Water Quality Assessment as "Urban Runoff" were Actually Caused by Water Supply Diversions, Leaking Septic Systems, Runoff from Industrial Sites, Discharge from Vessels and Marinas, Sediment from Erosion, Erosion of Stream Channels and Shorelines

In California, 97 percent of Wetlands Impairment Not Caused by Urban Stormwater Runoff

To determine the extent of over-generalization and inadvertent misrepresentation of data, the data collected in California was reviewed and compared with the data reported in the EPA water quality assessment report. The data from the State of California is based on data collected in 1991 and reported in the Water Quality Assessment study in 1992 (California 1992). This information is also related to the four main types of waterbodies.

- **Rivers and Streams:** Water quality in California rivers and streams was similar to the other reporting states. Only 6 percent of all California rivers were impaired, and 35 percent of the pollutant sources were due to agricultural runoff. The survey also listed 43 percent of the pollutant sources as "urban runoff". However, only 7 percent was actually due to runoff from urban areas. Other impacts attributed to "urban runoff problems" were caused by water diversions and leaking septic systems (27 and 9 percent of all impaired rivers, respectively) not urban runoff.
- **Lakes:** According to the EPA report, California reported the second largest lake acreages affected by urban sources (only Vermont had more acres of lakes impaired by urban runoff). However, careful review of the data from California indicated that 57 percent of the impairment was caused by leaking septic systems and erosion of exposed soils in recreation areas. Agricultural runoff impaired 40 percent of the lakes in California.
- **Wetlands:** The California data indicated that 97 percent of the impairment of wetlands was caused by agricultural runoff and 3 percent was caused by urban runoff (primarily from industrial sites).
- **Coastal Waters and Estuaries:** The California report indicated that 28 percent of these waters were impaired. Approximately 83 percent of these waters were located within and in the vicinity of San Francisco Bay, Santa Monica Bay, Newport Bay, San Diego Bay, and the Los Angeles Harbor.

Major Problems Identified in the Survey Findings will not be Addressed by Proposed Urban Stormwater Runoff Programs

Many Metropolitan Areas Have Already Implemented Non-Structural Stormwater Controls and Monitoring Programs

Initial Findings from Monitoring Programs in Metropolitan Areas Indicated that Sediments are the Most Critical and Frequent Pollutant

National Research Council also recommended to EPA and Congress to develop stormwater management programs based on local characteristics

Within these waters, causes of impairment included discharges from vessels, shipyards, marinas, industrial sites, agricultural areas, and wastewater treatment plants; habitat modifications; dredging activities; upstream freshwater diversions; and urban runoff. A recent report prepared by EPA (EPA 1992b) indicated that most pollutants in the San Francisco Bay Estuary were caused by agriculture and silviculture activities and natural sources. Urban runoff was the most significant contributor only for lead and total hydrocarbons.

Summary of EPA Water Quality Survey Findings. Overall, both the EPA and California reports indicated that the most significant contributor to stormwater pollution is agriculture, and that many pollutant sources attributed to "urban runoff" are not caused by discharges from residential and commercial areas. The "urban runoff" is usually caused by discharges from marine vessels, shipyards, marinas, leaking septic systems, industrial sites, and erosion of stream channels and shorelines. Proposed programs for "urban stormwater runoff" will not reduce the major causes stormwater pollution and may not be necessary after concurrent water quality programs are completed. It also should be noted that the concurrent programs to control agricultural runoff and failing septic systems will involve rural and recreation communities that are not subject to proposed stormwater runoff regulations.

National Research Council 1993 Report

The National Research Council was requested by EPA at the direction of Congress to examine wastewater and water quality issues in coastal urban areas (CWMCUA 1993). The findings and recommendations of this report relative to stormwater are summarized below.

- **Coastal wastewater and stormwater management strategies should be developed for local characteristics.** The report stated that due to wide variations throughout the nation, it was not possible to develop a standard technology or approach to address all water quality issues.

Source Controls should be Encouraged

All Pollutant Sources should be Considered in Developing Water Quality Programs

Water Quality Management Options should Reflect Social Goals, Risk Priorities, Costs, and Benefits

The report further stated that any attempt to develop national strategies would either fail or would be excessive for many areas.

- Emphasis should be placed on controlling sources of nitrogen and other nutrients.
- Source controls should be encouraged by incentives and regulations.
- Stormwater quality measures should be based on an understanding of local conditions, and developed with other regional programs to develop the most cost-effective program.
- Management programs should be flexible to allow changes based on new information on environmental quality and performance of existing management systems.
- Urban coastal stormwater and wastewater programs should be based on strategies to integrate local characteristics and local issues, based on the following findings.
 - Water and sediment quality criteria standards should reflect risk, uncertainty, and variability of regional and local sites.
 - Regional strategies should consider all pollutant sources and integrate policies for air, water, and land.
 - Management options should reflect social goals and priorities relative to risks, costs, and benefits.
 - An incremental implementation plan to allow feedback from monitoring of new water quality controls.

Lead Concentrations Have Decreased since 1980

Upstream Sources of Sediment and Metals are Frequently Larger than Urban Runoff Sources

Ongoing Programs to Eliminate Illicit Discharges Appear to Reduce Metals and Other Pollutants in Stormwater

Many Reports Do Not Specifically Separate Stormwater Quality Problems Associated with Runoff from Residential and Commercial Urban Areas from Other Stormwater Runoff in Urban Areas, such as Industrial Site Runoff, Hazardous Waste Site Runoff, and Sanitary Sewer Overflows

Recent Water Quality Surveys in Metropolitan Areas

A study in 1992 (APWA 1992) surveyed over 100 metropolitan areas throughout the United States. The purpose of the survey was to determine the types of urban stormwater runoff controls that were being used or were being considered. At that time, most of the urban areas had only started or were planning to start the Clean Water Act permit application process. These agencies also were contacted in conjunction with the preparation of this report. Most of the agencies had implemented programs in the past year to eliminate illicit discharges and initiate public education programs. In addition, these agencies completed water quality sampling programs as part of the stormwater pollution prevention plans that were required by the EPA. Several agencies also had completed their first annual monitoring efforts. The most frequently observed results of the monitoring programs are summarized below.

- Sediments were the most critical and frequently observed pollutant in stormwater flows.
- Lead concentrations in stormwater have decreased since the 1980s due to the reduction in the use of leaded gasoline.
- Metal concentrations in receiving waters appear to decrease as industrial sites, land disposal sites, and municipal and industrial point discharges implement water quality plans pursuant to stormwater and point source NPDES permit programs.
- Upstream sources of sediment and metals frequently generate more significant amounts and types of stormwater pollutants than urban stormwater runoff sources.
- Natural sources frequently were the cause of high concentrations of iron, mercury, and other metals.
- Water quality impacts vary greatly due to climatic, geographic, soil chemistry, and watershed configuration.

It is Difficult to Develop Urban Stormwater Quality Criteria that Will Determine the Need for Treatment Facilities Because Urban Stormwater Pollutant Sources and Impacts Have Not Been Specifically Identified; Some Data is Old and Reflects Water Quality Prior to Implementation of Other Water Quality Programs, and Aggregated Data is Over-generalized

Overstatement of the Problem Could Lead to Oversizing or Construction of Unnecessary Treatment Facilities

SEPARATING IMPACTS OF URBAN STORMWATER DISCHARGES

In 1992, EPA published a report titled Environmental Impacts of Stormwater Discharges, A National Profile. The report summarized the findings of the Managing Nonpoint Source Pollution Study and other reports. The EPA reviewed the water quality impacts discussed above and found that pollutant characteristics can vary based on land use, the storm event, and soil characteristics. Although data presented in the Environmental Impacts of Stormwater Discharges report indicated that agriculture activities were responsible for most of the impairment of the nation's waters (which is consistent with other EPA reports), the major portion of the report presented concerns associated with discharges from "urban areas".

The report reviewed case studies to illustrate the impacts of "urban runoff". However, the case studies included municipalities with CSOs, treatment plants that were not completely in compliance with NPDES permits, and upstream agricultural and mining activities which contributed to water quality problems, as shown in Table 3 (included at the end of this report).

Several of the municipalities cited in the report were contacted during the preparation of this paper to determine if the water quality problems had been corrected. All of the communities have implemented programs to reduce water quality problems. Two of the case studies did focus on communities with urban stormwater runoff problems. These communities have both implemented water quality programs that emphasize non-structural controls.

EXCESSIVE COSTS FOR STORMWATER TREATMENT FACILITIES

Currently, the EPA is attempting to define the urban stormwater runoff problem. Because of the lack of data and the difficulty in segregating impacts of urban stormwater runoff from other non-point and point pollution sources, EPA has relied upon data from previous reports, including data from the NURP studies completed prior to 1983.

Stormwater Quality Problems Do Exist, However Most of the Problems Are Not Due to Urban Stormwater and Are Being Addressed by Other Programs

Programs to Reduce Agricultural Runoff, Industrial Site Runoff, Illicit Connections, Leaking Septic Systems, and Sanitary Sewer Overflows are Being Implemented to Control the Majority of Stormwater Pollution

Following Implementation of the Other Programs, the Extent of the Remaining Urban Runoff Problems Should be Evaluated to Determine the Need for Stormwater Treatment Facilities for Residential and Commercial Areas

The NURP data is difficult to use for this purpose because the data also reflects water quality problems associated with lack of secondary wastewater treatment, wastewater overflows, illicit connections to storm drains and discharges from industrial sites, and uncontrolled discharges from numerous (and frequently unidentified) hazardous waste sites. In the past ten years, correction programs for many of these water quality problems have been initiated.

Another concern with NURP data was that receiving waters were not extensively monitored. Computer models were used to predict water quality problems. However, observed values for organics and suspended solids often are lower than projected loadings (EPA 1983). This discrepancy probably occurred because the models were based on stormwater quality in the upper portion of the watersheds. As the stormwater flows through the watershed, sediments are deposited in storm drains and metals absorb to other sediment particles.

The EPA also is using data from water quality surveys. However, as discussed above, over-generalization of the data and a lack of standard reporting methods has led to a misrepresentation of "urban stormwater runoff problems". Basing regulatory responses on older and/or over-generalized data will overstate the urban stormwater runoff problem, and lead to excessive spending of user fees in municipalities to construct and operate facilities that could be avoided.

Another concern is related to discussions relative to national water quality standards. The NURP studies recommended evaluation of local water quality standards based on local site-dependent "synergy" of conditions. This concern is also reflected through Congressional action in the adoption of the methods for "maximum extent practicable". It would be inappropriate to attempt to develop national water quality standards that would account for a wide variety of wet weather events, soils, land use patterns, and water quality characteristics of stormwater.

Costs for Treatment of Stormwater From Residential and Commercial Areas in Major Metropolitan Communities Throughout the United States Could be Over \$406 Billion for Construction and Over \$543 Billion Each Year for Operation and Maintenance

It should be noted that this paper recognizes that stormwater runoff problems do exist. However, these problems are being addressed by other programs, including the industrial stormwater runoff program (as required by the Clean Water Act), separation and/or treatment of sanitary sewer overflows, Rural Clean Water Programs that reduce agricultural chemical application rates and increase use of vegetative swales around fields, Clean Lakes Programs and Great Lakes Program to control erosion and nutrients, and programs to minimize discharges from marine vessels and leaking septic systems.

These programs will eliminate many of the water quality problems associated with the "urban stormwater runoff" as defined by the EPA. States and municipalities have initiated numerous programs in the past two to five years to reduce identifiable stormwater runoff problems. Most of the recommended facilities are under construction or only recently have become operational. Therefore, it is difficult to assess the impact of the remaining urban stormwater runoff constituents that may not be addressed by current programs. Additional data to be collected over the next three to five years will be extremely helpful in more specifically defining the nature and extent of the problem.

Cost Implications of Overstating The Urban Stormwater Runoff Problem

Cost implications of national effluent and/or treatment standards were evaluated in a recent study by the American Public Works Association of Southern California (APWA 1992). The study identified a potential range of national costs of \$147 million to \$406 billion for construction of stormwater controls and \$1.1 billion/year to \$543 billion/year for operation and maintenance costs for residential and commercial areas, as shown in Figure 1. The costs shown in Figure 1 are conservative estimates and may be as much as 50 percent low because the costs do not include the cost of stormwater pipelines, land and permits for the treatment facilities, and design costs.

