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Evaluation of Wet Weather Design Standards for Controlling Pollution from Combined Sewer Overflows

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EVALUATION OF WET WEATHER DESIGN STANDARDS FOR CONTROLLING POLLUTION FROM COMBINED SEWER OVERFLOWS

Final Report

Water Policy Branch
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INTRODUCTION

As Congress begins to consider reauthorization of the Clean Water Act, it is expected to focus considerable attention on the problem of combined sewer overflows (CSOs). Despite progress under the Act in reducing pollution from other point sources, pollution from CSOs continues to impair water quality and habitat nationwide. Hearings on proposals to address this problem, including significantly strengthening the Act's CSO control requirements, have recently been held. In conjunction with these hearings, the Environmental Protection Agency (EPA) is reevaluating its CSO control strategy and exploring a range of options for reducing CSO pollution.

Among the alternatives for reducing CSO pollution are several proposals to mandate a uniform national technology-based standard for all municipal combined sewer systems (CSSs). A common element of many of these proposals is a requirement that all CSSs provide sufficient storage and/or treatment capacity to prevent the discharge of untreated wastewater under most wet weather conditions. There are several ways to express such a standard, each of which has particular advantages and disadvantages. To date, however, these options have not been well defined and explored, and the debate has been clouded by confusion over basic data and technical concepts.

PURPOSE AND FINDINGS

The purpose of this report is twofold. Its first objective is to provide basic information on the number, location, and other characteristics of CSSs, to describe in general terms the adverse impacts of CSOs, and to summarize the current regulatory status of CSOs. Its findings in this regard include the following:

- There are approximately 1,100 CSSs nationwide, the majority of which are located in the Northeast and Great Lakes regions. Approximately 84 percent of the systems are located in EPA Regions 1, 2, 3, and 5.

- Approximately 62 percent of combined sewer systems serve 10,000 people or less. Only seven percent of the systems serve populations greater than 100,000. These large systems, however, account for 70 percent of the approximately 43 million people served by CSSs.

- According to States' 1990 water quality assessments, CSOs are known to contribute to the inability of 503 square miles of estuary and 132 shore-miles of coastal waters to meet designated uses. In addition, CSOs contribute to water quality violations in the Great Lakes (93 shore-miles impaired), other freshwater lakes (21,360 lake-acres impaired) and rivers and streams (5,163 river-miles impaired).

- According to the National Oceanic and Atmospheric Administration (NOAA), CSOs are a major source of pollutants that adversely affect shellfish beds, contributing to prohibitions, conditions or restrictions on 597 thousand acres of shellfish harvesting areas. CSOs also contribute to fish kills and are a principal cause of beach closures.

The report's second objective is to help illuminate the debate over CSO control by (1) defining alternative regulatory approaches for setting a wet weather design standard, (2) examining relationships between the different standards, and (3) evaluating the potential advantages and disadvantages of each approach. To address this goal, the report first describes CSO design standards developed by several states, focusing in particular on the rationale each state has employed in formulating regulations, policies, or permits for CSO control. It then discusses design storm concepts, the collection and maintenance of rainfall data, and the use of such data in analyzing the characteristics of storm events. Finally, it describes and evaluates the following approaches to establishing a CSO wet weather standard, each of which has been employed in at least one state:

(1) Basing the standard on a frequency/duration design storm (e.g., the 1-year/6-hour storm);

(2) Basing the standard on a rainfall depth/duration design storm (e.g., a 2.5-inch/24-hour storm);

(3) Requiring control of wet weather discharges up to some multiple of dry weather flow, such as a factor of 10 (the "10X" standard); and

(4) Specifying a direct limit on the frequency of CSO discharges (e.g., two overflows per year).

The evaluation of these approaches identifies underlying factors that are likely to influence the advantages and disadvantages of each, and uses these insights to describe how the implications of each approach are likely to vary for different regions or different types of systems. The evaluation also compares the ease of implementing and enforcing the alternatives. Its principal conclusions are as follows.

Administratively, the four alternatives analyzed are quite similar. Each would be implemented and enforced as a design standard. Each would require detailed study to demonstrate compliance, although the analysis needed to demonstrate compliance with an overflow frequency limit might prove more complex and statistically sophisticated than that required under the other approaches. Because CSO projects in general already rely on detailed facility plans, these requirements seem unlikely to pose a significantly greater analytic burden on CSO permittees. The implementation of a uniform national standard, however, is likely to increase the degree of regulatory oversight exercised by the States and EPA. To date, oversight of the recommendations proposed by permittees in facilities plans has been very limited, and in the absence of specific guidance or design criteria the CSO controls adopted have varied greatly. Implementation of a uniform national standard for CSOs would ensure greater consistency in CSO abatement, but would require EPA and state regulators to devote substantial time to review facility plans, request changes, and certify compliance.

Operationally, the four regulatory approaches evaluated fall into two general categories. The first category consists of alternatives that would consistently limit the frequency of overflows across systems regardless of likely differences in compliance costs; it includes a frequency/duration design storm or an overflow frequency limit. The second category consists of alternatives that would require comparable wet weather storage and treatment capacity for systems that are otherwise similar but, because of differences in rainfall and/or runoff, might differ markedly with respect to the frequency of overflows. It includes approaches that would specify a depth/duration design storm or set control requirements based on a factor of dry weather flow. Thus, these two categories reflect fundamentally different means of defining a "uniform" wet weather design standard. The first would set a standard that aims to achieve uniform performance, as measured by the frequency of untreated overflows. The second would set a standard that tends to equalize control capacity and, hence, compliance costs, regardless of resulting differences in the frequency with which untreated discharges would occur.

Ultimately, the choice need not be limited to the four options this report describes. One alternative is to continue to rely on best professional judgment to establish technology-based requirements for CSOs on a permit-by-permit basis. While this approach to date has not satisfactorily addressed the CSO problem nationwide, EPA's renewed efforts under the National CSO Strategy suggest that progress will be made. Another alternative -- albeit inconsistent with the standard NPDES approach of the Clean Water Act -- would be to forego a technology-based standard entirely, and instead tailor CSO permit requirements on a case-by-case basis according to the level of control needed to comply with water quality standards. In theory, this approach would offer the greatest economic efficiency in achieving water quality goals. In practice, however, setting CSO control standards based solely on water quality requirements has proved to be quite difficult, and the lack of a technology-based requirement for CSOs has been and remains a major factor in making their regulation complicated and their abatement elusive. Moreover, it is likely to be administratively infeasible to set water quality-based permit limits for each of the thousands of combined sewer outfalls nationwide. In light of these concerns, the establishment of a state or national technology-based standard that relates to water quality goals could prove to be essential to timely progress.

Should Congress or EPA determine that it is necessary to set a design standard for CSOs, the issue remains how best to balance cost, administrative feasibility and other concerns against environmental goals. One means of doing so would be to consider a targeted, risk-based approach that combines aspects of the alternatives described above. For example, the stringency of the design standard might be linked to the aquatic resources affected by CSOs: discharges to high priority or high use waters (e.g., discharges that damage a shellfish bed or swimming beach) could be prohibited, while discharges to lower priority waters could be held to a non-zero overflow frequency limit. Such a combined approach might prove a viable means of establishing a technology-based standard without (1) ignoring situations in which the cost of meeting that standard is disproportionately high relative to water quality benefits, or (2) imposing similar treatment requirements regardless of need. Such targeted flexibility could help make a technology-based standard for CSOs more efficient, equitable, and affordable.

INTRODUCTION AND BACKGROUND INFORMATION ON CSO ISSUES

CHAPTER 1

INTRODUCTION

As Congress begins to consider reauthorization of the Clean Water Act, it is expected to focus considerable attention on the problem of combined sewer overflows (CSOs). Despite progress under the Act in reducing pollution from other point sources, pollution from CSOs continues to impair water quality and habitat nationwide. Hearings on proposals to address this problem, including significantly strengthening the Act's CSO control requirements, have recently been held. In conjunction with these hearings, the Environmental Protection Agency (EPA) is reevaluating its CSO control strategy and exploring a range of options for reducing CSO pollution.

Among the alternatives for reducing CSO pollution are several proposals to mandate a uniform national technology-based standard for all municipal combined sewer systems (CSSs). A common element of many of these proposals is a requirement that all CSSs provide sufficient storage and/or treatment capacity to prevent the discharge of untreated wastewater under most wet weather conditions.[1] There are several ways to express such a standard, each of which has particular advantages and disadvantages. To date, however, these options have not been well defined and explored, and the debate has been clouded by confusion over basic data and technical concepts.

PURPOSE AND FINDINGS

The purpose of this report is twofold. Its first objective is to provide basic information on the number, location, and other characteristics of CSSs, to describe in general terms the adverse impacts of CSOs, and to summarize the current regulatory status of CSOs. Its findings in this regard include the following:

- There are approximately 1,100 CSSs nationwide, the majority of which are located in the Northeast and Great Lakes regions.

[1] For example, one proposal would require municipalities to treat all wet weather flows up to and including that associated with the one-year/six-hour storm.

Approximately 84 percent of the systems are located in EPA Regions 1, 2, 3, and 5.

- o Approximately 62 percent of combined sewer systems serve 10,000 people or less. Only seven percent of the systems serve populations greater than 100,000. These large systems, however, account for 70 percent of the approximately 43 million people served by CSSs.

- o According to States' 1990 water quality assessments, CSOs are known to contribute to the inability of 503 square miles of estuary and 132 shore-miles of coastal waters to meet designated uses. In addition, CSOs contribute to water quality violations in the Great Lakes (93 shore-miles impaired), other freshwater lakes (21,360 lake-acres impaired) and rivers and streams (5,163 river-miles impaired).

- o According to the National Oceanic and Atmospheric Administration (NOAA), CSOs are a major source of pollutants that adversely affect shellfish beds, contributing to prohibitions, conditions or restrictions on 597 thousand acres of shellfish harvesting areas. CSOs also contribute to fish kills and are a principal cause of beach closures.

The report's second objective is to help illuminate the debate over CSO control by (1) defining alternative regulatory approaches for setting a wet weather design standard, (2) examining relationships between the different standards, and (3) evaluating the potential advantages and disadvantages of each approach. To address this goal, the report first describes CSO design standards developed by several states, focusing in particular on the rationale each state has employed in formulating regulations, policies, or permits for CSO control. It then discusses design storm concepts, the collection and maintenance of rainfall data, and the use of such data in analyzing the characteristics of storm events. Finally, it describes and evaluates the following approaches to establishing a CSO wet weather standard, each of which has been employed in at least one state:

(1) Basing the standard on a frequency/duration design storm (e.g., the 1-year/6-hour storm);

(2) Basing the standard on a rainfall depth/duration design storm (e.g., a 2.5-inch/24-hour storm);

(3) Requiring control of wet weather discharges up to some multiple of dry weather flow, such as a factor of 10 (the "10X" standard); and

(4) Specifying a direct limit on the frequency of CSO discharges (e.g., two overflows per year).

The evaluation of these approaches identifies underlying factors that are likely to influence the advantages and disadvantages of each, and uses these insights to describe how the implications of each approach are likely to vary for different regions or different types of systems. The evaluation also compares the ease of implementing and enforcing the alternatives. The evaluation concludes that:

- As design standards, implementation and enforcement of the four approaches analyzed would be quite similar. Each would require detailed advanced study to demonstrate that any planned improvements would comply with the national standard. Because CSO projects in general already rely on detailed facilities plans, these requirements seem unlikely to impose a significantly greater analytic burden on CSO permittees. EPA and State regulators, however, would need to exercise additional regulatory oversight to ensure compliance with a national standard.

- Operationally, both a frequency/duration design storm and an overflow frequency limit could lead to significant inter-regional variation in compliance costs, due to underlying variation in rainfall conditions; however, the level of control achieved, as measured by the frequency of uncontrolled overflows, would be relatively uniform across systems.

- In contrast, a depth/duration design storm or a factor of flow approach would impose relatively similar costs on similar systems, regardless of underlying differences in regional rainfall; however, the frequency of uncontrolled overflows across systems could vary considerably.

To balance cost concerns against environmental goals, regulatory authorities may wish to consider a targeted approach that combines certain aspects of the alternatives analyzed. Such an approach could provide flexibility in the wet weather standard to take into account situations in which the cost of meeting the standard is extraordinarily high; for example, less stringent overflow frequency limits might be set for small communities or for systems whose compliance costs exceed a certain threshold, provided that the anticipated overflows would not impair the designated uses of the receiving waters. Conversely, the stringency of the wet weather standard might be linked to the aquatic resources affected by CSOs: discharges to high priority or high use waters (e.g., discharges that would damage a shellfish bed or recreational beach) could be prohibited, while discharges to lower priority waters could be held to a non-zero overflow frequency limit. Such an approach might prove a viable means of establishing a national wet weather control standard whose costs are proportional to resulting water quality benefits.

ORGANIZATION

The remainder of this chapter provides background information on CSO issues. It first discusses the number, location, and other general characteristics of CSSs. It then describes the adverse impacts of CSOs, outlines EPA's CSO strategy and elaborates on legislative efforts to date to strengthen CSO controls. Subsequent chapters are organized as follows:

- **Chapter 2** describes the CSO design standards developed and used by several states to control CSO discharges.

- **Chapter 3** discusses design storm concepts, the collection and maintenance of rainfall data, and the use of such data to analyze the characteristics of storm events.