LEVELS OF BEST MANAGEMENT PRACTICES

LEVEL 1



NON-STRUCTURAL SOURCE CONTROLS

- Prevent Illicit Discharges
- Increased Street & Sidewalk Sweeping
- Clean Storm Drains

LEVEL 2



MINOR STRUCTURAL SOURCE CONTROLS

- Diversion Channel
- Grass Swales
- Improve Natural Channels to Reduce Erosion
- Plant Vegetation on Exposed Soils

LEVEL 3



FLOATABLES AND OIL REMOVAL

- Parking Lot Oil/Grease Separators
- Parking Lot and Rooftop Runoff Storage and Separators

LEVEL 4



SOLIDS REMOVAL

- Detention Basin
- Primary Clarifiers
- Swirl Concentrators
- Screens
- Wetlands

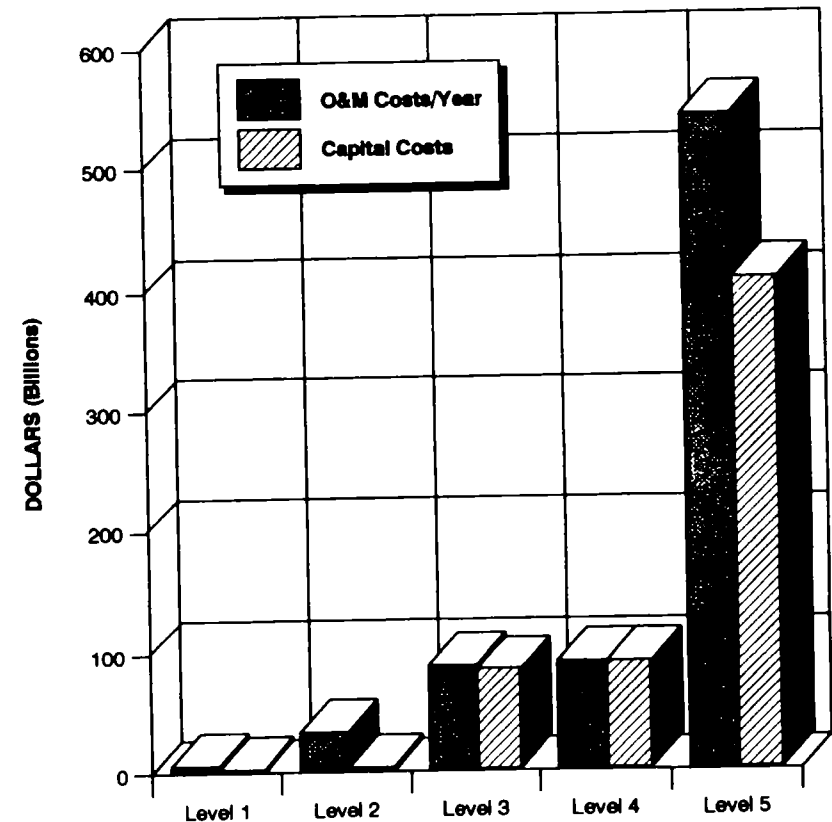
LEVEL 5



METALS REMOVAL

- Detention Basins and Wetlands
- Primary Clarifiers and Lime Precipitation

ESTIMATED NATIONAL COSTS TO IMPLEMENT BEST MANAGEMENT PRACTICES ALTERNATIVES (IN BILLION DOLLARS)



Source: APWA 1992
ENR 4800

Note: Costs do not include pipelines, land, permits, or design costs. Therefore costs could increase by 20 to 50 percent.

FIGURE 1

Annual Costs for Improving Stormwater Quality could be up to 500 times more Expensive than Wastewater Treatment Because of the Volume of Water and Intermittent Nature of Storms

Stormwater Control Measures should Focus on the Most Significant Pollutants and Actual Sources of Pollutants on a Watershed-by-Watershed Basis

These costs can be compared to the costs of providing municipal wastewater treatment. Since 1972, municipalities throughout the United States have spent about \$76 billion for construction (with about \$50 billion funded through federal grants). These municipalities continue to spend \$1.1 to 1.8 billion/year for operations and maintenance. It should be noted that these costs primarily remove solids and organic materials. This would be comparable to Level 4. The Level 5 treatment represents a treatment level significantly higher than most wastewater treatment plants provide. Level 5 controls would be mandated if national stormwater discharge standards are required to meet national water quality standards.

This wide range in costs for potential stormwater management plans and the potential implications for local governments validates the need for Congress to exercise great care and control to ensure that these costs are not singularly imposed on municipalities without first considering the results of ongoing programs to control more significant stormwater pollution sources (such as industrial site stormwater runoff, elimination of sanitary sewer overflows, and elimination of combined sewer overflows). The ongoing programs may reduce pollution in "urban stormwater runoff" to such an extent that further treatment may not be necessary.

It is also important that more significant pollutant sources located upstream of the municipalities also be controlled (such as agriculture, leaking septic tanks, and mining activities) to determine if urban stormwater runoff is actually impacting the receiving waters as compared with upstream pollutant sources.

As discussed in the next subsection, several agencies across the country have implemented watershed programs. These watershed programs have led to less costs than costs for complete stormwater treatment. For example, these agencies implemented what was approximately equivalent to non-structural controls, or Level 2 in the APWA study.

***Communities Are Successfully
Implementing Watershed
Management Programs that
Focus on Source Controls,
Erosion Controls, and
Upstream Pollutant Sources to
Solve the Majority of
Stormwater Quality Problems***

If these agencies had implemented complete stormwater treatment to remove solids, metals and microorganisms, as described under Level 5 in the APWA study, the construction costs would be significantly higher, based on data presented in the APWA report, as shown in Figure 2.

***COST-SAVINGS THROUGH A WATERSHED
APPROACH***

A watershed management approach would allow establishment of local water quality standards that would match beneficial uses. The recommendations could be integrated with recommendations of other regional studies to develop integrated water quality programs that would not lead to duplication of efforts.

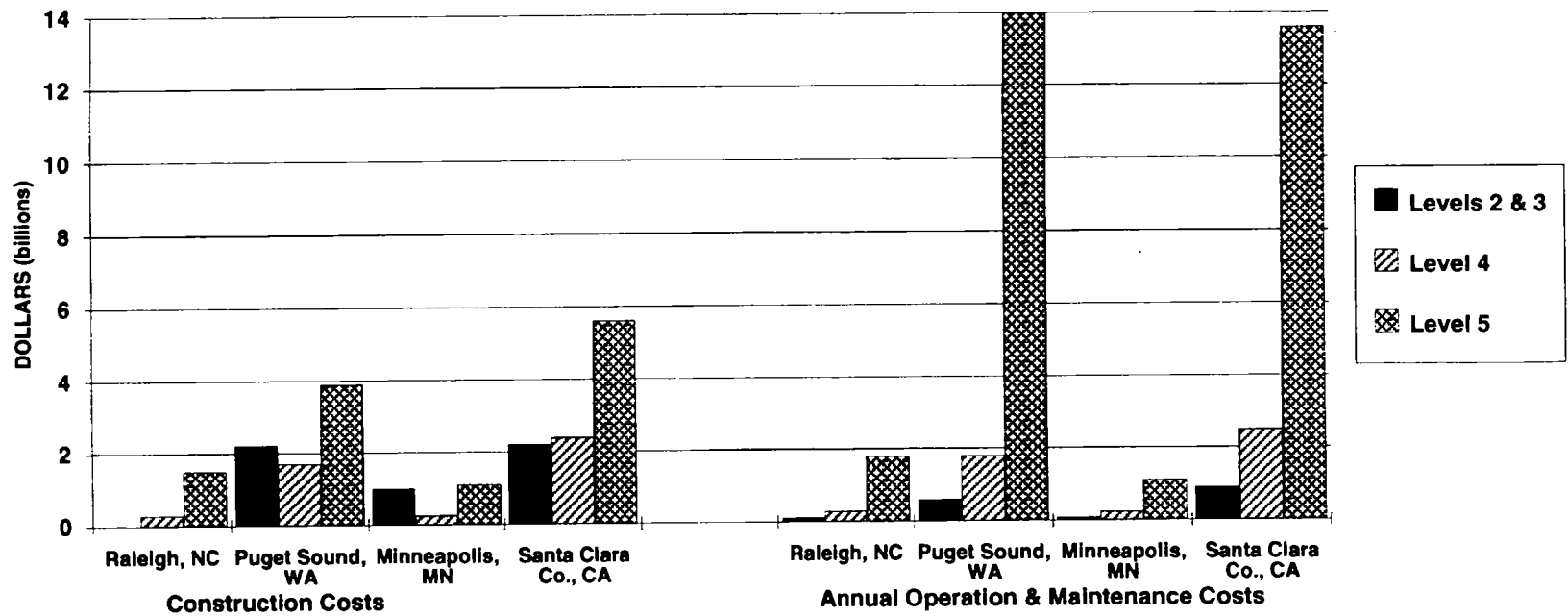
The use of a watershed approach also allows water quality management to focus on significant problems and prioritize solutions. The watershed management approach addresses all types of non-point source runoff, including sources which are not subject to stormwater requirements of the Clean Water Act Amendments (such as mining and agricultural runoff). This approach also would determine which pollutants and sources of pollutants were regulated by existing water quality programs.

The watershed management approach provides a more complete analysis of pollutant sources throughout the watershed and analysis of beneficial uses of the receiving waters. Several of the communities that were contacted for this paper have initiated watershed programs. Summaries of the early findings of these programs are summarized below.

Raleigh, North Carolina

The City of Raleigh implemented a stormwater management plan for several watersheds. Hydraulic modeling was used to determine flood hazards and sediment and nutrient loadings.

FIGURE 2
ESTIMATED COSTS TO IMPLEMENT BEST MANAGEMENT PRACTICES
ALTERNATIVES IN SELECTED COMMUNITIES
 (Source: APWA 1992)



Raleigh determined that actual water quality loading rates were lower than NURP projections

Water quality monitoring indicated that iron, nitrogen, and phosphorous concentrations were high. ***Most of these pollutants appeared to be caused by erosion and runoff from cultivated areas. The city implemented a major erosion control program and minor structural controls.***

The costs averaged about \$2,000/acre of land served. This cost is similar to costs presented in other studies (APWA 1992). The measures were estimated to reduce nitrogen loadings by 12 percent, phosphorous loadings by 31 percent, metal loadings by about 25 percent. During the study, the city determined that the previously projected NURP loading rates were higher than actual loading rates. In addition, previous runoff models had underestimated the amount of infiltration into the soils. This also led to an overestimation of mass loadings (Raleigh 1992).

Puget Sound, Washington

The State of Washington Department of Ecology identified ***sediment from erosion was the primary stormwater quality problem.*** The state developed a program that emphasized erosion controls, industrial discharge controls, increased maintenance of storm drains, and public education. The overall program emphasizes implementation of non-structural BMPs that maximizes infiltration (WCOG 1991).

Minneapolis, Minnesota

Sediment from Exposed Soils, Sand Used for Ice Controls, and Natural Upstream Sources Were Found to be Significant Sources of Stormwater Pollution

A large portion of the metropolitan area is tributary to numerous lakes that were evaluated in the "Chain of Lake Studies". The results of the studies indicated that ***sediment was the major water stormwater quality problem. The sediment sources included sand used for ice control and erosion of disturbed soils. Pollution from wastewater overflows also caused water quality problems.*** The overall stormwater control program emphasizes separation of the combined sewer system and erosion controls (Minneapolis 1992, Holzin 1993). These improvements also comply with Clean Lakes Program goals.

National Requirements for States to Implement Local Water Quality Criteria is More Appropriate than National Water Quality Criteria Due to the Wide Range of Conditions and Causes of Impairment

San Jose, California

Watershed stormwater quality programs identified metals from industrial discharges and natural sources as the most critical pollutant. The initial program emphasizes elimination of pollutants from industrial sites and gasoline stations, and of illicit discharges. The current cost of this program is about \$2.9 million/year. Monitoring results indicate that total metal concentrations exceeded local water quality standards, but dissolved metals concentrations were below the standards. Some of the metals, including mercury, occur naturally in the soils (Ho 1993, Drury 1993).

NATIONAL WATER QUALITY REGULATIONS REQUIREMENTS

The overall need to improve nationwide water quality is an accepted premise for water quality planning. However, the cause of water quality degradation is extremely complicated and varies widely depending upon location, water quality, wet weather storm patterns, and land use patterns. To address the wide variations in water quality concerns and solutions, local solutions should be developed. These solutions may include solving water quality problems upstream of municipal areas.

For example, in Sacramento County, California, metal concentrations were high in the receiving waters due to mine drainage from a hazardous waste site located over 200 miles upstream of Sacramento. Therefore, Sacramento County pursued the possibility of reducing the mine drainage contribution in the river rather than full treatment of stormwater. Other communities have used the watershed approach to implement "good housekeeping" methods and public education programs to eliminate significant pollutant sources. Finally, other areas have significantly reduced water quality problems by eliminating pollutant discharges from industrial or hazardous waste sites.