- **Chapter 4** describes and evaluates the four alternative CSO wet weather design standards listed above.

NUMBER, LOCATION, AND OTHER GENERAL INFORMATION ON COMBINED SEWER SYSTEMS

There are approximately 1,100 combined sewer systems nationwide, serving a population of some 43 million. These systems, most of which are located in the Northeast and Midwest, carry sanitary sewage, industrial process wastes and storm water runoff to a publicly owned treatment works (POTW) prior to discharge to receiving waters. During a storm, a system's interceptor sewers collect runoff and channel it to the POTW for treatment. In many systems, however, storm flow frequently exceeds the capacity of the interceptors and/or the POTW. To prevent overloading the system -- which could lead to backup and flooding or interference with POTW operations -- built-in regulators direct the excess flow to overflow points for discharge. The discharge from these outfalls consists of an untreated mixture of sanitary sewage, industrial wastewater, and storm water runoff.

The following discussion of CSS characteristics draws primarily on the published results of the 1980 Needs Survey and on a database containing disaggregated 1980 Survey data, which was provided to us by the Office of Wastewater Enforcement and Compliance (OWEC).[2] Because the supplementary database contains the preliminary results of the 1980 Needs Survey, not its final results, there are some discrepancies between the database and the published findings. For example, the final report for the 1980 Needs Survey indicates that there are 1,118 combined sewer systems nationwide. In contrast, the supplementary database consists of 1,191 records, each containing information on a sewage system that has at least some combined sanitary and storm drainage. While we have no information that explains or resolves these discrepancies, we believe that the published data are more reliable.[3] We therefore employ the published data whenever possible, using it to describe the number of CSS facilities in each state; the populations served by CSSs in each state; and the primary receiving water (PRW) class for CSS discharges. All other information from 1980 is drawn from the supplementary database. Appendix A lists, by state and municipality, each of the combined sewer systems identified in the supplementary database, along with additional information on each community's population, the populations reported to be served by the CSS, and the primary body of water to which the system discharges.

The degree to which the 1980 data are representative of current conditions is unknown. More current information would clearly be preferable, but little exists beyond more current counts

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[2] This database is an interim product of an ongoing Agency effort to create a comprehensive database on combined sewer systems.

[3] It is likely that the information presented in the published report underwent additional review and quality control. Many of the records in the supplementary database are incomplete. In addition, the database appears to contain a small number of typographical errors.

of CSSs. That information suggests that at least in this respect, the 1980 data are reasonably representative of conditions today.

Location of the Systems and Population Served

Exhibit 1-1 summarizes 1980 Needs Survey data on the distribution of CSSs and the populations they serve by state and EPA Region. Exhibits 1-2, 1-3 and 1-4 present this information graphically. As these exhibits show, the northeast and midwest report the greatest number of CSSs. Of the 1,118 systems reported in the 1980 Needs Survey, 941 (84 percent) are located in EPA Regions 1, 2, 3, and 5.

The number of people served by CSSs is even more heavily concentrated in these Regions. The 1980 data indicate that over 36.6 million (86 percent) of the 42.4 million people served by CSSs live in Regions 1,2,3, and 5. Note that although Region 2 ranks fourth in number of systems, it ranks second in population served, reflecting the high concentration of large, urban systems in the Region.[4]

Exhibit 1-4 indicates the percentage of each state's population served by CSSs.[5] Again, the midwest and northeast show the greatest reliance on CSSs.

Number of Outfalls

While the supplementary database for the 1980 Needs Survey includes information on the number of outfalls associated with combined sewer systems, this information is so sporadically reported that tabulations based upon it would likely be unreliable.[6] EPA's 1992 summary of the status of State CSO Strategies, however, provides information on the number of CSO discharge points in each state and region. Exhibit 1-5 presents this information. As the exhibit shows, the status report indicates that there are at least 10,770 combined sewer outfalls nationwide. Over 92 percent of these outfalls are located in Regions 1, 2, 3, and 5. The data contained in the report also

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[4] As shown in Appendix A, the population served by a municipality's combined sewer is frequently less than the total municipal population. In other cases the population served by CSSs exceeds the municipal population, suggesting that the system serves parts of other communities or unincorporated areas beyond the primary municipality's boundaries. Depending upon the methods used to finance sewer system improvements, this may suggest a broader funding base than the population served by CSOs would indicate.

[5] In creating Exhibit 1-4, we obtained data on state populations from the 1980 Census. The 1980 Needs Survey reports similar information, but relies on 1979 population estimates. The small difference in population statistics does not affect the general results.

[6] The 1980 database also reports that a single system in Sandusky, Ohio has more than 50,000 discharge points. If this information were correct, this single system would account for roughly five times as many discharge points as all other systems combined. In light of this discrepancy, we assume the entry is a typographical error.

suggest that the average number of outfalls per CSS nationwide is ten, but are insufficient to characterize the distribution of CSSs by the number of discharge points. The averages calculated for each state, however, suggest that systems are likely to vary significantly in this regard. The sole CSS in South Dakota, for example, reports only two discharge points; in contrast, the Washington, DC system reports 55.[7]

Drainage Area Served

Exhibit 1-6 shows the distribution of CSSs by the area they drain, according to the 1980 supplementary database. The exhibit shows that most of the systems contained in the database drain less than 1,000 acres. Conversely, approximately 5 percent of the systems drain an area greater than 10,000 acres.

Population Served

Exhibit 1-7 shows the distribution of CSSs in the supplementary database by population served.[8] The distribution ranges widely, from 19 (Rice Lake, WI) to close to 2½ million (W-SW Chicago, IL). Most facilities, however, serve between 1,000 and 50,000 customers.[9]

Using the 1980 data, we have grouped CSSs into three classes based on the number of people served -- under 10,000 (small); 10,000 to 100,000 (medium); and over 100,000 (large). Exhibit 1-8 shows the number of systems in each class, while Exhibit 1-9 shows the total number of people served by systems in each class. Despite there being many more small systems than large (62.1 percent vs. 6.7 percent), the larger systems serve far more people (69.9 percent vs. 5.1 percent).

Urban vs. Rural

According to the 1980 data, under one-third (29.1 percent) of CSSs are located in areas classified as urban by the U.S. Bureau of the Census (Exhibit 1-10).[10] Urban CSSs, however, serve

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[7] For consistency's sake, the averages reported in Exhibit 1-5 were calculated using the 1992 report's data on the number of CSSs in each state. As noted previously, these data differ slightly from the 1980 data.

[8] Population served by CSS was reported for 1,145 of the 1,191 systems in the database.

[9] It is important to note that the database reports information by facility, not sewage authority. Thus, facilities operated by the same authority are reported separately; the New York City system, for example, is listed as ten separate facilities. As a result, Exhibit 1-7 suggests a slightly different size distribution than would data reported by authority.

[10] The criteria for classification as an urban area are:

84.0 percent of the national CSS population (Exhibit 1-11). Due to the higher percentage of impervious surface in urban areas, these systems may be more susceptible to overflows.

Receiving Water for CSS Discharges

The primary receiving water (PRW) for CSS discharges was recorded in the 1980 Needs Survey for 918 (82.1 percent) of the 1,118 systems. PRW designations are based on EPA classifications detailed in the Survey. As shown in Exhibit 1-12, the majority of systems discharge into streams (45.3 percent) or rivers (26.2 percent). Smaller percentages discharge to estuaries (5.4 percent), lakes (3.8 percent), or oceans (1.3 percent).

It is important to note that the data on primary receiving waters do not necessarily represent the distribution of receiving waters that CSOs affect. It is possible, for example, that discharges to a river or stream may adversely affect an estuary downstream. As a result, these data probably understate the potential effects of CSOs on downstream lakes, estuaries and coastal waters.

ADVERSE IMPACTS OF CSO DISCHARGES

Pollution from combined sewer overflows can pose health risks, degrade the ecology of receiving waters, and impair the beneficial use of water resources. The following discussion describes the pollutants associated with CSOs. It then summarizes data on the extent to which CSOs impair water quality, force beach closures, and contribute to limits on shellfishing. Finally, it discusses the adverse health effects that may be caused by CSO discharges.

Pollutants from Combined Sewer Overflows

Combined sewer overflows discharge a mixture of domestic sewage, industrial wastewater, and stormwater runoff. Included in these flows are pathogens associated with human and animal fecal material, oxygen-demanding pollutants that deplete the concentration of dissolved oxygen in the aquatic environment, suspended solids that increase turbidity and damage benthic communities, nutrients that cause eutrophication, toxics that may persist and bioaccumulate through the food web, and floatable litter that may both harm aquatic fauna and become a health and aesthetic nuisance to swimmers and boaters. In addition, high peak volumes of CSO discharges can cause a variety of adverse impacts on surface water hydrology and the viability of aquatic habitats. The following discussion briefly outlines the health or environmental concerns associated with CSO discharges.

- A central city with a population of at least 50,000, or twin cities with a combined population of at least 50,000, with the smaller of the twin cities having at least 15,000 inhabitants.

- Closely settled surrounding territory, meeting specific criteria outlined in the Needs Survey.

Pathogens

Discharges from combined sewer systems include human and animal fecal wastes from sanitary sewers and urban runoff that may contain pathogens. Any pathogens that live in the human intestinal system may cause illness or disease through inadvertent ingestion of contaminated waters during swimming or other recreational activities, or via ingestion of contaminated seafood. These pathogens include viruses, bacteria, and protozoa that cause a wide range of diseases and illnesses. Viruses are believed to account for many water-borne diseases, including gastroenteritis, poliomyelitis, infectious hepatitis, and other gastrointestinal infections. Bacterial diseases, such as cholera and typhoid fever, and parasitic diseases, such as amoebic dysentery and parasitic diarrhea, can also be transmitted by direct or indirect contact with untreated discharges.

Biological and Chemical Oxygen Demand

The domestic and industrial wastewaters and urban runoff discharged by CSOs may also contain high concentrations of oxygen-demanding substances. Domestic sewage and urban runoff include human and animal wastes that consume oxygen through organic decomposition. Industrial wastewaters that contain organic materials also consume oxygen as these materials oxidize.

When discharged in large quantities, as may occur during overflow events, oxygen-demanding pollutants can cause oxygen sags in receiving waters, posing the risk of fish kills. These pollutants can also exacerbate eutrophication and pose aesthetic problems, such as unpleasant odors. These conditions may persist for short periods of time, but recur as storm events cause combined sewers to overflow.

Suspended Solids

A wide variety of solids find their way into domestic and industrial wastewaters, which, when combined with sediments from urban runoff, may result in high CSO loadings of suspended solids. Sedimentation alters aquatic environments primarily by increasing turbidity. Increased turbidity impairs the ability of aquatic organisms to obtain dissolved oxygen from the water by interfering with gill movement and water circulation. In addition, turbidity inhibits the penetration of light, greatly reducing plant production. Sedimentation also changes heat radiation and, by blanketing stream bottoms, can smother or otherwise create unfavorable conditions for benthic organisms.[11]

Other effects of sedimentation include the accumulation and resuspension of pollutants. Many toxic substances are attached to suspended solids and settle out and accumulate in bottom sediments. Some substances are broken down in sediments, but others are retained for many years and continue to serve as a source of toxics to the water body and to aquatic organisms.[12] These

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[11] Novotny, V. and G. Chesters, Handbook of Nonpoint Pollution Sources and Management, New York: Van Nostrand Reinhold Company, 1981.

[12] U.S. Environmental Protection Agency, National Water Quality Inventory, 1988: Report to Congress, Office of Water, EPA 440-4-90-003, 1990.

pollutants may be released as sediments are resuspended during periods of high flow and local scour, further affecting aquatic life. In addition, many navigational waterways must be continually dredged to remove accumulated sediments. This process causes additional water quality and aquatic life impacts as sediments and their associated pollutants are resuspended.[13]

Nutrients

Combined sewers contribute to overall loadings of nutrients (nitrogen and phosphorus), which are the main cause of eutrophication -- an alteration of ecology characterized by excessive growth of aquatic weeds and algae. The growth of aquatic vegetation requires both nutrients; in fresh water, however, plant growth typically is controlled by phosphorus input, while in marine waters, plant growth typically is controlled by nitrogen input. In either case, addition of the controlling pollutant results in greater plant growth.

Eutrophication is of particular concern in lakes, estuaries and slow-moving rivers. In addition to the obvious aesthetic problems associated with algae blooms and excessive plant growth, eutrophication typically reduces dissolved oxygen levels, raises water temperatures, and reduces the amount of light that reaches plant communities, altering the aquatic environment and threatening its ability to support sensitive species. Under certain conditions the decay of plant material associated with eutrophication can significantly deplete oxygen levels, leading to fish kills and the loss of benthic communities.[14]

Toxics

Municipal sewage systems receive toxics discharged by both domestic and industrial users. Industry typically accounts for the largest percentage of organic and inorganic toxics. Pretreatment standards limit the amount of toxics that can be discharged into municipal sewer systems, but urban areas typically generate large quantities of toxic effluents, including a wide variety of metals, such as mercury, lead, copper, chromium, and nickel, and organics from industrial and chemical process waters. Stormwater runoff also contains metals, lawn herbicides, and other pollutants that contribute to CSO discharges of toxic substances.

The discharge of toxic substances in toxic amounts poses an immediate threat to aquatic environments. Moreover, some toxics, such as metals and PCBs, persist in sediments for an extended time and bioaccumulate in higher predators, such as game fish. Ultimately, the bioaccumulation of toxics may require the closure of fishing and shellfishing areas or the issuance of health advisories that recommend limiting consumption of fish and shellfish from contaminated waters.

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[13] Novotny and Chesters, op. cit.

[14] U.S. Environmental Protection Agency, Report to Congress to Identify Stormwater Discharges and Determine the Nature and Extent of Pollutants in Stormwater Discharges, Office of Water, October 1, 1989 (Draft).

Floatables and Plastics

Litter and plastics found on land, if not removed, eventually are flushed, blown or swept down storm sewers, where they may be discharged along with sewage effluents in combined sewer overflows. Such pollutants degrade slowly, increasing the amount of time they remain in receiving waters. These conventional pollutants degrade the aesthetic quality of receiving waters, limiting recreational uses and damaging property values. In addition, wildlife is threatened by ingestion of or entanglement in plastic debris.

The amount of floatables that wash up on beaches in the Northeast has increased greatly over the last decade. The problem is attributed to CSOs, the ocean disposal of solid wastes, and other sources. It has become sufficiently severe in the New York City area that New York and New Jersey have developed a floatables action plan that includes tracking debris slicks in the New York/New Jersey harbor area, harvesting debris with nets, and notifying beach operators of the impending landfall of debris slicks.[15]

Temperature

Combined sewer discharges during warmer seasons generally have higher temperatures than receiving waters, and therefore raise water temperatures. In addition, discharges from storm water management devices that impound effluents in unshaded areas for long time periods can increase receiving water temperature. Increased temperature has both direct and indirect detrimental effects on fish. For example, some cold water fish species and stream insects are fatally affected by sustained water temperatures greater than 70 degrees. Indirectly, warmer water holds less oxygen, affecting habitat and increasing the risks associated with the discharge of oxygen demanding substances.

Hydrological or Habitat Modification

High peak volumes of CSO discharges -- which include storm water runoff -- can have a variety of adverse impacts on surface water hydrology and the viability of aquatic habitats. High volumes of discharge can cause stream scouring, which degrades aquatic and riparian habitat, widens stream channels, and increases erosion.

The Impact of CSOs on Water Quality

One measure of the adverse effects of CSO pollution is the extent to which CSOs contribute to the failure of receiving waters to support their designated uses. State 305(b) reports, which are submitted to EPA biennially, are the primary source of national data on this issue. These reports document State water quality assessments and indicate whether CSOs, among other sources of pollution, contribute to use impairment. They do not, however, attribute water quality problems to

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[15] U.S. Environmental Protection Agency, Region II, Assessment of the Floatables Action Plan: Summer 1989, New York, NY, December, 1989.

a single, exclusive cause, nor do they provide sufficient detail to determine the degree to which CSOs contribute to a specific cause of impairment, such as excess oxygen demand. Instead, they simply indicate whether CSOs are a major or moderate/minor cause of water quality violations. The following discussion presents this information, relying on preliminary data from the 1990 305(b) reports.[16]

Rivers and Streams

In their draft 1990 305(b) reports, 46 states indicated the degree to which 647,066 assessed river miles support designated uses.[17] The states reported that 63 percent of the assessed miles fully support such uses. Of the 177,792 impaired river miles for which detailed information on causes of impairment was available, combined sewer overflows had a major impact on 3,521 miles, and a moderate to minor impact on 1,642 miles, or 2.9 percent of the total.[18] Exhibit 1-13 summarizes this information.

Lakes

Data from the draft 1990 305(b) reports indicate that of the 18.5 million lake acres (not including Great Lakes) assessed by 46 states, about 30 percent fully support their designated uses. Causes of use impairment are reported for approximately 4 million lake acres. As shown in Exhibit 1-13, combined sewer discharges account at least in part for less than 1 percent of this total.

The draft 1990 data also indicate that only 85 of the 4,857 assessed Great Lakes shoreline miles support designated uses. This high rate of impaired use is due in large part to fish consumption restrictions in the near-shore waters of the lakes. The most extensive causes of nonsupport include synthetic organic chemicals, nutrients, and toxic contamination of sediments. Illinois, Indiana, New York, and Wisconsin identified the major sources of use impairment for 1,235 shoreline miles. As shown in Exhibit 1-13, these states reported that CSOs contributed to impairment of 93 shore miles, or 7.5 percent of those for which information on the cause of impairment is presented.

Estuaries and Coastal Waters

Of the 26,693 square miles of estuaries assessed by 20 states and the District of Columbia in the draft 1990 305(b) reports, 44 percent do not fully support designated uses. Sixteen states

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[16] The quality of the 305(b) reports can vary considerably across states. In general, most states have not assessed all waters to determine whether they support designated uses. As a result, the available data may understate the extent to which waters are impaired by CSOs or other sources.

[17] Data were not reported for Alaska, Idaho, New Jersey, or Virginia, but included the District of Columbia and Puerto Rico.

[18] Information on the cause(s) of impairment is not available in all cases.

provided information regarding the sources of use impairment. Of the 7,693 square miles impaired in these 16 states, combined sewer discharges had a major impact on 269 and a moderate to minor impact on 234, which together accounts for 6.5 percent of the total.

The draft 1990 305(b) reports contain information from twelve states that assessed water quality in coastal waters. Of the 4,230 coastal miles assessed by these states, 89 percent fully support their designated uses. Only four states (Florida, Mississippi, New Jersey, and New York) provided information regarding the sources and causes of non-attainment of designated uses in coastal waters. Of the 361 impaired miles in these 4 states, CSOs had a major impact on 12 miles and a moderate to minor impact on 120 miles, which together constitutes 36.6 percent of the total.

Exhibit 1-13 summarizes the data on use impairment in estuaries and coastal waters.

Fish Kills, Shellfishing
Restrictions, and Beach Closures

The preceding discussion offers a sense of CSOs' contributions to water quality problems nationwide. The following discussion expands upon the implications of these problems by describing, to the extent available data permit, CSOs' role as a contributing cause of fish kills, shellfishing restrictions, and beach closures.

Fish Kills

When discharged in excessive amounts, oxygen demanding pollutants like those discharged by CSOs can deplete dissolved oxygen concentrations below those required to support fish. The discharge of toxic pollutants, which may be contained in CSOs, can also cause fish kills. In EPA's 1988 National Water Quality Inventory, 38 states reported 996 fish kill incidents. Twenty-four of those states reported the number of fish killed -- a total of 36 million. Of the incidents reported, 605 were caused by conventional pollutants (primarily oxygen demanding substances), while 135 were caused by toxic pollutants. Sixteen states reported municipal facilities, which may include combined sewer overflows, as a source of fish kills. Additional information on the number or severity of such incidents, however, was not reported.[19]

Shellfishing Restrictions

Pathogens discharged by CSOs to receiving waters can contaminate shellfish. Bivalve mollusks, such as oysters, clams, and mussels, are filter feeders. These shellfish strain food and particulate matter that is carried by currents. They filter large volumes of water relative to their size, concentrating pollutants and pathogens that may be present in the water. Bacterial or viral pathogens may then be passed to humans through consumption. To protect public health, shellfish

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[19] U.S. Environmental Protection Agency, National Water Quality Inventory: 1988 Report to Congress, Office of Water, EPA 440-4-90-003, 1990.

harvest is not permitted in areas that are near potential pollution sources or that contain high levels of indicator bacteria.

Studies conducted by the National Oceanic and Atmospheric Administration indicate that discharges by combined sewers are a major source of pollutants that adversely affect shellfish harvesting areas.[20] Exhibit 1-14 shows that in 1990, 6.4 million of 18.7 million total acres of shellfish beds were harvest-limited. Combined sewer overflows contributed to prohibitions, conditions or restrictions on 597 thousand acres, or 9.4 percent of the total harvest-limited acreage.[21]

Beach Closures

Exposure to pathogens discharged by combined sewers is a potential cause of illness and disease. Recreational swimmers, boaters, and others who engage in full body contact recreation may be exposed to pathogens in fecal material that can cause a wide variety of illnesses, ranging from hepatitis to gastro-intestinal problems.

State and county health boards attempt to minimize exposures to pathogens by testing beaches and closing them or posting swimming advisories whenever concentrations of indicator bacteria exceed threshold limits. In some areas, beaches are automatically closed following a storm event, and reopened only when test results indicate that concentrations of indicator bacteria meet state or local criteria.

The presence of plastics and other floatable waste or debris, which in some cases can be traced to CSOs, may also prompt health authorities to close public beaches or issue beach advisories. The floatables problem has become particularly acute in some urban areas, particularly in the vicinity of New York City.

A recent report published by the Natural Resources Defense Council (NRDC) provides data on beach closings and advisories attributable to high counts of indicator bacteria.[22] The report covers 10 states and the years 1989 and 1990. Exhibit 1-15 summarizes the data from this study. As the exhibit shows, the report documents 1,753 days of beach closures or advisories in 1989, and 1,467 days of closures or advisories in 1990. In both years, Connecticut, New York and New Jersey account for over 70 percent of the reported days on which beach closures or advisories were in

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[20] National Oceanic and Atmospheric Administration, The 1990 National Shellfish Register of Classified Estuarine Water, U.S. Department of Commerce, Rockville, MD, July 1991.

[21] More than half of the shellfishing area reported to be limited due to CSO discharges is along the Gulf Coast. This result is surprising, since relatively few combined sewer systems serve this area. To date we have been unable to determine the explanation for this apparent discrepancy.

[22] Kassalow, Jennifer, et al., Testing the Waters: A Study of Beach Closings in Ten Coastal States, Natural Resources Defense Council, August 1991.

effect.[23] The report does not specifically link closures or advisories to CSOs or any other cause, but CSOs are implicated as an important contributor to sewage effluent loadings.

Adverse Effects on Human Health

Despite the efforts of health authorities to minimize exposures to CSO pollution, health risks remain. Pollutants from sewage overflows may affect human health through at least three exposure routes: dermal contact, inadvertent ingestion of contaminated water while swimming, and ingestion of contaminated fish and shellfish. Exposure through consumption of contaminated drinking water is also a possibility, but in most cases disinfection and other practices typically employed to treat drinking water should significantly reduce any risks attributable to pollution from CSOs.

As described above, CSOs may discharge a variety of pollutants that pose risks to human health, including heavy metals and other toxic compounds. Some of the compounds that may be discharged by CSOs are known or suspected carcinogens; others may cause kidney ailments, developmental retardation, or other problems. Many of these effects are only likely to develop after chronic exposure, but acute effects as a result of exposure to high concentrations of pollutants are also possibile. Of particular concern, however, is the bioaccumulation of toxic compounds in fish and shellfish, which can pose significant health risks. In 1988, for example, 39 states reported finding concentrations of toxic substances in fish tissue high enough to warrant fish bans or fish consumption advisories. The data, however, do not uniformly indicate whether bans or advisories were attributable to CSOs, although in one case, in Lake Champlain, they suggest that CSOs may contribute to elevated concentrations of PCBs in trout.[24] This is consistent with the general lack of information on toxics in CSOs, and with the consequent lack of information on related health risks.

The health risks associated with pathogens discharged by CSOs are also of particular concern. Disease-carrying microbes and parasites in ineffectively treated wastewater effluent can be transmitted to humans via several pathways. Transmission most commonly occurs via one of three exposure routes: (1) ingestion of aquatic food species (fish and shellfish) infected with pathogens; (2) ingestion or dermal absorption of contaminated water during recreational activities; and (3) ingestion of contaminated drinking water.

The potential for human exposure via these different pathways depends on the activity in question. For example, ingestion of pathogen-contaminated water is likely while swimming and can

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[23] The NRDC report indicates that in 1989, five New York beaches were under advisories for the entire summer; in 1990, three New York beaches were under season-long advisories. For purposes of Exhibit 1-15, we assume that each of these advisories was in effect for 90 days. Similarly, the NRDC report indicates that in 1990, one beach in Maine was under an advisory for six weeks; for Exhibit 1-15, we have converted this to 42 days.

[24] U.S. EPA, National Water Quality Inventory: 1988 Report to Congress, Office of Water, Washington, DC, April 1990, pp. 108-111. The data indicate that six states reported fishing restrictions due to urban runoff and three reported restrictions due to municipal facilities, but a separate listing for CSOs is not provided.

lead to gastroenteritis and other water-borne disease. Wading or boating results in dermal exposure and can lead to skin rashes and secondary infections of wounds.

Shellfish are especially susceptible to pathogen contamination, and the discharge of untreated sewage to shellfish harvesting areas poses a serious public health threat.[25] In contrast, the discharge of undisinfected wastewaters to surface waters used as public drinking water supplies generally does not pose significant risks, since chlorine disinfection occurs in the treatment of public water supplies. However, problems may exist in waters where pathogen levels exceed those that can be adequately treated by water supply facilities.[26] Such may be the case with CSOs.

REGULATORY AND LEGISLATIVE INITIATIVES

CSOs are point sources subject to the limitations on point source discharges set forth in the Clean Water Act. The Clean Water Act of 1977 mandated that by July 1, 1977, all point sources must meet discharge limits consistent with the Best Practicable Technology (BPT) then available. The Water Quality Act Amendments of 1987 set a deadline of March 31, 1989 for all point sources to comply with more stringent standards, based upon the best conventional pollutant control technology (BCT) and best available technology economically achievable (BAT). These technology-based requirements represent minimum standards of control; under the Act, more stringent water quality-based controls are required whenever technology-based limits are insufficient to comply with state water quality standards. The statutory deadline for compliance with water quality standards was July 1, 1977.