All of these examples underscore the need to implement watershed management programs and best management practices, such as public education programs. It appears impossible to develop national water quality standards to address the wide variety of pollutant sources, concentrations, and effective solutions. These conclusions have been presented by many different studies including the NURP studies and others (EPA 1983, NRDC 1993, CWMCUA 1993).

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TABLE 1
SUMMARY OF CONCLUSIONS OF THE NATIONAL URBAN RUNOFF PROGRAM STUDIES

1. Heavy Metals

Copper, lead, and zinc were found in more than 91 percent of all samples. The concentrations frequently exceeded acute and chronic toxicity standards.

Projected receiving water quality problems were not observed during storm events in the two communities that monitored receiving water quality.

Heavy metal concentrations in stormwater runoff appeared to be related to the pH and hardness of the stormwater. The most significant concentrations appeared to be in states located along the Atlantic Ocean and the Gulf of Mexico.

2. Organic Priority Pollutants

Organic priority pollutants were found less frequently and at lower concentrations than heavy metals. These pollutants were primarily pesticides (including compounds which are no longer available for non-licensed use, such as chlordane).

3. Coliform Bacteria

Coliform bacteria sources appeared to be leaking septic systems, connections of sanitary sewers to storm drains, and sanitary sewer overflows.

Significant concentrations were observed in eastern, southern, and midwestern states during warm weather storm periods.

No long-term receiving water quality problems were observed, possibly due to dilution or high die-off rates.

4. Nutrients

Urban stormwater runoff discharges generally contained fewer nutrients and oxygen-demanding substances than treated wastewater discharges which have been permitted by EPA for continuous discharge throughout the year.

Nutrients (primarily phosphorous) appeared to cause eutrophication problems in lakes, but not in rivers or streams.

5. Suspended Solids

Unlike sanitary wastewater, stormwater suspended solids are primarily soils and refuse.

6. Groundwater Quality

Groundwater quality under stormwater recharge areas does not appear to be impacted by stormwater quality.

7. Stormwater Quality Management Facilities

Detention basins, grass swales, recharge basins, and wetlands appear to reduce flow, solids, nutrients, and metals.

TABLE 2
SUMMARY OF RECOMMENDATIONS OF THE NATIONAL URBAN RUNOFF PROGRAM STUDIES

1. Recommendations

Find and disconnect illicit connections of sanitary sewers and industrial discharges to storm drains.

Find and correct sanitary sewer overflows into storm drains.

Develop high-priority programs to control CSO discharges.

EPA should evaluate and develop wet weather standards (that may be different than point source year-round standards) to reflect local aquatic water quality criteria and the intermittent/short-duration nature of wet weather events. The NURP final report discussed the differences between high-intensity, short-duration, and high-frequency storms that occur in warm weather periods in the eastern and mid-western states as compared to the infrequent, but longer duration storms that occur in during winter months in western states.

EPA should determine the local site-dependent "synergy" of pH, temperature, and water quality to develop local water quality standards.

2. Suggestions for Further Studies

Evaluate receiving water quality issues, instead of end-of-pipe water quality, including fate, transport mechanisms, and accumulation issues.

Determine the relationship between pH and heavy metal concentrations in stormwater flows.

Evaluate industrial site stormwater runoff which may have higher pollutant concentrations than runoff from residential and commercial areas.

Evaluate the impacts of higher flows, erosion, and scour which have higher receiving water impacts than urban stormwater runoff.

EPA should develop guidance documents for stormwater quality controls.

Evaluate coliform bacteria sources to determine if high bacterial concentrations are indicative of urban stormwater runoff problems or sanitary sewer problems (including leaking septic systems).

TABLE 3
UPDATE OF EPA CASE STUDIES OF STORMWATER RUNOFF PROBLEMS

<u>Case Study Location</u>	<u>Major Pollution Sources</u>	<u>Recommended Program</u>	<u>Comments (a)</u>
Duwamish River, Washington	Metals from Wastewater Treatment Plants with NPDES permits and Hazardous Waste Sites	Implemented Programs for Treatment Plant Compliance and Hazardous Waste Site Cleanup	Cleanup Programs in Accordance with Industrial Treatment and Hazardous Waste Programs; Not an Urban Stormwater Runoff Problem
South San Francisco Bay, California	Metals from fuel, industrial site discharges, and natural sources (including mercury and iron ores)	Implemented Stringent Industrial Permitting Program and Fuel Station Monitoring Program	Cleanup Programs in Accordance with Industrial Discharge and Treatment Programs; Not an Urban Stormwater Runoff Problem
Westport River, Massachusetts	Bacteria from Dairies and Rural Roads	Runoff Containment Programs for Dairies	Not an Urban Stormwater Runoff Problem
Occoquan Reservoir, Virginia	Nutrients from Agricultural Areas and Forests and from Discharges of 13 Wastewater Treatment Plant Outfalls	Implemented Erosion Controls; and Conveyed Wastewater to 1 Treatment Plant that Provided Tertiary Treatment to Remove Nutrients	Not an Urban Stormwater Runoff Problem
Milwaukee, Wisconsin	Combined Sewer Overflows and Discharges from Wastewater Treatment Plants that Exceeded NPDES Limits	Separated storm drains and sanitary sewers; and Mandated Compliance with NPDES permits	Not an Urban Stormwater Runoff Problem
Kelsey and Bear Creeks, Washington	Sediment and Erosion from Exposed Soils	Local Erosion and Flow Controls	Problem due to Habitat Modification; Could be Associated with Urban Stormwater Runoff Problems
Rouge River, Michigan and Long Island Sound, New York	Combined Sewer Overflows	Ongoing studies	Not an Urban Stormwater Runoff Problem

Note: (a) "Urban Runoff" is defined as Stormwater Runoff from Residential and Commercial areas, only.

GLOSSARY

APWA	American Public Works Association
CSO	Combined Sewer Overflow Systems
CWMCUA	Committee on Wastewater Management for Coastal Urban Areas
EPA	U.S. Environmental Protection Agency
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
NSF	National Science Foundation
NURP	National Urban Runoff Program
ORD	Office of Research and Development
WCOG	Washington Council of Governments
WPCF	Water Pollution Control Federation

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March 15, 1994

National Realty Committee, which serves as Real Estate's Roundtable in Washington, believes that national policies should facilitate a healthy environment. After all, such a result is essential to Americans' quality of life and, in fact, the viability of private industry. We also believe that prudent environmental policy should be based on sound, documented scientific evidence; be cost-effective; and be measured to address issues that are significant relative to their contribution to underlying problems.

With this in mind, last year NRC and the National League of Cities asked Montgomery Watson, a noted environmental engineering firm, to assess current knowledge of the impacts of urban stormwater runoff and review the findings of studies completed for Congress, the Environmental Protection Agency (EPA) and other entities.

The Montgomery Watson study, *Defining the Urban Stormwater Runoff Problem*, concluded that the urban stormwater runoff problem has been overstated. Agriculture, erosion, wastewater overflows and leaking septic systems are the major causes of runoff-related water quality impairment, not urban stormwater runoff. In addition, the study found, the most effective strategy for stormwater management entails the use of a watershed approach that will allow local problems to be identified and prioritized. National standards, on the other hand, would result in many oversized, unnecessary and quite costly facilities. A copy of the Montgomery Watson report is enclosed for your information.

Based on the study's conclusions, we believe that national policy should:

- recognize the limited extent to which urban stormwater runoff contributes to overall water quality impairment; and
- recognize that only a small percentage of commercial (including real estate) uses justify costly regulation. (In fact, we believe EPA should identify these types of uses *before* proceeding with regulation of non-industrial commercial activities.)

As you work to reauthorize the Clean Water Act, we hope you will consider the facts documented in and the conclusions of this study. Please call if we can answer any questions or provide additional information.

Steven A. Wechsler
President

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MONTGOMERY WATSON

Defining The Urban Stormwater Runoff Problem

February 1994

Prepared for:

**National League of Cities
National Realty Committee**



February 3, 1994

National League of Cities
and National Realty Committee

Montgomery Watson is pleased to provide this paper on defining the urban stormwater problem. As Congress considers amendments to the 1987 Clean Water Act, the impacts of non-point source discharges must be clearly understood. This understanding is imperative to structure control strategies that will yield the greatest benefit at the least cost. This assessment includes a review of current knowledge of the impacts of urban stormwater runoff and summarizes the findings of studies completed for Congress, the U.S. Environmental Protection Agency, and other entities.

This report includes an Executive Summary with concise conclusions and recommendations of this report, a summary of studies concerning urban stormwater runoff completed in the past 15 years, a discussion of cost implications of stormwater quality controls, and brief summaries of watershed management programs that several communities have implemented.

In summary, this report found that the impacts of urban stormwater runoff need to be separated from the impacts of other non-point sources such impacts of: agricultural and industrial site runoff, erosion, and wastewater overflows and leaking septic systems. In addition, it appears that the most effective strategy for stormwater management is to use a watershed management approach that will allow local problems to be identified and prioritized. It would be extremely difficult to approach this problem with national standards due to the wide variety of watershed characteristics and storm events. National standards would result in many oversized and unnecessary facilities. Rather it would be more appropriate to develop watershed-specific programs.

If you have any questions concerning this paper, please contact us.

Very Truly Yours,

Gwendolyn M. Buchholz
Principal Engineer

EXECUTIVE SUMMARY

*An Understanding of the
Extent of Urban Stormwater
Problems and Other Types of
Stormwater Pollution is
Imperative Prior to Initiating
National Urban Stormwater
Quality Programs*

PURPOSE OF THE REPORT

As Congress considers amendments to the 1987 Clean Water Act, the impacts of non-point source discharges must be clearly understood. This understanding is imperative to structure control strategies that will yield the greatest benefit at the least cost. At this time, the impacts of urban stormwater runoff are not clearly understood because the specific effects have been masked by the greater impacts of industrial, agricultural, erosion, point source discharges, and wastewater overflow discharges.

This assessment includes a review of current knowledge of the impacts of urban stormwater runoff. Reports completed by the U.S. Environmental Protection Agency (EPA) and other agencies relating to urban stormwater runoff have been summarized in an attempt to define "water quality impairment due to urban stormwater runoff". In addition, several metropolitan areas throughout the nation were contacted to determine if new stormwater quality programs initiated in response to the 1987 Clean Water Act Amendments had changed water quality.

OVERVIEW

The nature of stormwater discharges is significantly different from that of wastewater point source discharges. Congress recognized these differences by establishing a separate National Pollutant Discharge Elimination System permit process for non-point source discharges and by defining a separate standard for stormwater based on the "maximum extent practicable" management measures. The stormwater program established by Congress in 1987 incorporated a phased program intended in part to provide the information base for a more comprehensive program to be developed when Congress re-authorized the Clean Water Act.

The Urban Stormwater Runoff Problem has been Overstated. Agriculture, Erosion, Wastewater Overflows, and Leaking Septic Systems are the Major Causes of Water Quality Impairment, not Urban Stormwater Runoff.

The National Urban Runoff Program (NURP) study completed in 1983 is often cited as the basis for stormwater management programs. However, the NURP study indicated that agriculture, erosion, and wastewater were the primary causes of water quality impairment due to storm events. In addition, NURP suggested that illicit connections to storm drains be eliminated and local water quality strategies should be developed.

The findings that agriculture, erosion, wastewater overflows, and leaking septic systems are the major causes of water quality impairment have been reiterated in several EPA reports. The EPA and other agencies also found that many pollutant sources attributed to "urban runoff" are not caused by discharges from residential and commercial areas. The "urban runoff" problem is frequently caused by discharges from marine vessels, shipyards, marinas, leaking septic systems, industrial sites, and erosion of stream channels and shorelines.

The need for local water quality strategies, preferably on an integrated watershed basis, has been supported by the National Research Council in a report for EPA and Congress. The findings of the National Research Council indicated that regional strategies should consider all pollutant sources and integrate policies for air, water, and land. The study also stated that local management options should reflect social goals and priorities relative to risks, costs, and benefits. The plans must be flexible to allow changes based on information collected after new management programs are implemented. This could allow agencies to eliminate non-viable programs or improve ongoing programs.

COST IMPLICATIONS

This assessment clearly indicates that expenditures for new regulatory stormwater control strategies should be limited until studies can be completed to define the effectiveness of ongoing water quality management programs and the extent of the remaining problem. Additional studies should be conducted on a watershed basis to accurately identify pollutant sources and prioritize solutions.