Action to bring CSOs into compliance with Clean Water Act requirements has lagged well behind the Act's statutory deadlines. Most communities with CSSs have not begun to implement improved CSO controls, and many have not undertaken facilities planning efforts to evaluate control strategies. Recently, both EPA and Congress have initiated efforts to redress the situation. EPA has published a national CSO control strategy, while Congress is considering several bills to strengthen existing standards and set firm schedules for CSO compliance. In response to these legislative initiatives, EPA is implementing an expedited CSO control program. The following discussion outlines these efforts, providing additional detail on both EPA and Congressional action.

The National CSO Strategy

EPA's National Combined Sewer Overflow Control Strategy, released on August 10, 1989, described for the first time EPA policies for bringing CSO discharges into compliance with the requirements of the Clean Water Act. The Strategy defined combined sewer overflows as:

> ...flows from a combined sewer in excess of the interceptor or regulator capacity that are discharged into a receiving water without going to a publicly owned treatment works (POTW). CSOs occur prior to reaching the headworks of a treatment facility

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[25] U.S. EPA, "Notice of Policy on Municipal Wastewater Disinfection," 1989.

[26] Ibid.

and are distinguished from bypasses, which are "intentional diversions of waste streams from any portion of a treatment facility" (40 CFR 122.41(m)).[27]

The Strategy affirmed that CSOs are point sources subject to National Pollution Discharge Elimination System (NPDES) permit requirements, and stipulated that all CSO discharges must be brought into compliance with the CWA's technology-based and water quality-based standards. It clarified, however, that CSOs are not subject to the secondary treatment requirements that apply to POTWs.[28]

The Strategy set forth the following objectives:

(1) To ensure that if CSO discharges occur, they are only as a result of wet weather;

(2) To bring all wet weather CSO discharge points into compliance with the technology-based requirements of the Clean Water Act and applicable State water quality standards; and

(3) To minimize water quality, aquatic biota, and human health impacts from wet weather overflows.

To achieve these goals, the Strategy called for States and Regions to develop plans that would enable them to issue NPDES permits to all CSOs. Implementation of the Strategy included:

- Identifying and categorizing the permit status of each CSO discharge point;
- Setting permitting priorities;
- Issuing permits, using system-wide permits when possible;
- Establishing compliance schedules consistent with the Clean Water Act;
- Establishing minimum technology-based requirements;
- Requiring additional control measures as needed to meet water quality standards;
- Setting compliance monitoring requirements; and
- For certain limited cases, modifying state water quality standards.

The CSO Strategy called on both States and EPA Regions to develop BPT, BCT, and BAT limits based on best professional judgment (BPJ).[29] The strategy specified the following minimum technology-based requirements for compliance with BCT/BAT:

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[27] U.S. Environmental Protection Agency, National Combined Sewer Overflow Control Strategy, August 10, 1989, p. 1.

[28] Ibid., p. 2.

[29] Ibid., p. 2.

(1) Proper operation and regular maintenance programs for the sewer system and combined sewer overflow points;

(2) Maximum use of the collection system for storage;

(3) Review and modification of pretreatment programs to assure CSO impacts are minimized;

(4) Maximization of flow to the POTW for treatment;

(5) Prohibition of dry weather overflows;[30] and

(6) Control of solid and floatable materials in CSO discharges.[31]

The Strategy also called for CSO control programs to incorporate best managment practices and other low-cost operational methods whenever possible, and to incorporate more expensive control measures only if necessary to meet water quality standards. The strategy specifically identified the following control measures that should be considered to bring wet weather CSOs into compliance: improved operation and maintenance; best management practices; system-wide storm water management programs; supplemental pretreatment program modifications; sewer ordinances; local limits program modifications; identification and elimination of illegal discharges; monitoring requirements; pollutant specific limitations; compliance schedules; flow minimization and hydraulic improvements; direct treatment of overflows; sewer rehabilitation; in-line and off-line storage; reduction of tidewater intrusion; construction of CSO controls within the sewer system or at the CSO discharge point; sewer separation; and new or modified wastewater treatment facilities.[32] If additional permit limits proved necessary to protect State water quality standards, the Strategy directed the permittee to choose the most cost-effective control measures that would ensure compliance.

EPA Headquarters oversees implementation of the National CSO Strategy. Through this oversight, EPA seeks to ensure that actions taken by the Regions and States are consistent with the National Strategy, and that the Agency as a whole makes progress toward meeting the requirements and water quality objectives of the CWA. The National Strategy required the States and Regions to develop statewide permitting strategies that are consistent with the national approach. Such strategies were to have been developed no later than January 15, 1990 and approved by the Regions

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[30] The Strategy defined dry weather flow as the flow in a combined sewer that results from domestic sewage, industrial wastes and ground water infiltration, with no contribution from storm water runoff or storm water induced infiltration. Wet weather flow was defined as a combination of sanitary flow, industrial flow, infiltration from ground water, and storm water flow, including storm water induced infiltration and snow melt.

[31] U.S. EPA, National Combined Sewer Overflow Control Strategy, August 10, 1989, p. 6.

[32] Ibid., p. 6.

no later than March 31, 1990.[33] As of January 16, 1992, 30 States (including the District of Columbia) had submitted strategies. Twenty-six of these strategies had been unconditionally approved, two had been conditionally approved, and two had yet to be approved.[34] The 21 States that have not submitted strategies are not required to do so, either because they have no combined sewer systems or because they report no overflows from such systems. Exhibit 1-16 summarizes the status of state CSO strategies for each state.

Proposed Legislation

While EPA's National CSO Strategy promised progress in resolving the CSO problem, several members of Congress have remained concerned that legislative action is needed to ensure adequate and consistent efforts to control CSOs nationwide. In 1990, Senators Mitchell (ME), D'Amato (NY), Moynihan (NY), Bradley (NJ), Lautenberg (NJ), Chaffee (RI), and Pell (RI) sponsored the Coastal Protection Act (S. 1178), which contained a provision requiring the control of discharges from combined sewer overflows. Section 207 of that bill required the elimination of discharges from CSOs for all storm events up to and including the 1-year/6-hour storm. This 1990 legislation did not reach the Senate floor, but its proposed CSO control requirements have become part of subsequent proposals.

In April 1991 members of the Senate Environment and Public Works Committee introduced a Clean Water Act reauthorization bill entitled the Water Pollution Prevention and Control Act (S. 1081). Among its provisions, the bill would require municipalities to implement programs that would eliminate all CSO discharges caused by rainfall events up to a 1-year/6-hour design storm. In May 1991 the Senate Public Works Committee held hearings on this bill. The committee's majority staff is currently circulating a revised draft of the bill; this draft retains the 1-year/6-hour standard. Hearings on the revised bill are expected to be held in the spring of 1992.

Several other bills that would affect CSOs have been filed or are under development. For example, the CSO Partnership, a coalition of sewer authority interests, has developed legislation recently introduced by Congressman Olin as H.R. 3477. The bill stresses the site-specific nature of CSO problems and the need for flexibility and cost-effectiveness in implementing CSO controls. It also calls for Federal grants to fund CSO improvements, to be awarded on the basis of financial need and water quality benefit. The bill would require localities with CSOs to provide EPA and the State with information on their systems, complete a CSO study, develop a CSO control plan, file an NPDES permit application, and comply with the permit when issued. Permits would be issued in two phases. Phase 1 permits would require the elimination of dry weather overflows, proper operation and maintenance of the system to minimize wet weather overflows, maximum use of the existing system's capacity, and implementation of the study and planning requirements. Phase 2 permits would incorporate the technology-based and water quality-based requirements set forth in the bill. The bill specifies two levels of technology-based controls, and requires compliance with water quality standards as soon as possible, but specifies no deadline for compliance. The bill also

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[33] Ibid., pp. 2-3.

[34] Office of Water, U.S. Environmental Protection Agency, "Status of Strategy Approvals," January 16, 1992.

provides for the development of wet weather water quality standards, and a variance from water quality-based requirements when certain criteria are met.

A bill introduced by Congressman Manton (H.R. 2126) would require EPA, in consultation with NOAA, to issue regulations setting forth permit requirements for CSO discharges to estuarine and marine waters. In addition, the bill would prohibit EPA from issuing permits to CSOs after 1999 unless the Agency determines that the permittee has undertaken reasonable efforts to eliminate dry weather discharges and minimize wet weather discharges. The bill would also authorize EPA, as an enforceable condition of a permit, to require permittees to budget and expend funds to improve CSO control.

Senator Moynihan's staff has also developed CSO legislation. This bill, which we understand to be in draft form, would authorize, over five years, demonstration studies that would evaluate methods to address the adverse impacts of CSOs. Each study would evaluate CSO problems and impacts, the financial and economic implications of complying with water quality standards, and innovative techniques to remedy water quality concerns. These studies would in turn support the development of water quality management strategies for each area, and a Report to Congress detailing study findings and recommendations. The Moynihan bill also calls for the development, over six years, of a Federal strategy on the optimal expenditure of Federal funds to minimize the impacts of CSOs on the nation's waters. This strategy is to include an inventory of combined sewer systems, with an emphasis on regional, demographic and historical similarities and differences; an analysis of the relationship between hydrologic and hydraulic variables and pollutant loadings; a model to optimize Federal investment in CSO control infrastructure; an analysis of the costs of improving this infrastructure; and recommendations on how current water quality standards could be improved to provide more flexibility to address CSO discharges.[35]

EPA's Expedited CSO Control Program

In response to continuing concerns about inadequate and inconsistent national progress on CSO abatement, EPA has undertaken actions to accelerate the implementation of its CSO Strategy. The Office of Wastewater Enforcement and Compliance (OWEC), Office of Water, is coordinating several workgroups that are pursuing a better understanding of CSO issues and impacts, with the intention of developing an accelerated permitting and enforcement program for CSOs. This approach calls for EPA to target CSO facilities that cause the greatest harm to water quality. Targeting would occur in two phases:

- Identifying the five percent of CSSs in each Region that cause the most severe water quality impacts.

- Identifying all remaining CSSs that cause significant water quality problems, as well as those causing less severe impacts.

[35] The discussion of the Olin, Manton and Moynihan bills is taken from a series of handouts prepared for a September 9, 1991 meeting of EPA's CSO Workgroup and/or from a November, 1991 progress report on EPA's expedited CSO control plan.

Each group would be subject to CSO control requirements in a phased approach designed to bring about compliance with the National Strategy. The following are the major components of the expedited strategy:

(1) **Ensure that all CSO dischargers have enforceable permits that include the following three compliance phases**

- First, require the discharger to meet the minimum technology-based requirements of the National Strategy;
- Second, require the discharger to design and construct the facilities needed to meet the designated uses of the receiving waters; and
- Third, require the discharger to design and construct the facilities needed to fully compy with the CWA's technology- and water quality-based standards.

(2) **Provide enforcement support**

- In conjunction with permit issuance, determine which CSO facilities have insufficient permit limits, unpermitted CSOs, or CSOs in violation of permit conditions;
- For those with insufficient limits, require submission of a facilities plan to correct deficiencies, thus enabling the permit writer to modify or reissue the permit;
- For those with unpermitted CSOs or CSOs in violation of permit conditions, issue compliance orders to evaluate and address violations;
- Negotiate an enforceable schedule to implement corrections; and
- Monitor permitting and enforcement schedules for compliance.

(3) **Assess and review water quality standards and technology-based requirements**

- Review current State approaches for establishing and implementing water quality-based CSO controls, analyze current CSO control requirements, and evaluate existing flexibility to develop wet weather water quality controls;

-- Within three years, revise State standards based on the results of the above assessment; and

-- Review the National CSO Strategy's minimum technology requirements for effectiveness and appropriateness, and revise them if necessary.[36]

This approach would be similar to that taken by EPA in developing the Agency's National Municipal Policy, through which the Agency set strict deadlines and pursued sanctions against municipalities that failed to comply with sewage treatment requirements.

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[36] The description of the expedited permitting and enforcement strategy presented above is taken from a series of handouts prepared for a September 9, 1991 meeting of EPA's CSO Workgroup.

Exhibit 1-1

CSS FACILITY AND POPULATION DATA BY EPA REGION AND STATE

EPA Region	State	Number of Facilities	Percent of Total Facilities	Population Served	Percent of National CSS Population	Percent of State Population Served by CSS's
1	Connecticut	14	1.25%	415,217	0.98%	13.36%
	Maine	61	5.46%	390,776	0.92%	34.73%
	Massachusetts	34	3.04%	1,865,156	4.40%	32.51%
	New Hampshire	22	1.97%	283,156	0.67%	30.76%
	Rhode Island	2	0.18%	190,550	0.45%	20.12%
	Vermont	31	2.77%	128,312	0.30%	25.09%
	Subtotal	164	14.67%	3,273,167	7.72%	
2	New Jersey	30	2.68%	2,268,782	5.35%	30.80%
	New York	74	6.62%	9,595,263	22.62%	54.65%
	Puerto Rico	1	0.09%	600,000	1.41%	18.77%
	Subtotal	105	9.39%	12,464,045	29.38%	
3	Delaware	5	0.45%	90,068	0.21%	15.15%
	District of Columbia	1	0.09%	489,093	1.15%	76.61%
	Maryland	11	0.98%	53,886	0.13%	1.28%
	Pennsylvania	113	10.11%	4,175,996	9.84%	35.20%
	Virginia	12	1.07%	537,350	1.27%	10.05%
	West Virginia	47	4.20%	435,050	1.03%	22.31%
	Subtotal	189	16.91%	5,781,443	13.63%	
4	Florida	1	0.09%	4,370	0.01%	0.04%
	Georgia	8	0.72%	473,018	1.12%	8.66%
	Kentucky	17	1.52%	768,556	1.81%	21.00%
	North Carolina	1	0.09%	8,000	0.02%	0.14%
	Tennessee	3	0.27%	150,500	0.35%	3.28%
	Subtotal	30	2.68%	1,404,444	3.31%	
5	Illinois	117	10.47%	5,651,169	13.32%	49.45%
	Indiana	131	11.72%	2,808,981	6.62%	51.16%
	Michigan	86	7.69%	2,614,925	6.16%	28.23%
	Minnesota	17	1.52%	251,855	0.59%	6.18%
	Ohio	119	10.64%	3,133,923	7.39%	29.02%
	Wisconsin	13	1.16%	627,347	1.48%	13.33%
	Subtotal	483	43.20%	15,088,200	35.57%	
6	Texas	1	0.09%	35,000	0.08%	0.25%
	Subtotal	1	0.09%	35,000	0.08%	
7	Iowa	19	1.70%	404,264	0.95%	13.87%
	Kansas	3	0.27%	464,000	1.09%	19.63%
	Missouri	14	1.25%	874,301	2.06%	17.78%
	Nebraska	3	0.27%	199,405	0.47%	12.70%
	Subtotal	39	3.49%	1,941,970	4.58%	
8	Colorado	5	0.45%	152,341	0.36%	5.27%
	Montana	16	1.43%	130,416	0.31%	16.58%
	North Dakota	8	0.72%	34,249	0.08%	5.25%
	South Dakota	10	0.89%	90,991	0.21%	13.17%
	Utah	1	0.09%	3,818	0.01%	0.26%
	Wyoming	1	0.09%	14,645	0.03%	3.12%
	Subtotal	41	3.67%	426,460	1.01%	
9	California	5	0.45%	852,119	2.01%	3.60%
	Subtotal	5	0.45%	852,119	2.01%	
10	Alaska	2	0.18%	4,860	0.01%	1.21%
	Idaho	14	1.25%	46,012	0.11%	4.87%
	Oregon	11	0.98%	397,001	0.94%	15.08%
	Washington	34	3.04%	706,821	1.67%	17.10%
	Subtotal	61	5.46%	1,154,694	2.72%	
	TOTAL	1118	100.00%	42,421,542	100.00%	