Costs for Treatment of Stormwater From Residential and Commercial Areas in Major Metropolitan Communities Throughout the United States Could be Over \$406 Billion for Construction and Over \$543 Billion Each Year for Operation and Maintenance

Annual Costs for Improving Stormwater Quality could be up to 500 times more Expensive than Wastewater Treatment Because of the Volume of Water and Intermittent Nature of Storms

To the extent that existing and future watershed studies identify urban runoff as a specific problem, additional measures should be employed that are appropriate for each watershed.

Cost implications of national effluent and/or treatment standards were evaluated in a recent study by the American Public Works Association of Southern California. The study identified a potential range of national costs of \$147 million to \$406 billion for construction of stormwater controls and \$1.1 billion/year to \$543 billion/year for operation and maintenance.

The costs shown in Figure 1 (located at the end of this section) are conservative estimates and may be as much as 50 percent low because the costs do not include the cost of stormwater pipelines, land and permits for the treatment facilities, and design costs.

These costs can be compared to the costs of providing municipal wastewater treatment. Since 1972, municipalities throughout the nation have spent about \$76 billion for construction (with about \$50 billion funded through federal grants). These municipalities continue to spend \$1.1 to 1.8 billion/year for operations and maintenance. It should be noted that these costs primarily remove solids and organic materials. This would be comparable to Level 4 Best Management Practices, as shown in Figure 1. The Level 5 treatment represents a treatment level significantly higher than most wastewater treatment plants provide, as shown in Figure 1. The Level 5 controls would be mandated if national stormwater discharge standards were required to meet national water quality standards.

Several agencies across the country have implemented watershed programs. These watershed programs have led to less costs than costs for complete stormwater treatment. For example, these agencies implemented what was approximately equivalent to non-structural controls, or Level 2 in the APWA study. If these agencies had implemented complete stormwater treatment to remove solids, metals and microorganisms, as described under Level 5 in the APWA study, the construction costs would be significantly higher, based on data presented in the APWA report, as shown in Figure 2.

Results of Recent Water Quality Surveys Indicate that Urban Stormwater Runoff is a Small Source of Stormwater Pollutants. Applying National End-of-Pipe Standards for Urban Stormwater Discharges Would be Extremely Costly

CONCLUSIONS

Based upon this review of studies completed over the past 15 years and discussions with stormwater quality management agencies throughout the nation, the following specific conclusions are provided.

- The urban stormwater runoff problem has been overstated.
- The urban stormwater runoff problem frequently has been described using old or over-generalized data.
- Results of recent water quality surveys indicate that urban stormwater runoff is a small source of stormwater pollutants compared to other non-point sources (less than 4 percent in some categories of receiving waters).
- Future monitoring results are needed to identify the extent of remaining urban stormwater quality problems and the cost-effectiveness of control strategies and measures.
- Applying national end-of-pipe standards for urban stormwater discharges would be extremely costly.
- Vast differences in hydrology, soils, vegetation, precipitation patterns, and land uses argues against national urban stormwater discharge standards.
- Proposed urban stormwater quality controls and national water quality standards would require urban areas to fund costly facilities to collect and treat stormwater flows while not addressing for more significant sources.

Existing Programs for Source Controls Should be Continued and Watershed Management Programs Should be Implemented to Evaluate Identify and Address Water Quality Problems

RECOMMENDATIONS

A watershed evaluation approach would identify the most significant stormwater pollutant sources, including pollutant discharges from industrial sites, agricultural areas, and leaking septic systems. Therefore, based upon the findings presented in this paper, the following recommendations are presented.

- Continue and expand the use of initial "good-housekeeping" and public education measures that are currently being implemented by most metropolitan areas.
- Continue the Stormwater National Pollutant Discharge Elimination System permit programs for industrial and hazardous waste sites.
- Limit the scope of measures for urban runoff in a watershed to primarily non-structured measures until non-point source problems are understood.
- Develop and initiate a watershed approach applicable to all pollution sources to identify and address water quality problems.
- Develop watershed water quality plans that address water quality constraints, opportunities, and priorities within the framework of the unique physical and economic situation each watershed.

By identifying the specific sources of stormwater quality impairment, pollution control efforts can be targeted and made more effective. This approach would save billions of potentially unnecessary construction dollars and annual operation and maintenance dollars that are needed for other programs and services.

LEVELS OF BEST MANAGEMENT PRACTICES

LEVEL 1



NON-STRUCTURAL SOURCE CONTROLS

- Prevent Illicit Discharges
- Increased Street & Sidewalk Sweeping
- Clean Storm Drains

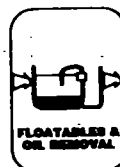
LEVEL 2



MINOR STRUCTURAL SOURCE CONTROLS

- Diversion Channel
- Grass Swales
- Improve Natural Channels to Reduce Erosion
- Plant Vegetation on Exposed Soils

LEVEL 3



FLOATABLES AND OIL REMOVAL

- Parking Lot Oil/Grease Separators
- Parking Lot and Rooftop Runoff Storage and Separators

LEVEL 4



SOLIDS REMOVAL

- Detention Basin
- Primary Clarifiers
- Swirl Concentrators
- Screens
- Wetlands

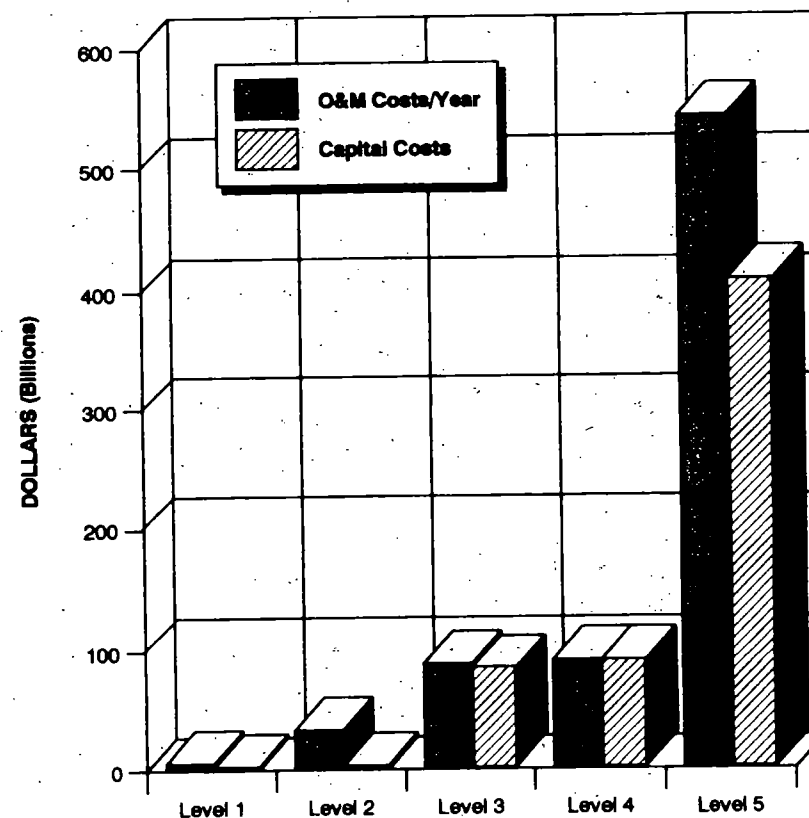
LEVEL 5



METALS REMOVAL

- Detention Basins and Wetlands
- Primary Clarifiers and Lime Precipitation

ESTIMATED NATIONAL COSTS TO IMPLEMENT BEST MANAGEMENT PRACTICES ALTERNATIVES (IN BILLION DOLLARS)

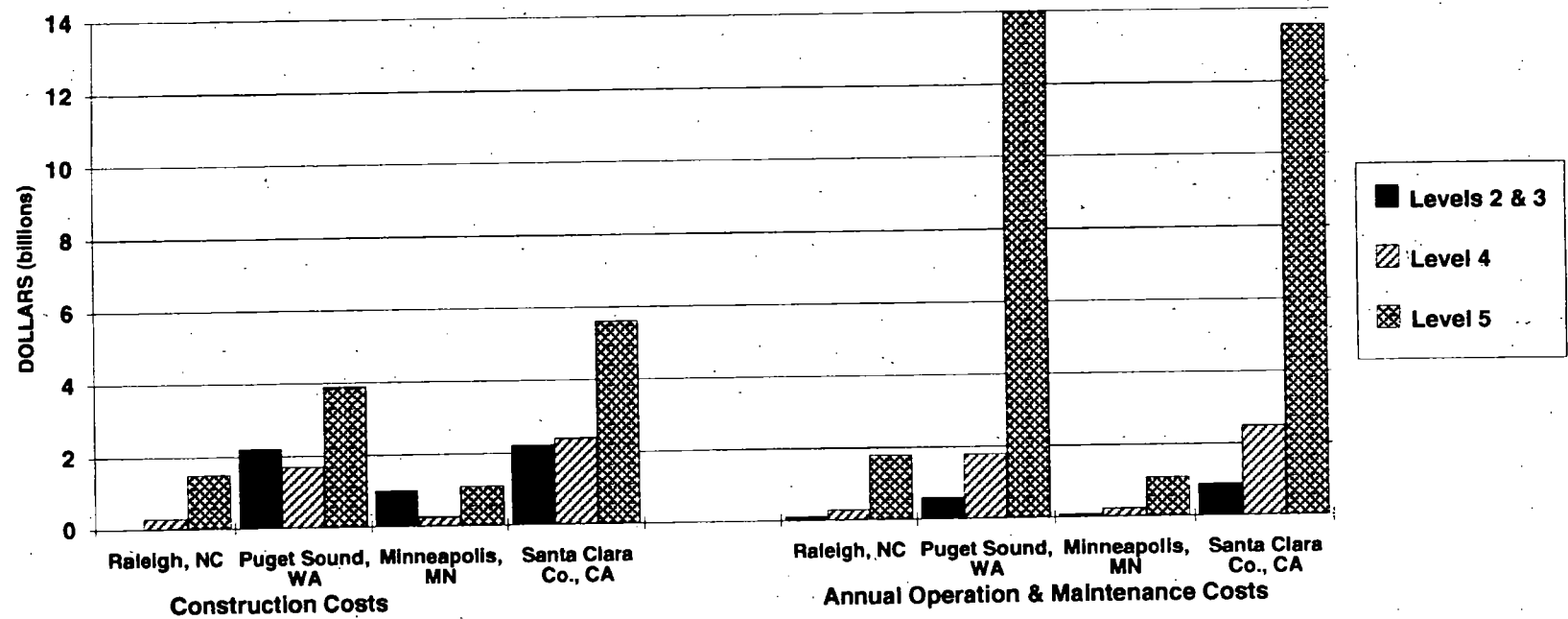


Source: APWA 1992
ENR 4800

Note: Costs do not include pipelines, land, permits, or design costs.
Therefore costs could increase by 20 to 50 percent.

FIGURE 1

FIGURE 2
ESTIMATED COSTS TO IMPLEMENT BEST MANAGEMENT PRACTICES
ALTERNATIVES IN SELECTED COMMUNITIES
 (Source: APWA 1992)





MONTGOMERY WATSON

Defining The Urban Stormwater Runoff Problem

February 1994

Prepared for:

**National League of Cities
National Realty Committee**

Montgomery Watson is an employee-owned environmental engineering firm with over 2300 employees in 65 offices worldwide. In the 45 offices in the United States, Montgomery Watson specializes in water and wastewater planning and design projects conducted for federal, state, and local agencies. Many of these projects have included assessments of receiving waters to identify sources of pollution and development of plans to reduce or eliminate pollutant discharges.

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DEFINING THE URBAN STORMWATER RUNOFF PROBLEM

*An Understanding of the
Extent of Urban Stormwater
Problems and Other Types of
Stormwater Pollution is
Imperative Prior to Initiating
National Urban Stormwater
Quality Programs*

PURPOSE OF THE REPORT

Various reports completed since the early 1960s by the U.S. Environmental Protection Agency (EPA) and other agencies have indicated that urban stormwater runoff may impair receiving water quality. However, these reports have not been able to identify the degree of impairment, the extent of the problem, or the costs and benefits of the solution.

As Congress considers amendments to the 1987 Clean Water Act, the impacts of non-point source discharges need to be clearly understood. This understanding is imperative to structure control strategies that will direct limited resources to valid needs. At this time, the impacts of urban stormwater runoff are not clearly understood because the specific effects have been masked by the greater impacts of industrial, agricultural, erosion, point source discharges, and combined sewer systems (CSOs) discharges. Most studies indicate that urban runoff causes less than 10 percent of the total non-point source pollution problem.