Sources: 1980 Needs Survey
1980 Census

Exhibit 1-2

DISTRIBUTION OF COMBINED SEWER SYSTEMS BY EPA REGION

1980 NEEDS SURVEY

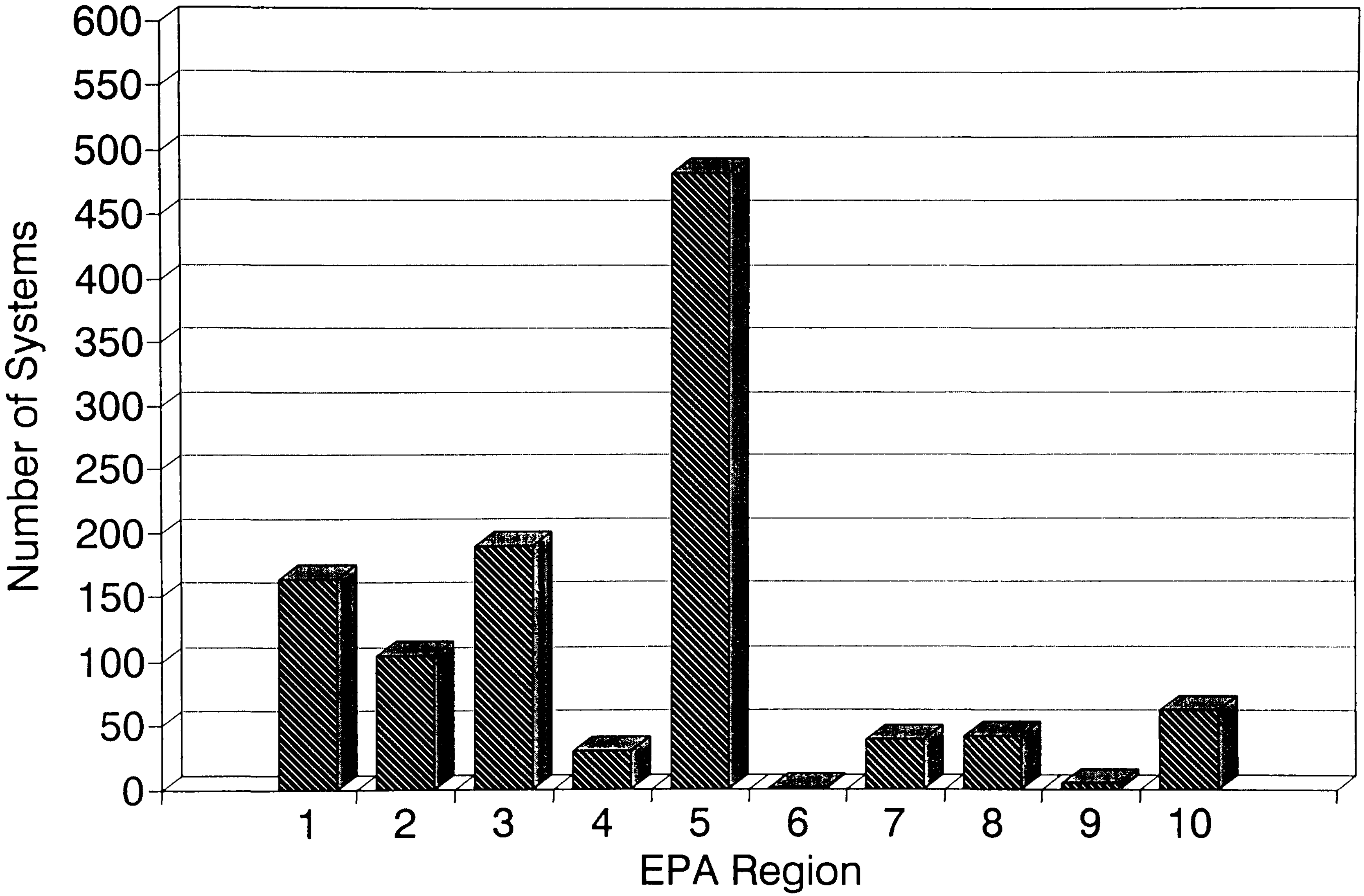


Exhibit 1-3

POPULATION SERVED BY COMBINED SEWER SYSTEMS BY EPA REGION

1980 NEEDS SURVEY

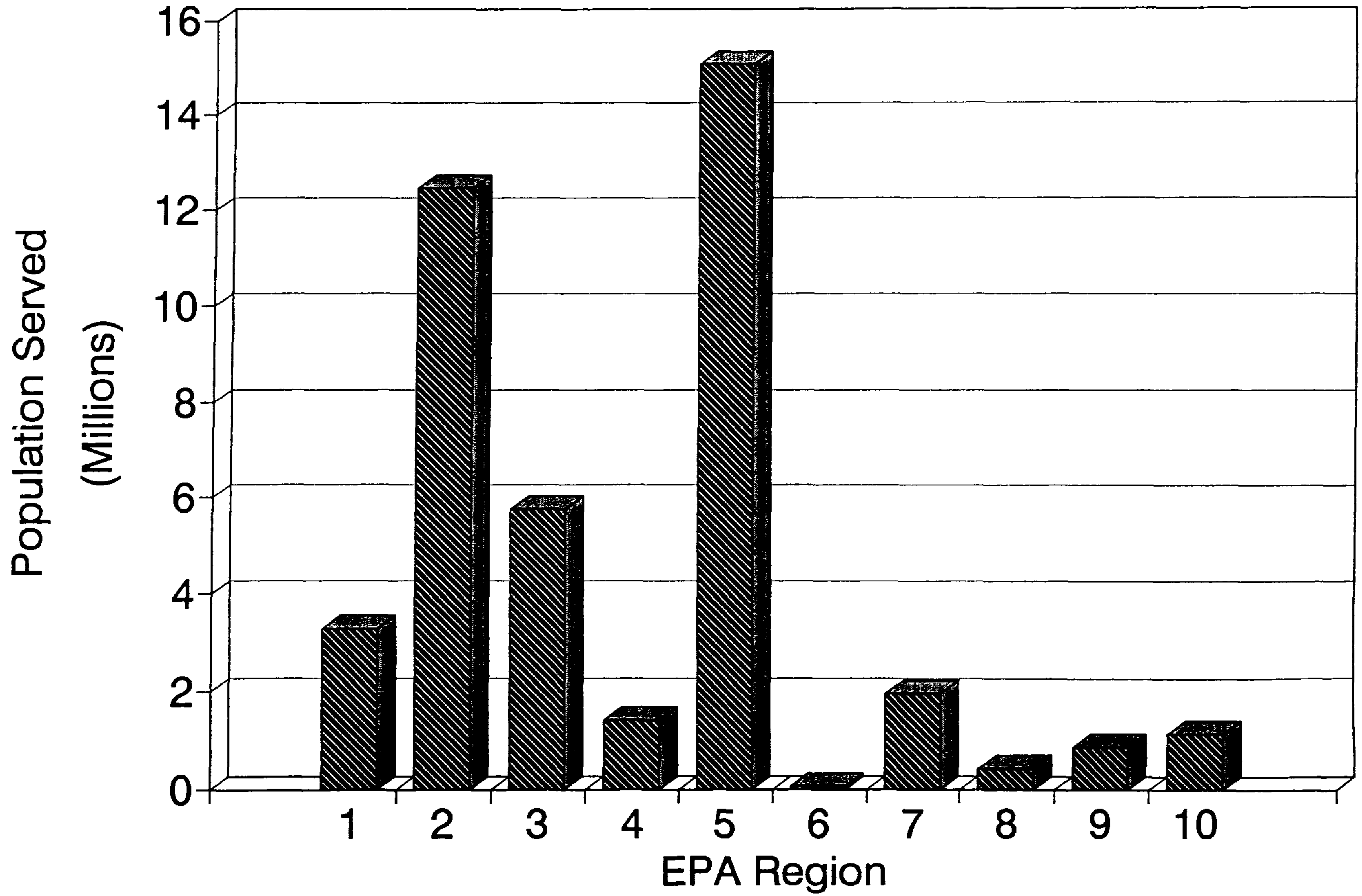


Exhibit 1-4

PORTION OF POPULATION SERVED BY CS SYSTEMS, BY STATE

1980 NEEDS SURVEY

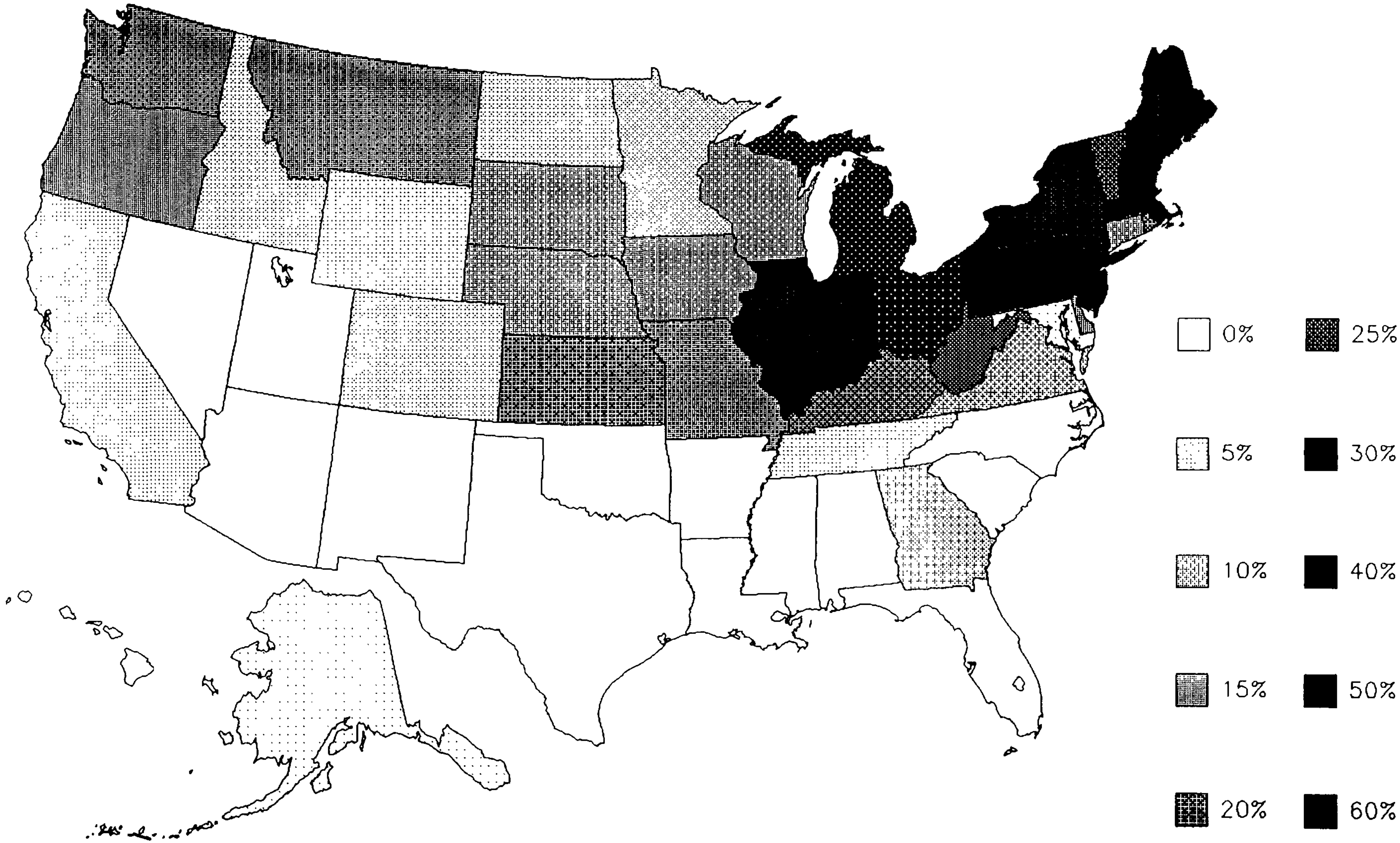


Exhibit 1-5

DISTRIBUTION OF COMBINED SEWER DISCHARGE POINTS
BY STATE AND EPA REGION

EPA REGION	STATE	OUTFALLS	PERCENT OF TOTAL OUTFALLS	MEAN OUTFALL PER CSS
1	Connecticut	242	2.25	18.62
	Maine	351	3.26	5.75
	Massachusetts	388	3.60	14.92
	New Hampshire	164	1.52	7.45
	Rhode Island	95	0.88	31.67
	Vermont	169	1.57	5.45
	SUBTOTALS	**1409**	**13.08**	**9.03**
2	New Jersey	281	2.61	10.04
	New York	1200	11.14	13.33
	SUBTOTALS	**1481**	**13.75**	**12.55**
3	Delaware	38	0.35	12.67
	District of Columbia	55	0.51	55.00
	Maryland	74	0.69	10.57
	Pennsylvania	1260	11.70	9.00
	Virginia	155	1.44	38.75
	West Virginia	700	6.50	14.00
	SUBTOTALS	**2282**	**21.19**	**11.13**
4	Alabama	0	0	NA
	Florida	0	0	NA
	Georgia	31	0.29	6.20
	Kentucky	206	1.91	9.36
	Mississippi	0	0	NA
	North Carolina	0	0	NA
	South Carolina	0	0	NA
	Tennessee	49	0.45	16.33
	SUBTOTALS	**286**	**2.66**	**9.53**
5	Illinois	1015	9.42	7.52
	Indiana	1100	10.21	7.80
	Michigan	594	5.52	6.99
	Minnesota	105	0.97	17.50
	Ohio	1593	14.79	14.61
	Wisconsin	275	2.55	137.50
	SUBTOTALS	**4682**	**43.47**	**9.79**
6	Arkansas	NA	NA	NA
	Louisiana	0	0	NA
	New Mexico	0	0	0
	Oklahoma	0	0	NA
	Texas	0	0	NA
	SUBTOTALS	**0**	**0.00**	**0.00**
7	Iowa	82	0.76	4.32
	Kansas	17	0.16	5.67
	Missouri	91	0.84	6.50
	Nebraska	23	0.21	7.67
	SUBTOTALS	**213**	**1.98**	**5.46**

Exhibit 1-5
(continued)

DISTRIBUTION OF COMBINED SEWER DISCHARGE POINTS
BY STATE AND EPA REGION

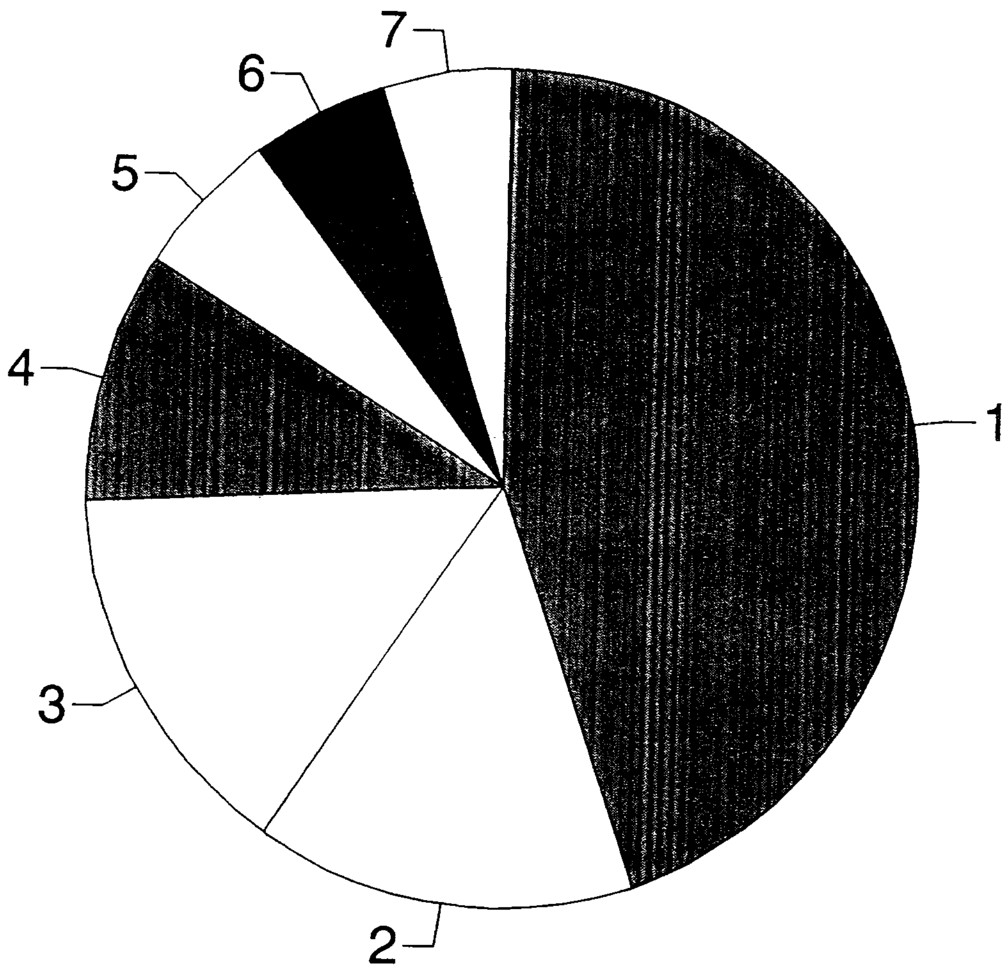
EPA REGION	STATE	OUTFALLS	PERCENT OF TOTAL OUTFALLS	MEAN OUTFALL PER CSS
8	Colorado	6	0.06	6.00
	Montana	NA	NA	NA
	North Dakota	0	0	NA
	South Dakota	2	0.02	2.00
	Utah	0	0	NA
	Wyoming	0	0	NA
	SUBTOTALS	**8**	**0.07**	**4.00**
9	Arizona	0	0	NA
	California	39	0.36	19.50
	Hawaii	0	0	NA
	Nevada	0	0	NA
	SUBTOTALS	**39**	**0.36**	**19.50**
10	Alaska	0	0	NA
	Idaho	0	0	NA
	Oregon	100	0.93	25.00
	Washington	270	2.51	24.55
	SUBTOTALS	**370**	**3.44**	**24.67**
	TOTALS	**10770**	**100.00**	**10.26**

Source: U.S. EPA, "Status of Strategy Approvals," January 16, 1992.

Exhibit 1-6

AREA DRAINED BY COMBINED SEWER SYSTEMS

1980 Supplementary Database



1- under 500 acres, (44.8%)
2- from 500 to 999 acres, (14.7%)
3- from 1,000 to 2,499 acres, (14.8%)
4- from 2,500 to 4,999 acres, (9.7%)
5- from 5,000 to 9,999 acres, (5.7%)
6- over 10,000 acres, (5.4%)
7- no response, (5.0%)

Exhibit 1-7

DISTRIBUTION OF CS SYSTEMS BY POPULATION SERVED

1980 SUPPLEMENTARY DATABASE

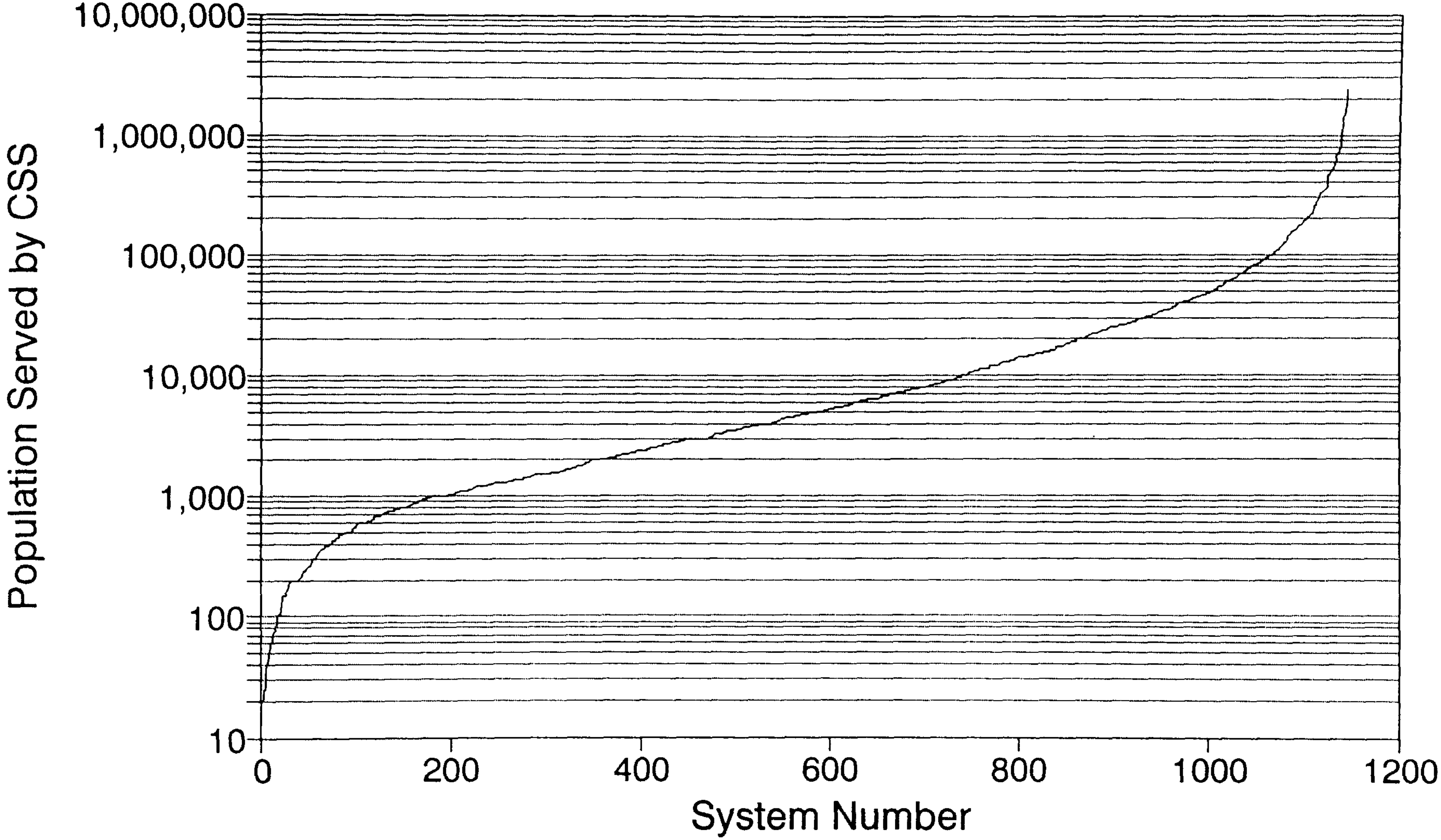
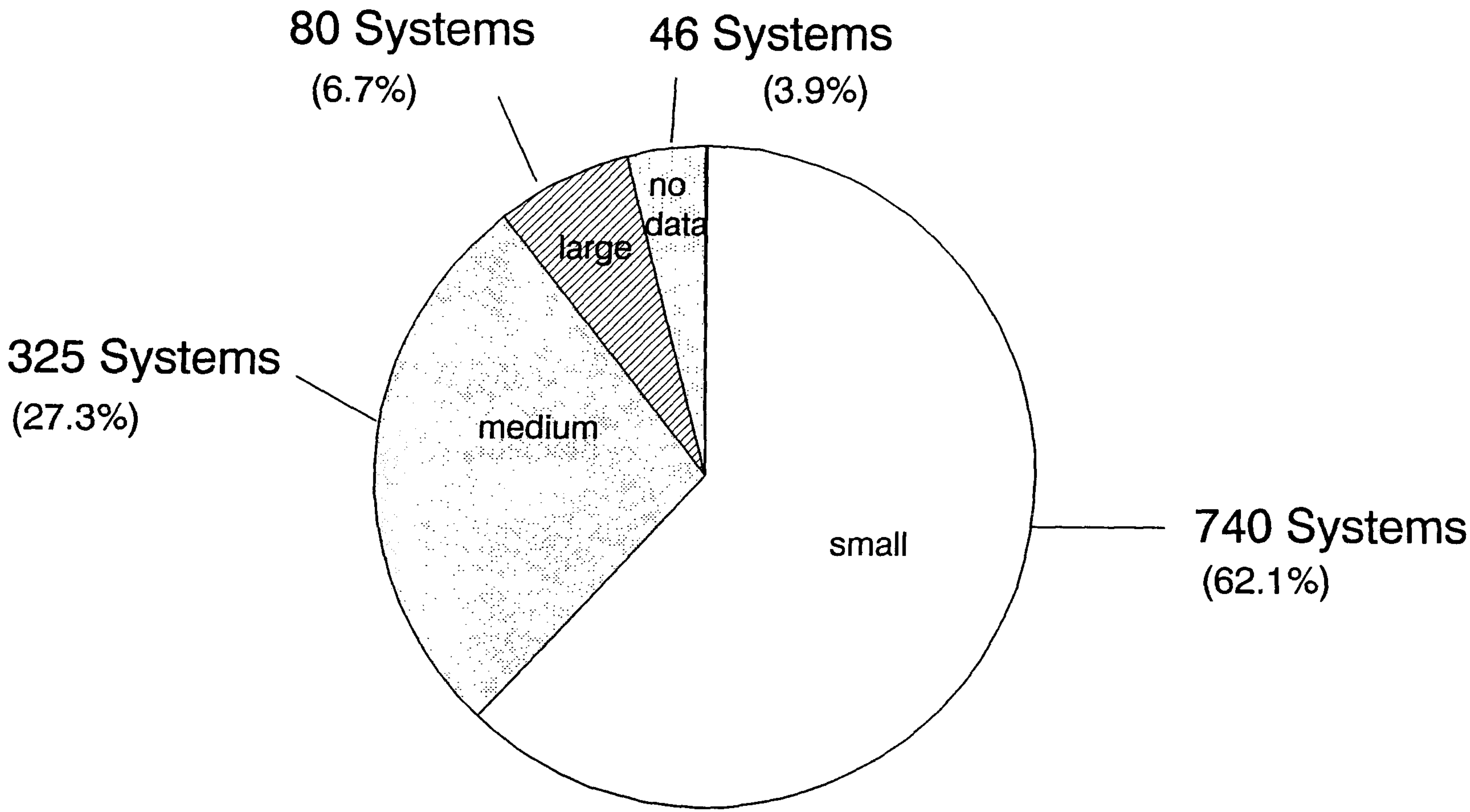