The purpose of this paper is to assess the current level of knowledge of and the current regulatory and legislative approach to addressing the impacts of urban stormwater runoff. To meet that objective, this paper provides a summary of reports by the EPA and other agencies relating to urban stormwater runoff that were prepared in an effort to define "water quality impairment due to urban stormwater runoff". In preparing this report, several metropolitan areas throughout the nation were contacted to determine if new stormwater quality programs initiated in response to the 1987 Clean Water Act Amendments had changed water quality.

OVERVIEW

Overall, EPA and other agency reports have found that the most significant contributor to stormwater pollution is agriculture, and that many pollutant sources attributed to "urban runoff" are not caused by discharges from residential and commercial areas. The "urban runoff" is usually caused by discharges from marine vessels, shipyards, marinas, leaking septic systems, industrial sites, and erosion of stream channels and shorelines.

Results of Recent Water Quality Surveys Indicate that Urban Stormwater Runoff is a Small Source of Stormwater Pollutants. Applying National End-of-Pipe Standards for Urban Stormwater Discharges Would be Extremely Costly

Specific Water Quality Control Plans Can be Developed for Agricultural Runoff and Sediment Source Controls, Industrial Site Runoff and Discharge Source Controls, Sanitary Sewer and Leaking Septic System Overflows, and the Remaining Urban Stormwater Runoff Flows

Proposed programs for "urban stormwater runoff" will not reduce the major causes of stormwater pollution and may not be necessary after concurrent water quality programs are completed.

CONCLUSIONS

Based upon this review of existing studies and discussions with stormwater quality management agencies throughout the nation, specific conclusions are as follows.

- **The urban stormwater runoff problem has been overstated.** Reported urban stormwater runoff problems frequently include problems due to erosion, leaking septic systems, CSOs, and industrial site runoff. These problems have been recognized and are regulated under different portions of the Clean Water Act. The proposed urban stormwater programs would only treat pollutant sources and flows from residential and commercial areas rather than more significant sources of non-point source pollutants.
- **The urban stormwater runoff problem frequently has been described using old or over-generalized data.** Therefore, impacts due to stormwater runoff and the beneficial effects of measures employed over the past several years cannot be specifically defined.
- **Results of recent water quality surveys indicate that urban stormwater runoff is a small source of stormwater pollutants compared to other non-point sources (less than 4 percent in some categories of receiving waters).** Rather, the most significant sources of stormwater water quality problems are:
 - Agricultural Activities
 - Non-point Natural Sources
 - Wastewater Sewer Overflows
 - Municipal and Industrial Point Sources
 - Illicit Discharges
 - Erosion from Disturbed Soils

A Watershed Management Approach Will Address the Most Significant Pollutant Sources, Thereby Reducing the Amount of Stormwater Flows that Require Treatment, Prioritize Solutions, and Lead to Solutions that are Funded Equitably by the Pollutant Sources

- **Future monitoring results are needed to identify the extent of remaining urban stormwater quality problems and the cost-effectiveness of control strategies and measures.** The programs to reduce the other types of stormwater runoff pollution (noted above) were only recently implemented and will probably reduce the overall water quality problem. There is a need to evaluate the effectiveness of current urban runoff programs before considering additional regulatory measures.
- **Applying national end-of-pipe standards for urban stormwater discharges would be extremely costly.** The costs and potential disruption associated with trying to capture and treat stormwater from existing urban areas are so great as to necessitate careful and thorough analysis of the nature and degree of the problem areas and potential alternative solutions.
- **Vast differences in hydrology, soils, vegetation, precipitation patterns, and land uses argue against national urban stormwater standards.** Any attempt to define guidance at the national level for stormwater treatment requirements or "best management practices" will either be very general and therefore, not useful; or too specific as to result in impossible solutions that are not cost-effective.
- **Proposed urban stormwater quality controls and national water quality standards would require urban areas to fund costly facility to collect and treat most of the stormwater flows while not addressing for more significant sources.** However, these types of controls will be extremely costly and will not eliminate the majority of stormwater pollutants.

***Programs for Source Controls
Should be Continued and
Watershed Management
Programs Should be
Implemented to Identify and
Address Water Quality
Problems***

RECOMMENDATIONS

Based upon the inconclusive nature of stormwater runoff studies, it is important that stormwater control strategies are based upon additional studies that define the specific impacts on ongoing water quality management programs and the extent of the remaining problem. Additional studies should be conducted on a watershed basis to accurately identify primary pollutant sources and to prioritize solutions.

A watershed evaluation would identify the most significant stormwater pollutant sources, including pollutant discharges from industrial sites, agricultural areas, and leaking septic systems. Therefore, based upon the findings presented in this paper, the following recommendations are presented.

- Continue and expand initial "good-housekeeping" and public education measures that are currently being implemented by most metropolitan areas.
- Continue to implement the Stormwater National Pollutant Discharge Elimination System permit programs for industrial and hazardous waste sites.
- Limit the scope of measures for urban runoff in a watershed until non-point source problems are understood.
- Develop and initiate a watershed approach applicable to all pollution sources and address water quality problems.
- Develop watershed water quality plans that address water quality constraints, opportunities, and priorities within the framework of the unique physical and economic situation in each watershed.

Recent Studies Indicate that NURP Mass Loading Projections may be Overstated. If Stormwater Quality Regulations are Based on Overstated Projections, Municipalities Could Construct Unnecessary or Oversized Treatment Facilities

By identifying the specific sources of stormwater quality impairment in specific watersheds, pollution control efforts can be prioritized and targeted. This approach would save billions of unnecessary construction dollars and annual operation and maintenance dollars that are needed for other programs and services.

LEGISLATIVE BACKGROUND

The 1972 Clean Water Act prohibited pollutant discharges to navigable waters from point sources unless the discharges were authorized by a National Pollutant Discharge Elimination System (NPDES) permit. This program focused on reducing municipal and industrial point-source pollutant discharges.

As the control measures for point sources were implemented, the need to address non-point pollution sources was considered. Non-point source water quality management studies and the National Urban Runoff Program (NURP) studies were initiated in the 1970s in an effort to quantify the overall problem. Limited amounts of sampling were used to develop unit mass loading rates (such as 1,000 lbs/acre of a pollutant). Results of the NURP studies were used to develop stormwater plans to reduce pollutant discharges. The results of the NURP studies also have been considered in the development of wet weather effluent requirements.

Recent water quality studies indicate that pollutant mass loadings projected by NURP studies were overstated. These studies also identified a great variability in loadings and impacts throughout the country. Therefore, the management plans and/or the effluent regulations may be inappropriate and result in excessive spending for construction and operation of future urban stormwater treatment facilities.

In 1987, amendments to the Clean Water Act were adopted. Some of the amendments defined stormwater discharges that are required to have a NPDES permit, prohibited non-stormwater discharges to storm sewers (including dry weather discharges from industrial sites) unless a NPDES permit is issued, and required controls to reduce the discharge of pollutants to the "maximum extent practicable" management measures. This term was included because Congress recognized that stormwater controls must be based upon local conditions. This finding was consistent with 1992 findings of the Ninth Circuit Federal Appellate Court (Court). The Court determined that Congress did not mandate a minimum standards approach or specify that EPA develop minimal performance requirements. The Court also determined that Congress could have written a statute requiring stricter standards, but Congress adopted a statute that allowed local interpretations.

To correctly interpret "maximum extent practicable", EPA must have a thorough knowledge of local water quality problems, and determine the real cost/benefit of required controls for each community or watershed.

DEFINING THE URBAN STORMWATER RUNOFF WATER QUALITY PROBLEM

The Urban Stormwater Runoff Problem has been Overstated. Agriculture, Erosion, Wastewater Overflows, and Leaking Septic Systems are the Major Causes of Water Quality Impairment, not Commercial and Residential Runoff

It is difficult to segregate the impacts of urban stormwater runoff from the impacts of other discharges. First, urban stormwater runoff is discharged into receiving water bodies that also contain discharges from industrial sites, combined sewer (stormwater and sanitary sewer) overflows (CSOs), point-source municipal wastewater treatment plants, and irrigation runoff. Second, the receiving waters frequently include pollution from upstream sources, such as mines, erosion of disturbed soils, and agricultural lands. The impacts of the other pollution sources are usually greater than the impacts of urban stormwater runoff from residential and commercial areas, and therefore, mask the impacts of specific sources.

Studies did not Identify a Specific Correlation between Stormwater Runoff from Separate Storm Sewers and Significant Receiving Water Quality Problems

Recent Studies also Indicate that Urban Stormwater Runoff did not Appear to Cause Large Scale or Immediate Water Quality Problems Based on Water Quality Monitoring During and Following Storm Events

Initial Stormwater Runoff Studies

Concerns about potential pollution from urban stormwater runoff were raised almost 30 years ago by the U.S. Public Health Service. These concerns have been evaluated many times by the Urban Water Resources Research Committee of the American Society of Civil Engineers, the Council on Environmental Quality, the U.S. Environmental Protection Agency, and other organizations and agencies.

The first non-point sources investigations identified a correlation between discharges from CSOs and water quality problems in the receiving waters. These problems were primarily due to the sanitary sewer flows in the CSO discharges which are regulated under separate portions of the Clean Water Act.

Importantly, the investigations did not identify a specific correlation between urban stormwater runoff from separate storm sewers and significant water quality problems in the receiving waters (EPA 1983). These conclusions also were corroborated by the Office of Research and Development (ORD) which investigated urban stormwater runoff from 250 communities. The results of the ORD study indicated that receiving water quality was highly variable throughout the nation and that there was no correlation between urban stormwater runoff flows and water quality problems as defined by dissolved oxygen concentrations.

Recent Stormwater Runoff Studies

The EPA and state water quality agencies have completed additional studies in the past 10 years to define urban stormwater runoff water quality impairment. The studies have indicated that sediment and nutrients are the most significant pollutants, and that agricultural activities were the source of most pollutants during storm periods (EPA 1977, EPA 1992, EPA 1983, EPA 1993, Mancinini 1987, WPCF 1990).

Observed Wet Weather Fish Kills were Frequently Related to Pesticides, Herbicides, Spilled Oil, and Wastewater Overflows, not Urban Stormwater Runoff

The NURP Studies Identified the Most Significant Impairments to the Nation's Waterbodies as Erosion of River Banks, Phosphorous from Fertilizers and Other Chemical Applications Upstream of Lakes, and Bacteria due to Wastewater Overflows and Leaking Septic Systems in Estuaries and Coastal Waters

Most of the studies by EPA and other groups also indicated that urban stormwater runoff did not appear to cause large scale or immediate water quality problems based on water quality monitoring during and following storm events (Hearrey et al 1984, Mancinini 1987, EPA 1977, EPA 1983, Hvitred et al 1986). The findings of the many studies indicated that the impacts of stormwater discharges varied widely and were mostly affected by upstream pollution sources and the assimilation capacity of specific receiving waters (EPA 1983).

Recent studies have indicated that fish kills that occurred during wet weather periods generally were not directly related to urban stormwater runoff. Rather, the fish kills were frequently related to upstream runoff that contained pesticides, herbicides, spilled oil, and wastewater overflows from leaking septic systems and sanitary sewer overflows (Hearrey et al 1984).

These studies also found that many of the wet weather water quality problems in lakes were caused by eutrophication due to pollutants from leaking septic systems, sediments and fertilizers from agricultural sites, chemical spills, wastewater overflows, and wastewater treatment plant effluent that did not comply with NPDES permits. Many of these sources had been eliminated years before the water quality problems were observed. However, the pollutants had remained in the sediments of the lakes and the problems continued. Therefore, the remaining urban stormwater runoff from residential and commercial areas could be falsely identified as the source of pollutants that were causing water quality problems (Hearrey et al 1984).

National Urban Runoff Program Studies

The National Urban Runoff Program (NURP) studies were initiated to provide information and develop methods that could be used for stormwater quality plans throughout the nation. The program developed stormwater quality plans for 28 communities. The communities were selected to include a wide range of conditions in order that the results could be extrapolated to other communities.

Many of the Proposed Urban Stormwater Regulations are Focused on Constituents in the Stormwater which have not been Shown to Significantly Impact Surface Waters

The selected communities did not include CSO systems. However, stormwater from several of the selected communities was discharged into receiving waters that contained CSO discharges from adjacent communities. The NURP studies also were designed to determine impacts of urban stormwater runoff on receiving waters. Significantly, only two of the 28 studies included consistent monitoring of the receiving waters.

The conclusions of the NURP studies were presented in Results of the Nationwide Urban Runoff Program Final Report in 1983 (EPA 1983). The NURP studies found that flows and quality of urban stormwater runoff varied significantly not only between sites, but also within the same storm event at the same site. Therefore, it was difficult to develop consistent findings that could be used throughout the nation. By comparing, findings of all the studies, several overall conclusions regarding major impacts to different types of receiving waters can be developed, as summarized below.

- **Rivers and Streams:** Most significant impacts resulting in habitat changes are caused by high stormwater flows and associated erosion. Significant impacts do not appear to be caused by stormwater quality.
- **Lakes:** Most significant impacts are due to phosphorous, possibly from fertilizer in irrigation runoff.
- **Estuaries, Embayments, and Wetlands:** Most significant impacts can be attributed to bacteria associated with leaking septic systems, sanitary sewer connections to storm drains, and sanitary sewer overflows.

The NURP studies found that the most significant impacts to receiving waters were due to erosion, agricultural or fertilizer sources of phosphorous, and sanitary sewage. These are not constituents that are currently the focus of many proposed urban stormwater regulations. Instead, many of the proposed urban stormwater regulations are focused on constituents in the stormwater which have not been shown to significantly impact receiving waters.

EPA has Recently Implemented Several NURP Study Recommendations, Including Elimination of Illicit Connections Between Sanitary Sewers and Storm Drains and Control of Industrial Site Stormwater Runoff

Recent Water Quality Surveys have indicated that Sediment, Pesticides, and Nutrients from Non-Urban Activities Impair More Waterbodies Than Urban Stormwater Runoff

Other conclusions of the NURP studies are summarized in Table 1 (included at the end of this report).

The NURP studies acknowledged the limitations of the study program due to its scope and schedule. Therefore, the final report included recommendations for stormwater management and for further study to better define the impacts of urban stormwater runoff. These recommendations are listed in Table 2 (included at the end of this report).

Since the completion of the NURP studies, EPA has initiated programs to implement several of the recommendations. These programs have been recently implemented and include elimination of illicit connections between sanitary sewers and storm drains and control of stormwater runoff from industrial sites.

The results of the recent discharge elimination programs and the resolution of outstanding issues identified by the NURP studies should be considered prior to establishing control strategies for urban and other non-point sources.

1992 EPA Water Quality Surveys

Each year water quality surveys are conducted by EPA or by the states which have received authorization from EPA to manage local water quality. The survey results are used to assess water quality problems and allocate federal funds to mitigate the worst water quality problems.

The most recent report completed by EPA to assess the water quality problems due to non-point pollution was summarized in Managing Nonpoint Source Pollution in 1992 (EPA 1992a). The primary findings are summarized below.

- Wildlife habitat and recreation are the "beneficial uses" most impacted by non-point pollution.
- Agricultural activities are the primary sources of non-point pollution, including sediments, nutrient, and pesticides.

Due to the Need to Aggregate Data, Highly Disparate Activities Associated with "Urban Runoff" including Discharges from Industrial Sites, Vessels, Marinas, Shipyards, and Leaking Septic Systems, and Diversions of Water Supplies were aggregated together

For the 1992 National Water Quality Survey of Nonpoint Source Pollution, Only 40 States Reported on Rivers, 18 States Reported on Lakes, 3 States Reported on Wetlands, and 18 States Reported on Coastal and Estuarine Waters

- Siltation due to sediments and eutrophication due to nutrients are the most significant non-point pollutants. These pollutants are generally from non-urban areas.

This study and other reports have indicated that pollution due to point source discharges significantly reduced over the past 20 years (EPA 1992, NRDC 1993, CWMCUA 1993). Pollution from CSOs and other non-point sources also has decreased.

For the 1992 non-point source study, the states submitted data for each receiving waterbody, including waterbody type, degree of impairment to beneficial uses, designated beneficial uses, type of monitoring, sources of pollution (ie, urban runoff), and pollutant type.

Due to the wide variety of water quality problems that occur throughout the nation, many of the responses from the states were aggregated into nine categories, one of which is called "urban runoff". However, each category included many types of pollution sources. The term "urban runoff" included stormwater runoff from industrial sites, wastewater overflows, shipyards, and marinas, as well as runoff from commercial and residential neighborhoods. In addition, due to a lack of standard methods to identify water quality impairment and pollution sources, urban runoff problems in one state included impairment due to leaking septic systems and diversion of water for local water supplies.

The information presented in the EPA report addressed four types of waterbodies: rivers and streams, lakes, wetlands, and coastal waters and estuaries. Information presented in the report is presented below in accordance with these categories.

- **Rivers and Streams:** Only 40 states reported any findings. All 40 reporting states indicated that waters were impaired. The impaired waters represented only 11.8 percent of all rivers and streams in the nation and 16 percent of all rivers and streams in the reporting states.

The Limited Data Set Does Not Provide a Balanced Definition of the Problem

Agriculture was the primary pollutant source impacting nation's rivers (41 percent of all pollutant sources). *Urban runoff (including all categories such as shipyards and leaking septic systems) represented about 4 percent of all pollutant categories.*

- **Lakes:** About 20 percent of all lakes in the nation (excluding the Great Lakes, the Great Salt Lake, and lakes in Alaska) were considered impaired. All of the impaired lakes were located in 18 states. The primary source of pollutants is agriculture (23 percent of all pollutant sources). *Urban runoff caused only 6 percent of the impairment.*
- **Wetlands:** Only three states reported impaired wetlands: California, Delaware, and Iowa. Because of the absence of other data, EPA could not extrapolate the information to a nationwide conclusion. For California and Iowa (the only states that reported pollution sources), 81 percent of the impairment was caused by agricultural runoff. *Only 4 percent was caused by urban runoff sources.*
- **Coastal Waters and Estuaries:** Only five states reported data for coastal waters and thirteen states reported data for estuaries. The EPA report indicated that most of the impairment was due to fuel and oil spills from leaking tanks, hydrologic modification due to erosion, and construction in estuaries. *Urban runoff (including discharges from vessels, marinas, shipyards, and industrial sites) only impacted about 10 percent of the area.*

Based on the reporting states with wide variations in data sources and interpretations, only 4 to 10 percent of the water quality impacts resulted from urban runoff.

California Survey. Because of the diverse nature of the pollutants and types of impairment, the California survey used in the EPA reports appears to present over-generalized conclusions. The over-generalizations are primarily caused by the need to aggregate data and the lack of standard reporting methods.

Most of the Pollutant Sources Categorized in the California Water Quality Assessment as "Urban Runoff" were Actually Caused by Water Supply Diversions, Leaking Septic Systems, Runoff from Industrial Sites, Discharge from Vessels and Marinas, Sediment from Erosion, Erosion of Stream Channels and Shorelines

In California, 97 percent of Wetlands Impairment Not Caused by Urban Stormwater Runoff

To determine the extent of over-generalization and inadvertent misrepresentation of data, the data collected in California was reviewed and compared with the data reported in the EPA water quality assessment report. The data from the State of California is based on data collected in 1991 and reported in the Water Quality Assessment study in 1992 (California 1992). This information is also related to the four main types of waterbodies.

- **Rivers and Streams:** Water quality in California rivers and streams was similar to the other reporting states. Only 6 percent of all California rivers were impaired, and 35 percent of the pollutant sources were due to agricultural runoff. The survey also listed 43 percent of the pollutant sources as "urban runoff". However, only 7 percent was actually due to runoff from urban areas. Other impacts attributed to "urban runoff problems" were caused by water diversions and leaking septic systems (27 and 9 percent of all impaired rivers, respectively) not urban runoff.
- **Lakes:** According to the EPA report, California reported the second largest lake acreages affected by urban sources (only Vermont had more acres of lakes impaired by urban runoff). However, careful review of the data from California indicated that 57 percent of the impairment was caused by leaking septic systems and erosion of exposed soils in recreation areas. Agricultural runoff impaired 40 percent of the lakes in California.
- **Wetlands:** The California data indicated that 97 percent of the impairment of wetlands was caused by agricultural runoff and 3 percent was caused by urban runoff (primarily from industrial sites).
- **Coastal Waters and Estuaries:** The California report indicated that 28 percent of these waters were impaired. Approximately 83 percent of these waters were located within and in the vicinity of San Francisco Bay, Santa Monica Bay, Newport Bay, San Diego Bay, and the Los Angeles Harbor.

Major Problems Identified in the Survey Findings will not be Addressed by Proposed Urban Stormwater Runoff Programs

Many Metropolitan Areas Have Already Implemented Non-Structural Stormwater Controls and Monitoring Programs

Initial Findings from Monitoring Programs in Metropolitan Areas Indicated that Sediments are the Most Critical and Frequent Pollutant

National Research Council also recommended to EPA and Congress to develop stormwater management programs based on local characteristics

Within these waters, causes of impairment included discharges from vessels, shipyards, marinas, industrial sites, agricultural areas, and wastewater treatment plants; habitat modifications; dredging activities; upstream freshwater diversions; and urban runoff. A recent report prepared by EPA (EPA 1992b) indicated that most pollutants in the San Francisco Bay Estuary were caused by agriculture and silviculture activities and natural sources. Urban runoff was the most significant contributor only for lead and total hydrocarbons.

Summary of EPA Water Quality Survey Findings. Overall, both the EPA and California reports indicated that the most significant contributor to stormwater pollution is agriculture, and that many pollutant sources attributed to "urban runoff" are not caused by discharges from residential and commercial areas. The "urban runoff" is usually caused by discharges from marine vessels, shipyards, marinas, leaking septic systems, industrial sites, and erosion of stream channels and shorelines. Proposed programs for "urban stormwater runoff" will not reduce the major causes stormwater pollution and may not be necessary after concurrent water quality programs are completed. It also should be noted that the concurrent programs to control agricultural runoff and failing septic systems will involve rural and recreation communities that are not subject to proposed stormwater runoff regulations.

National Research Council 1993 Report

The National Research Council was requested by EPA at the direction of Congress to examine wastewater and water quality issues in coastal urban areas (CWMCUA 1993). The findings and recommendations of this report relative to stormwater are summarized below.

- Coastal wastewater and stormwater management strategies should be developed for local characteristics. The report stated that due to wide variations throughout the nation, it was not possible to develop a standard technology or approach to address all water quality issues.

Source Controls should be Encouraged

All Pollutant Sources should be Considered in Developing Water Quality Programs

Water Quality Management Options should Reflect Social Goals, Risk Priorities, Costs, and Benefits

The report further stated that any attempt to develop national strategies would either fail or would be excessive for many areas.

- Emphasis should be placed on controlling sources of nitrogen and other nutrients.
- Source controls should be encouraged by incentives and regulations.
- Stormwater quality measures should be based on an understanding of local conditions, and developed with other regional programs to develop the most cost-effective program.
- Management programs should be flexible to allow changes based on new information on environmental quality and performance of existing management systems.
- Urban coastal stormwater and wastewater programs should be based on strategies to integrate local characteristics and local issues, based on the following findings.
 - Water and sediment quality criteria standards should reflect risk, uncertainty, and variability of regional and local sites.
 - Regional strategies should consider all pollutant sources and integrate policies for air, water, and land.
 - Management options should reflect social goals and priorities relative to risks, costs, and benefits.
 - An incremental implementation plan to allow feedback from monitoring of new water quality controls.

Lead Concentrations Have Decreased since 1980

Upstream Sources of Sediment and Metals are Frequently Larger than Urban Runoff Sources

Ongoing Programs to Eliminate Illicit Discharges Appear to Reduce Metals and Other Pollutants in Stormwater

Many Reports Do Not Specifically Separate Stormwater Quality Problems Associated with Runoff from Residential and Commercial Urban Areas from Other Stormwater Runoff in Urban Areas, such as Industrial Site Runoff, Hazardous Waste Site Runoff, and Sanitary Sewer Overflows

Recent Water Quality Surveys in Metropolitan Areas

A study in 1992 (APWA 1992) surveyed over 100 metropolitan areas throughout the United States. The purpose of the survey was to determine the types of urban stormwater runoff controls that were being used or were being considered. At that time, most of the urban areas had only started or were planning to start the Clean Water Act permit application process. These agencies also were contacted in conjunction with the preparation of this report. Most of the agencies had implemented programs in the past year to eliminate illicit discharges and initiate public education programs. In addition, these agencies completed water quality sampling programs as part of the stormwater pollution prevention plans that were required by the EPA. Several agencies also had completed their first annual monitoring efforts. The most frequently observed results of the monitoring programs are summarized below.