Exhibit 1-8

DISTRIBUTION OF CSSs BY SYSTEM SIZE

1980 SUPPLEMENTARY DATABASE

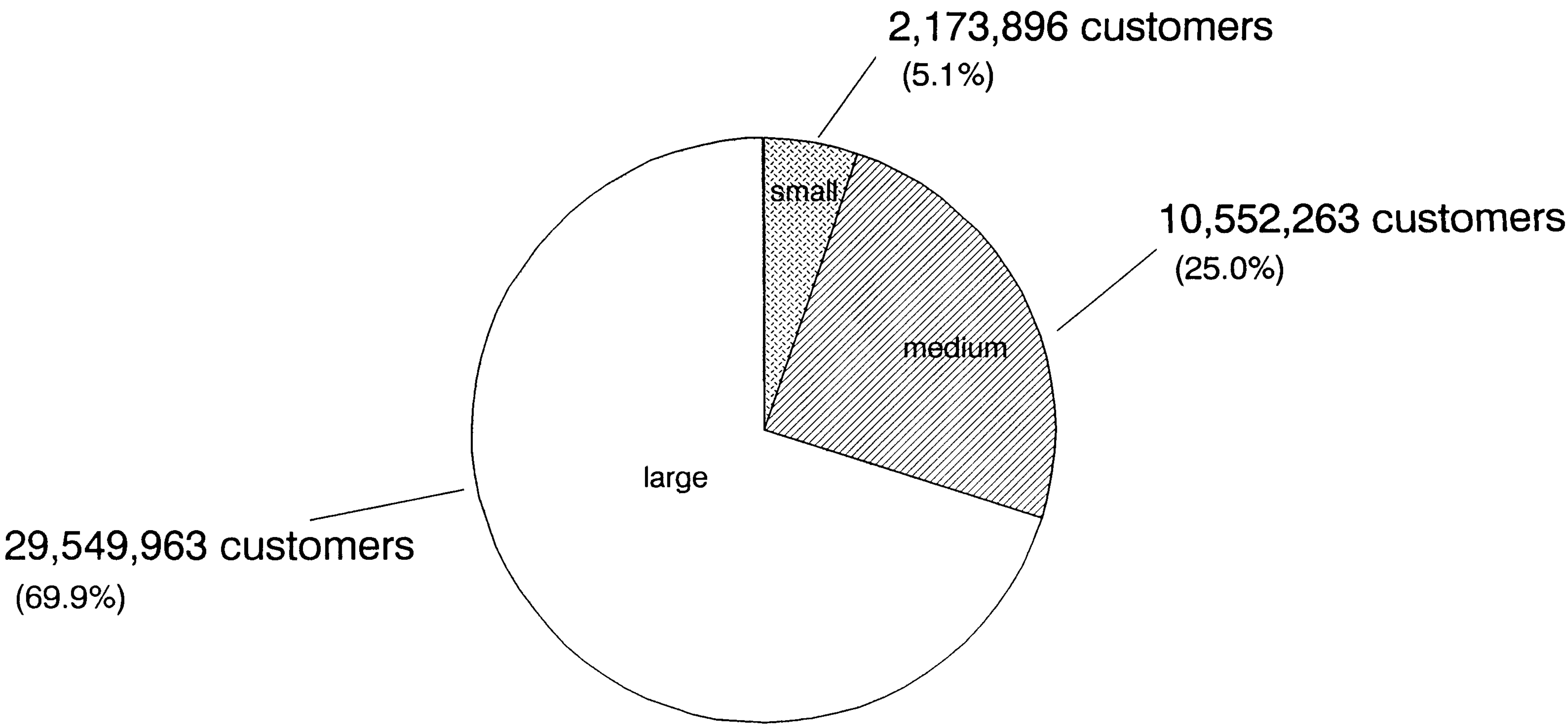


small-- fewer than 10,000 customers served by combined sewers
medium-- between 10,000 and 100,000 customers served by combined sewers
large-- more than 100,000 customers served by combined sewers

Exhibit 1-9

DISTRIBUTION OF POPULATION SERVED BY CSSs BY SYSTEM SIZE

1980 SUPPLEMENTARY DATABASE

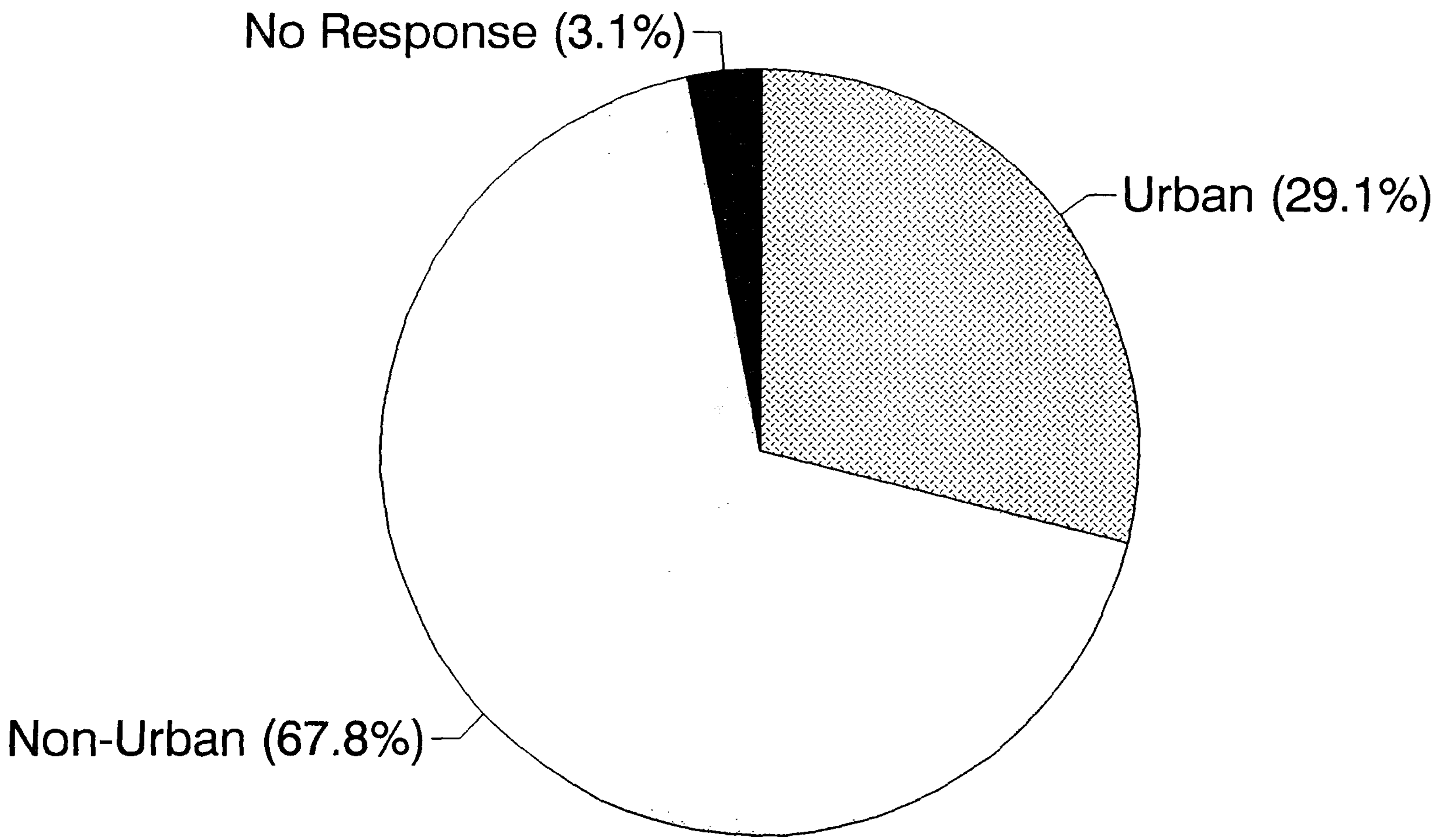


small-- fewer than 10,000 customers served by combined sewers
medium-- betweem 10,000 and 100,000 customers served by combined sewers
large-- more than 100,000 customers served by combined sewers

Exhibit 1-10

DISTRIBUTION OF CSSs: URBAN vs. NON-URBAN AREAS

1980 SUPPLEMENTARY DATABASE



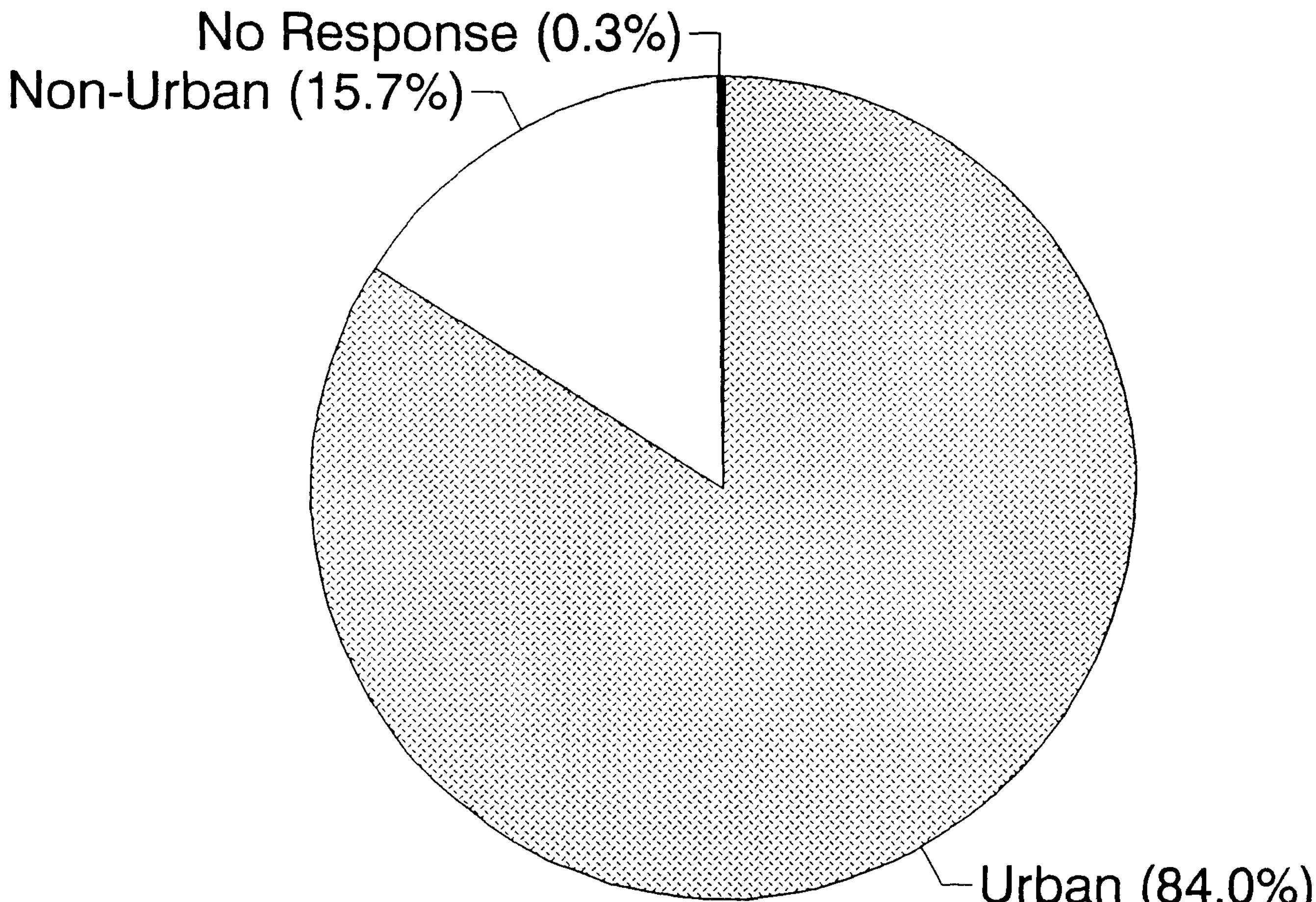
The criteria for classification as an urban area are:

- A central city with a population of at least 50,000 or twin cities with a combined population of at least 50,000, with the smaller of the twin cities having at least 15,000 inhabitants.
- Closely settled surrounding territory, meeting specific criteria outlined in the Needs Survey.