- Sediments were the most critical and frequently observed pollutant in stormwater flows.
- Lead concentrations in stormwater have decreased since the 1980s due to the reduction in the use of leaded gasoline.
- Metal concentrations in receiving waters appear to decrease as industrial sites, land disposal sites, and municipal and industrial point discharges implement water quality plans pursuant to stormwater and point source NPDES permit programs.
- Upstream sources of sediment and metals frequently generate more significant amounts and types of stormwater pollutants than urban stormwater runoff sources.
- Natural sources frequently were the cause of high concentrations of iron, mercury, and other metals.
- Water quality impacts vary greatly due to climatic, geographic, soil chemistry, and watershed configuration.

It is Difficult to Develop Urban Stormwater Quality Criteria that Will Determine the Need for Treatment Facilities Because Urban Stormwater Pollutant Sources and Impacts Have Not Been Specifically Identified; Some Data is Old and Reflects Water Quality Prior to Implementation of Other Water Quality Programs, and Aggregated Data is Over-generalized

Overstatement of the Problem Could Lead to Oversizing or Construction of Unnecessary Treatment Facilities

SEPARATING IMPACTS OF URBAN STORMWATER DISCHARGES

In 1992, EPA published a report titled Environmental Impacts of Stormwater Discharges. A National Profile. The report summarized the findings of the Managing Nonpoint Source Pollution Study and other reports. The EPA reviewed the water quality impacts discussed above and found that pollutant characteristics can vary based on land use, the storm event, and soil characteristics. Although data presented in the Environmental Impacts of Stormwater Discharges report indicated that agriculture activities were responsible for most of the impairment of the nation's waters (which is consistent with other EPA reports), the major portion of the report presented concerns associated with discharges from "urban areas".

The report reviewed case studies to illustrate the impacts of "urban runoff". However, the case studies included municipalities with CSOs, treatment plants that were not completely in compliance with NPDES permits, and upstream agricultural and mining activities which contributed to water quality problems, as shown in Table 3 (included at the end of this report).

Several of the municipalities cited in the report were contacted during the preparation of this paper to determine if the water quality problems had been corrected. All of the communities have implemented programs to reduce water quality problems. Two of the case studies did focus on communities with urban stormwater runoff problems. These communities have both implemented water quality programs that emphasize non-structural controls.

EXCESSIVE COSTS FOR STORMWATER TREATMENT FACILITIES

Currently, the EPA is attempting to define the urban stormwater runoff problem. Because of the lack of data and the difficulty in segregating impacts of urban stormwater runoff from other non-point and point pollution sources, EPA has relied upon data from previous reports, including data from the NURP studies completed prior to 1983.

Stormwater Quality Problems Do Exist, However Most of the Problems Are Not Due to Urban Stormwater and Are Being Addressed by Other Programs

Programs to Reduce Agricultural Runoff, Industrial Site Runoff, Illicit Connections, Leaking Septic Systems, and Sanitary Sewer Overflows are Being Implemented to Control the Majority of Stormwater Pollution

Following Implementation of the Other Programs, the Extent of the Remaining Urban Runoff Problems Should be Evaluated to Determine the Need for Stormwater Treatment Facilities for Residential and Commercial Areas

The NURP data is difficult to use for this purpose because the data also reflects water quality problems associated with lack of secondary wastewater treatment, wastewater overflows, illicit connections to storm drains and discharges from industrial sites, and uncontrolled discharges from numerous (and frequently unidentified) hazardous waste sites. In the past ten years, correction programs for many of these water quality problems have been initiated.

Another concern with NURP data was that receiving waters were not extensively monitored. Computer models were used to predict water quality problems. However, observed values for organics and suspended solids often are lower than projected loadings (EPA 1983). This discrepancy probably occurred because the models were based on stormwater quality in the upper portion of the watersheds. As the stormwater flows through the watershed, sediments are deposited in storm drains and metals absorb to other sediment particles.

The EPA also is using data from water quality surveys. However, as discussed above, over-generalization of the data and a lack of standard reporting methods has led to a misrepresentation of "urban stormwater runoff problems". Basing regulatory responses on older and/or over-generalized data will overstate the urban stormwater runoff problem, and lead to excessive spending of user fees in municipalities to construct and operate facilities that could be avoided.

Another concern is related to discussions relative to national water quality standards. The NURP studies recommended evaluation of local water quality standards based on local site-dependent "synergy" of conditions. This concern is also reflected through Congressional action in the adoption of the methods for "maximum extent practicable". It would be inappropriate to attempt to develop national water quality standards that would account for a wide variety of wet weather events, soils, land use patterns, and water quality characteristics of stormwater.

Costs for Treatment of Stormwater From Residential and Commercial Areas in Major Metropolitan Communities Throughout the United States Could be Over \$406 Billion for Construction and Over \$543 Billion Each Year for Operation and Maintenance

It should be noted that this paper recognizes that stormwater runoff problems do exist. However, these problems are being addressed by other programs, including the industrial stormwater runoff program (as required by the Clean Water Act), separation and/or treatment of sanitary sewer overflows, Rural Clean Water Programs that reduce agricultural chemical application rates and increase use of vegetative swales around fields, Clean Lakes Programs and Great Lakes Program to control erosion and nutrients, and programs to minimize discharges from marine vessels and leaking septic systems.

These programs will eliminate many of the water quality problems associated with the "urban stormwater runoff" as defined by the EPA. States and municipalities have initiated numerous programs in the past two to five years to reduce identifiable stormwater runoff problems. Most of the recommended facilities are under construction or only recently have become operational. Therefore, it is difficult to assess the impact of the remaining urban stormwater runoff constituents that may not be addressed by current programs. Additional data to be collected over the next three to five years will be extremely helpful in more specifically defining the nature and extent of the problem.

Cost Implications of Overstating The Urban Stormwater Runoff Problem

Cost implications of national effluent and/or treatment standards were evaluated in a recent study by the American Public Works Association of Southern California (APWA 1992). The study identified a potential range of national costs of \$147 million to \$406 billion for construction of stormwater controls and \$1.1 billion/year to \$543 billion/year for operation and maintenance costs for residential and commercial areas, as shown in Figure 1. The costs shown in Figure 1 are conservative estimates and may be as much as 50 percent low because the costs do not include the cost of stormwater pipelines, land and permits for the treatment facilities, and design costs.

LEVELS OF BEST MANAGEMENT PRACTICES

LEVEL 1



NON-STRUCTURAL SOURCE CONTROLS

- Prevent Illicit Discharges
- Increased Street & Sidewalk Sweeping
- Clean Storm Drains

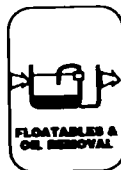
LEVEL 2



MINOR STRUCTURAL SOURCE CONTROLS

- Diversion Channel
- Grass Swales
- Improve Natural Channels to Reduce Erosion
- Plant Vegetation on Exposed Soils

LEVEL 3



FLOATABLES AND OIL REMOVAL

- Parking Lot Oil/Grease Separators
- Parking Lot and Rooftop Runoff Storage and Separators

LEVEL 4



SOLIDS REMOVAL

- Detention Basin
- Primary Clarifiers
- Swirl Concentrators
- Screens
- Wetlands

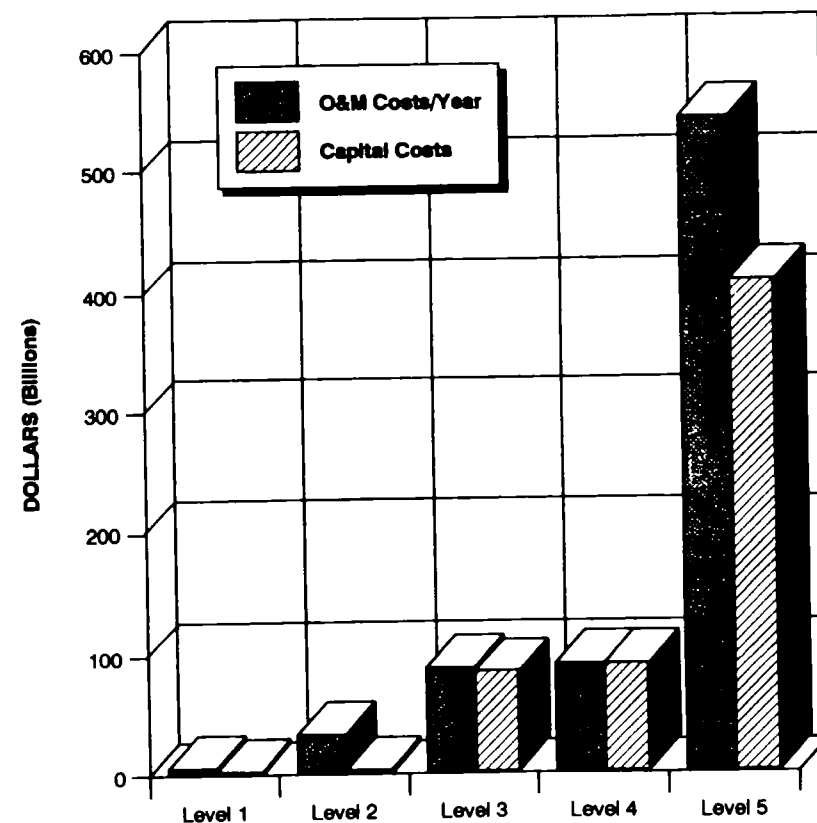
LEVEL 5



METALS REMOVAL

- Detention Basins and Wetlands
- Primary Clarifiers and Lime Precipitation

ESTIMATED NATIONAL COSTS TO IMPLEMENT BEST MANAGEMENT PRACTICES ALTERNATIVES (IN BILLION DOLLARS)



Source: APWA 1992
ENR 4900

Note: Costs do not include pipelines, land, permits, or design costs.
Therefore costs could increase by 20 to 50 percent.

FIGURE 1

Annual Costs for Improving Stormwater Quality could be up to 500 times more Expensive than Wastewater Treatment Because of the Volume of Water and Intermittent Nature of Storms

Stormwater Control Measures should Focus on the Most Significant Pollutants and Actual Sources of Pollutants on a Watershed-by-Watershed Basis

These costs can be compared to the costs of providing municipal wastewater treatment. Since 1972, municipalities throughout the United States have spent about \$76 billion for construction (with about \$50 billion funded through federal grants). These municipalities continue to spend \$1.1 to 1.8 billion/year for operations and maintenance. It should be noted that these costs primarily remove solids and organic materials. This would be comparable to Level 4. The Level 5 treatment represents a treatment level significantly higher than most wastewater treatment plants provide. Level 5 controls would be mandated if national stormwater discharge standards are required to meet national water quality standards.

This wide range in costs for potential stormwater management plans and the potential implications for local governments validates the need for Congress to exercise great care and control to ensure that these costs are not singularly imposed on municipalities without first considering the results of ongoing programs to control more significant stormwater pollution sources (such as industrial site stormwater runoff, elimination of sanitary sewer overflows, and elimination of combined sewer overflows). The ongoing programs may reduce pollution in "urban stormwater runoff" to such an extent that further treatment may not be necessary.

It is also important that more significant pollutant sources located upstream of the municipalities also be controlled (such as agriculture, leaking septic tanks, and mining activities) to determine if urban stormwater runoff is actually impacting the receiving waters as compared with upstream pollutant sources.

As discussed in the next subsection, several agencies across the country have implemented watershed programs. These watershed programs have led to less costs than costs for complete stormwater treatment. For example, these agencies implemented what was approximately equivalent to non-structural controls, or Level 2 in the APWA study.

***Communities Are Successfully
Implementing Watershed
Management Programs that
Focus on Source Controls,
Erosion Controls, and
Upstream Pollutant Sources to
Solve the Majority of
Stormwater Quality Problems***

If these agencies had implemented complete stormwater treatment to remove solids, metals and microorganisms, as described under Level 5 in the APWA study, the construction costs would be significantly higher, based on data presented in the APWA report, as shown in Figure 2.

***COST-SAVINGS THROUGH A WATERSHED
APPROACH***

A watershed management approach would allow establishment of local water quality standards that would match beneficial uses. The recommendations could be integrated with recommendations of other regional studies to develop integrated water quality programs that would not lead to duplication of efforts.

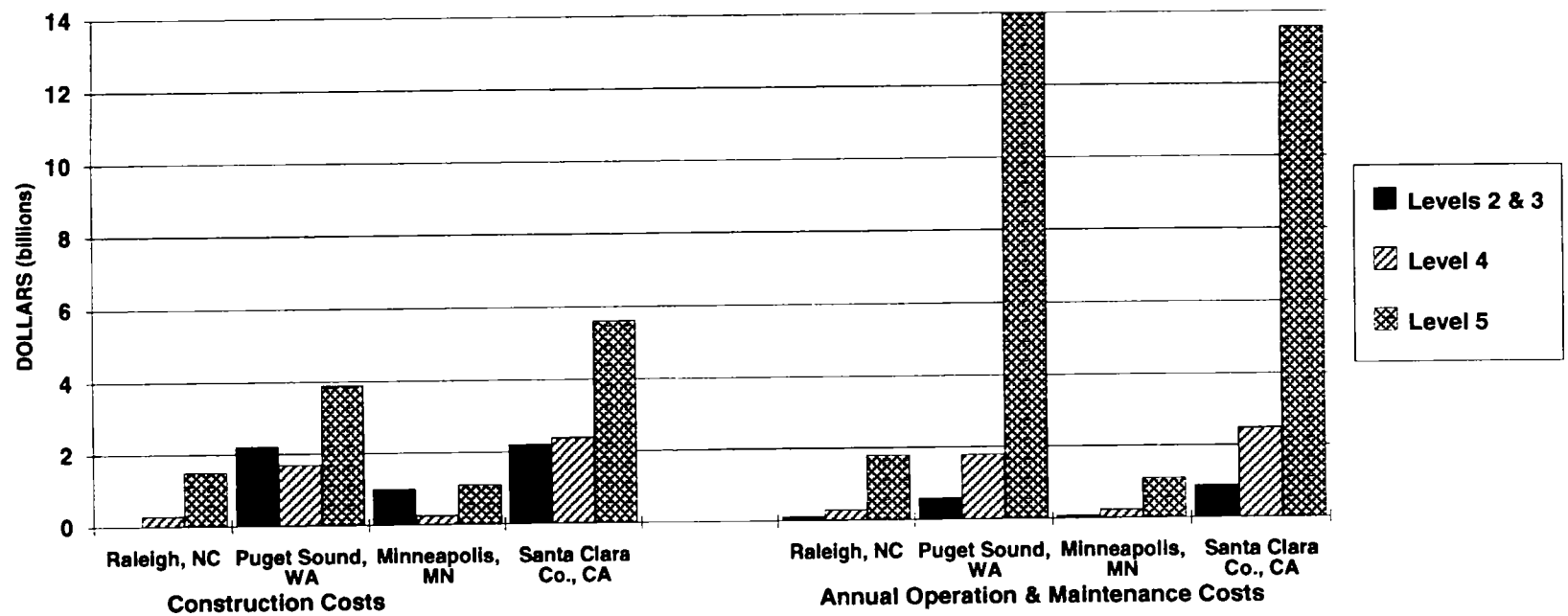
The use of a watershed approach also allows water quality management to focus on significant problems and prioritize solutions. The watershed management approach addresses all types of non-point source runoff, including sources which are not subject to stormwater requirements of the Clean Water Act Amendments (such as mining and agricultural runoff). This approach also would determine which pollutants and sources of pollutants were regulated by existing water quality programs.

The watershed management approach provides a more complete analysis of pollutant sources throughout the watershed and analysis of beneficial uses of the receiving waters. Several of the communities that were contacted for this paper have initiated watershed programs. Summaries of the early findings of these programs are summarized below.

Raleigh, North Carolina

The City of Raleigh implemented a stormwater management plan for several watersheds. Hydraulic modeling was used to determine flood hazards and sediment and nutrient loadings.

FIGURE 2
ESTIMATED COSTS TO IMPLEMENT BEST MANAGEMENT PRACTICES
ALTERNATIVES IN SELECTED COMMUNITIES
 (Source: APWA 1992)



Raleigh determined that actual water quality loading rates were lower than NURP projections

Water quality monitoring indicated that iron, nitrogen, and phosphorous concentrations were high. *Most of these pollutants appeared to be caused by erosion and runoff from cultivated areas. The city implemented a major erosion control program and minor structural controls.*

The costs averaged about \$2,000/acre of land served. This cost is similar to costs presented in other studies (APWA 1992). The measures were estimated to reduce nitrogen loadings by 12 percent, phosphorous loadings by 31 percent, metal loadings by about 25 percent. During the study, the city determined that the previously projected NURP loading rates were higher than actual loading rates. In addition, previous runoff models had underestimated the amount of infiltration into the soils. This also led to an overestimation of mass loadings (Raleigh 1992).

Puget Sound, Washington

The State of Washington Department of Ecology identified *sediment from erosion was the primary stormwater quality problem*. The state developed a program that emphasized erosion controls, industrial discharge controls, increased maintenance of storm drains, and public education. The overall program emphasizes implementation of non-structural BMPs that maximizes infiltration (WCOG 1991).

Minneapolis, Minnesota

Sediment from Exposed Soils, Sand Used for Ice Controls, and Natural Upstream Sources Were Found to be Significant Sources of Stormwater Pollution

A large portion of the metropolitan area is tributary to numerous lakes that were evaluated in the "Chain of Lake Studies". The results of the studies indicated that *sediment was the major water stormwater quality problem. The sediment sources included sand used for ice control and erosion of disturbed soils. Pollution from wastewater overflows also caused water quality problems*. The overall stormwater control program emphasizes separation of the combined sewer system and erosion controls (Minneapolis 1992, Holzin 1993). These improvements also comply with Clean Lakes Program goals.

San Jose, California

Watershed stormwater quality programs identified metals from industrial discharges and natural sources as the most critical pollutant. The initial program emphasizes elimination of pollutants from industrial sites and gasoline stations, and of illicit discharges. The current cost of this program is about \$2.9 million/year. Monitoring results indicate that total metal concentrations exceeded local water quality standards, but dissolved metals concentrations were below the standards. Some of the metals, including mercury, occur naturally in the soils (Ho 1993, Drury 1993).

NATIONAL WATER QUALITY REGULATIONS REQUIREMENTS

National Requirements for States to Implement Local Water Quality Criteria is More Appropriate than National Water Quality Criteria Due to the Wide Range of Conditions and Causes of Impairment

The overall need to improve nationwide water quality is an accepted premise for water quality planning. However, the cause of water quality degradation is extremely complicated and varies widely depending upon location, water quality, wet weather storm patterns, and land use patterns. To address the wide variations in water quality concerns and solutions, local solutions should be developed. These solutions may include solving water quality problems upstream of municipal areas.

For example, in Sacramento County, California, metal concentrations were high in the receiving waters due to mine drainage from a hazardous waste site located over 200 miles upstream of Sacramento. Therefore, Sacramento County pursued the possibility of reducing the mine drainage contribution in the river rather than full treatment of stormwater. Other communities have used the watershed approach to implement "good housekeeping" methods and public education programs to eliminate significant pollutant sources. Finally, other areas have significantly reduced water quality problems by eliminating pollutant discharges from industrial or hazardous waste sites.

All of these examples underscore the need to implement watershed management programs and best management practices, such as public education programs. It appears impossible to develop national water quality standards to address the wide variety of pollutant sources, concentrations, and effective solutions. These conclusions have been presented by many different studies including the NURP studies and others (EPA 1983, NRDC 1993, CWMCUA 1993).

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TABLE 1
SUMMARY OF CONCLUSIONS OF THE NATIONAL URBAN RUNOFF PROGRAM STUDIES

1. Heavy Metals

Copper, lead, and zinc were found in more than 91 percent of all samples. The concentrations frequently exceeded acute and chronic toxicity standards.

Projected receiving water quality problems were not observed during storm events in the two communities that monitored receiving water quality.

Heavy metal concentrations in stormwater runoff appeared to be related to the pH and hardness of the stormwater. The most significant concentrations appeared to be in states located along the Atlantic Ocean and the Gulf of Mexico.

2. Organic Priority Pollutants

Organic priority pollutants were found less frequently and at lower concentrations than heavy metals. These pollutants were primarily pesticides (including compounds which are no longer available for non-licensed use, such as chlordane).

3. Coliform Bacteria

Coliform bacteria sources appeared to be leaking septic systems, connections of sanitary sewers to storm drains, and sanitary sewer overflows.

Significant concentrations were observed in eastern, southern, and midwestern states during warm weather storm periods.

No long-term receiving water quality problems were observed, possibly due to dilution or high die-off rates.

4. Nutrients

Urban stormwater runoff discharges generally contained fewer nutrients and oxygen-demanding substances than treated wastewater discharges which have been permitted by EPA for continuous discharge throughout the year.

Nutrients (primarily phosphorous) appeared to cause eutrophication problems in lakes, but not in rivers or streams.

5. Suspended Solids

Unlike sanitary wastewater, stormwater suspended solids are primarily soils and refuse.

6. Groundwater Quality

Groundwater quality under stormwater recharge areas does not appear to be impacted by stormwater quality.

7. Stormwater Quality Management Facilities

Detention basins, grass swales, recharge basins, and wetlands appear to reduce flow, solids, nutrients, and metals.

TABLE 2
SUMMARY OF RECOMMENDATIONS OF THE NATIONAL URBAN RUNOFF PROGRAM STUDIES

1. Recommendations

Find and disconnect illicit connections of sanitary sewers and industrial discharges to storm drains.

Find and correct sanitary sewer overflows into storm drains.

Develop high-priority programs to control CSO discharges.

EPA should evaluate and develop wet weather standards (that may be different than point source year-round standards) to reflect local aquatic water quality criteria and the intermittent/short-duration nature of wet weather events. The NURP final report discussed the differences between high-intensity, short-duration, and high-frequency storms that occur in warm weather periods in the eastern and mid-western states as compared to the infrequent, but longer duration storms that occur in during winter months in western states.

EPA should determine the local site-dependent "synergy" of pH, temperature, and water quality to develop local water quality standards.

2. Suggestions for Further Studies

Evaluate receiving water quality issues, instead of end-of-pipe water quality, including fate, transport mechanisms, and accumulation issues.

Determine the relationship between pH and heavy metal concentrations in stormwater flows.

Evaluate industrial site stormwater runoff which may have higher pollutant concentrations than runoff from residential and commercial areas.

Evaluate the impacts of higher flows, erosion, and scour which have higher receiving water impacts than urban stormwater runoff.

EPA should develop guidance documents for stormwater quality controls.

Evaluate coliform bacteria sources to determine if high bacterial concentrations are indicative of urban stormwater runoff problems or sanitary sewer problems (including leaking septic systems).

TABLE 3
UPDATE OF EPA CASE STUDIES OF STORMWATER RUNOFF PROBLEMS

<u>Case Study Location</u>	<u>Major Pollution Sources</u>	<u>Recommended Program</u>	<u>Comments (a)</u>
Duwamish River, Washington	Metals from Wastewater Treatment Plants with NPDES permits and Hazardous Waste Sites	Implemented Programs for Treatment Plant Compliance and Hazardous Waste Site Cleanup	Cleanup Programs in Accordance with Industrial Treatment and Hazardous Waste Programs; Not an Urban Stormwater Runoff Problem
South San Francisco Bay, California	Metals from fuel, industrial site discharges, and natural sources (including mercury and iron ores)	Implemented Stringent Industrial Permitting Program and Fuel Station Monitoring Program	Cleanup Programs in Accordance with Industrial Discharge and Treatment Programs; Not an Urban Stormwater Runoff Problem
Westport River, Massachusetts	Bacteria from Dairies and Rural Roads	Runoff Containment Programs for Dairies	Not an Urban Stormwater Runoff Problem
Occoquan Reservoir, Virginia	Nutrients from Agricultural Areas and Forests and from Discharges of 13 Wastewater Treatment Plant Outfalls	Implemented Erosion Controls; and Conveyed Wastewater to 1 Treatment Plant that Provided Tertiary Treatment to Remove Nutrients	Not an Urban Stormwater Runoff Problem
Milwaukee, Wisconsin	Combined Sewer Overflows and Discharges from Wastewater Treatment Plants that Exceeded NPDES Limits	Separated storm drains and sanitary sewers; and Mandated Compliance with NPDES permits	Not an Urban Stormwater Runoff Problem
Kelsey and Bear Creeks, Washington	Sediment and Erosion from Exposed Soils	Local Erosion and Flow Controls	Problem due to Habitat Modification; Could be Associated with Urban Stormwater Runoff Problems
Rouge River, Michigan and Long Island Sound, New York	Combined Sewer Overflows	Ongoing studies	Not an Urban Stormwater Runoff Problem

Note: (a) "Urban Runoff" is defined as Stormwater Runoff from Residential and Commercial areas, only.

GLOSSARY

APWA	American Public Works Association
CSO	Combined Sewer Overflow Systems
CWMCUA	Committee on Wastewater Management for Coastal Urban Areas
EPA	U.S. Environmental Protection Agency
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
NSF	National Science Foundation
NURP	National Urban Runoff Program
ORD	Office of Research and Development
WCOG	Washington Council of Governments
WPCF	Water Pollution Control Federation

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