Exhibit 1-11

POPULATION SERVED BY URBAN & NON-URBAN CS SYSTEMS

1980 SUPPLEMENTARY DATABASE



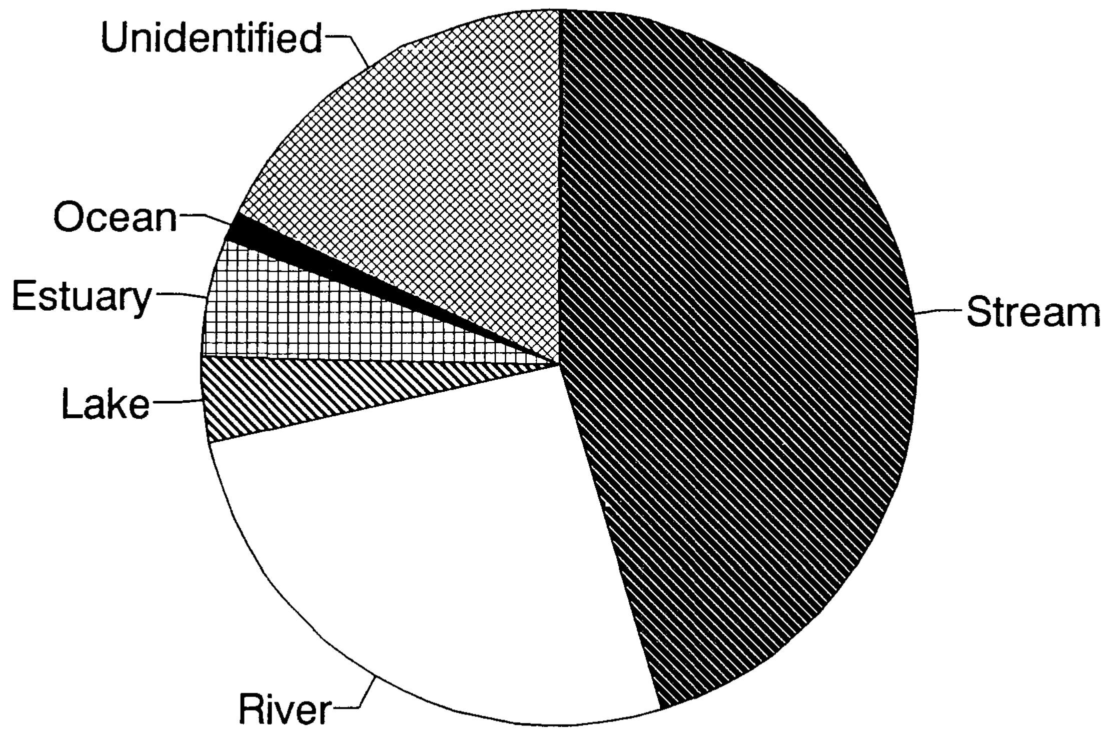
The criteria for classification as an urban area are:

- o A central city with a population of at least 50,000 or twin cities with a combined population of at least 50,000, with the smaller of the twin cities having at least 15,000 inhabitants.
- o Closely settled surrounding territory, meeting specific criteria outlined in the Needs Survey.

Exhibit 1-12

DISTRIBUTION OF CSSs BY PRIMARY RECEIVING WATER

1980 NEEDS SURVEY



Stream	45.3%
River	26.2%
Lake	3.8%
Estuary	5.4%
Ocean	1.3%
Unidentified	17.9%

Note: These data do not necessarily represent the distribution of receiving waters that CSOs affect. For example, it is possible that discharges to a river may adversely affect an estuary downstream. As a result, these data may understate the potential effects of CSOs on downstream water resources.

Exhibit 1-13

CONTRIBUTION OF CSOs TO IMPAIRED WATER QUALITY IN THE UNITED STATES (1990 305(b) Data)

Water	Assessed	Impaired Waters for which Sources of Impairment are Identified	CSOs a Major Source of Impairment	CSOs a Moderate or Minor Source of Impairment	CSO-Impaired Waters as a Percent of all Waters for which Sources of Impairment are Identified
Rivers (miles)	647,066	177,792	3,521	1,642	2.9%
Lakes (acres)	18,488,636	3,971,330	7,967	13,393	0.6%
Great Lakes (shore-miles)	4,857	1,235	0	93	7.5%
Estuaries (square miles)	26,693	7,693	269	234	6.5%
Oceans (shore-miles)	4,230	361	12	120	36.6%

Source: 1990 State Section 305(b) Reports, as documented in U.S. EPA, National Water Quality Inventory: 1990 Report to Congress (Draft), Office of Water, Washington, DC, 1991.

Exhibit 1-14

SHELLFISH HARVEST-LIMITED AREAS

Region	Approved Acres (1,000)	Harvest-Limited Acres (1,000)	Acres Limited Due to CSOs (1,000)	Acres Limited Due to CSOs as a Percentage of Total Limited Area
North Atlantic	2,014	396	20	5.1%
Middle Atlantic	4,426	1,181	229	19.4%
South Atlantic	2,092	830	0	0%
Gulf Coast	3,434	3,662	348	9.5%
Pacific Coast	338	306	0	0%
Total	12,304	6,375	597	9.4%

Source: National Oceanic and Atmospheric Administration, The 1990 National Shellfish Register of Classified Estuarine Water, U.S. Department of Commerce, Rockville, MD, July 1991.

Exhibit 1-15

BEACH CLOSURES OR ADVISORIES DUE TO HIGH BACTERIA COUNTS (Days)

State	1989	1990
Maine	1	72
Massachusetts	60	59
Rhode Island	0	0
Connecticut	103	218
New York	923	581
New Jersey	266	228
Delaware	62	11
Maryland	0	0
Florida	N/A	234
California	338	64
Total:	1,753	1,467

Source: Kassalow, J., et al., Testing the Waters: A Study of Beach Closings in Ten Coastal States, Natural Resources Defense Council, August 1991.

Exhibit 1-16

STATUS OF STATE CSO STRATEGY APPROVALS

EPA REGION	STATE	STATE STRATEGY SUBMITTED: NO ACTION	STATE STRATEGY SUBMITTED: APPROVED	STATE STRATEGY SUBMITTED: CONDITIONALLY APPROVED	NO STRATEGY REQUIRED: NO CSSs	NO STRATEGY REQUIRED: WITH CSSs
1	Connecticut		X			
	Maine		X			
	Massachusetts		X			
	New Hampshire		X			
	Rhode Island		X			
	Vermont		X			
2	New Jersey			X		
	New York			X		
3	Delaware	X				
	District of Columbia		X			
	Maryland		X			
	Pennsylvania		X			
	Virginia	X				
	West Virginia		X			
4	Alabama				X	
	Florida				X	
	Georgia		X			
	Kentucky		X			
	Mississippi				X	
	North Carolina				X	
	South Carolina				X	
	Tennessee		X			
5	Illinois		X			
	Indiana		X			
	Michigan		X			
	Minnesota					X
	Ohio		X			
	Wisconsin					X
6	Arkansas					X
	Louisiana				X	
	New Mexico					X
	Oklahoma				X	
	Texas				X	
7	Iowa		X			
	Kansas		X			
	Missouri		X			
	Nebraska		X			
8	Colorado		X			
	Montana				X	
	North Dakota				X	
	South Dakota		X			
	Utah				X	
	Wyoming				X	
9	Arizona				X	
	California		X			
	Hawaii				X	
	Nevada				X	
10	Alaska				X	
	Idaho					X
	Oregon		X			
	Washington		X			
	TOTALS	2	26	2	16	5

Source: EPA, "Status of Strategy Approvals," January 16, 1992.

INTRODUCTION

While the Federal government is considering the need for and possible form of a national technology-based design standard for controlling combined sewer overflows, several states have already implemented wet weather CSO design standards. Knowledge of state approaches to setting these standards is of obvious interest in designing a Federal approach. With this in mind, this chapter describes CSO regulations or policies in selected states.

The review of CSO policies presented here is based primarily upon telephone contacts with state regulators; Appendix B gives a complete list of state contacts and source documents.[1] This research suggests that states have employed a range of logic in developing CSO standards; consequently, the policies they have adopted vary significantly. As described below, many standards have been developed as ad hoc responses to a particular CSO problem. As a result, the development of the state CSO standards reviewed here provides limited guidance for the selection of a Federal approach. Nevertheless, simply by illustrating the broad range of CSO wet weather standards currently in place, this review provides a starting point for defining practical alternatives.

STATE COMBINED SEWER OVERFLOW STANDARDS

We have identified nine states that have taken steps to control CSOs through regulations, policies, or permitting actions that include wet weather design standards. Table 2-1 summarizes these actions. As the table shows, one state, Illinois, has adopted a factor of flow standard, requiring primary treatment for all flows up to 10 times the dry weather flow (the state also requires that treatment for the "first flush" of storm flows meet applicable effluent standards; the "10X" approach extends primary treatment requirements beyond the first flush). Three other states have developed standards based upon design storm concepts: Michigan and Rhode Island have developed CSO control policies based on a frequency/duration design storm, while Vermont specifies a depth/duration (2.5-inch/24-hour) design storm. Four others -- California (for San Francisco),

[1] Initial interviews were conducted by Jeff Albert under separate contract to EPA. Additional interviews, including some follow-up interviews, were conducted by Douglas Rae, an independent consultant to IEc. Appendix B lists all individuals interviewed.

Massachusetts, Washington, and Wisconsin (for Milwaukee) -- have set overflow frequency standards that expressly limit the number of overflows per year, while one state, Oregon (for Portland), has used a hybrid approach that specifies an overflow limit with reference to a design storm. Each of these approaches is described below; where available information allows, the discussion also includes the rationale underlying selection of the standard.

Table 2-1

STATE COMBINED SEWER WET WEATHER DESIGN STANDARDS

State	Type of Standard	Standard	Legal Form
California (San Francisco)	Overflow Frequency Limit	8 untreated overflows per outfall per year (weighted average)	System Permit
Illinois	Factor of Flow	10 times dry weather flow	State Regulation
Massachusetts	Overflow Frequency Limit	4 untreated overflows per outfall per year	State Policy
Michigan	Frequency/Duration Design Storm	1-year/1-hour for secondary treatment; 10-year/1-hour for primary treatment	State Policy
Oregon (Portland)	Overflow Frequency Limit*	1 untreated overflow every 10 years in summer; 1 every 5 years in winter	System Permit
Rhode Island	Frequency/Duration Design Storm	1-year/6-hour storm	State Policy
Washington	Overflow Frequency Limit	1 untreated overflow per outfall per year	State Policy
Wisconsin (Milwaukee)	Overflow Frequency Limit	1.7 untreated overflows per outfall per year	System Permit
Vermont	Depth/Duration Design Storm	2.5-inch/24-hour storm	State Regulation

*As noted in the text, the standard that Oregon is applying to Portland may also be interpreted as a design storm limit.

Source: Industrial Economics, Incorporated

California

There are three combined sewer systems in California, operated by San Francisco, the East Bay Municipal Utility District, and Sacramento, respectively. The state has received conditional EPA approval for a CSO policy governing these systems. The policy includes the following minimum technology-based limitations:

1) proper operation and regular maintenance for the sewer system and CSO points;

2) maximum use of the collection system for storage;

3) maximization of flow to the POTW for treatment;

4) prohibition of dry weather overflows;

5) control of solid and floatable materials in CSO discharges; and

6) review and modification of pretreatment programs to ensure that CSO impacts are minimized.

The state's policy, which is to be implemented by Regional Water Quality Control Boards (WQCBs), does not include a wet weather design standard; however, the permit requirements for San Francisco's system specify overflow frequency limits.

The San Francisco Bay Region WQCB has issued three NPDES permits for San Francisco's CSOs: one for a wet weather treatment plant, one for CSOs discharging to San Francisco Bay, and one for CSOs discharging to the Pacific Ocean. These permits limit overflows to an average of eight per year to the Pacific Ocean, and to an average of one, four or ten per year in San Francisco Bay, depending on "relative receiving-water sensitivity and cost of control[.]" The WQCB established these limits based upon an analysis of the cost-effectiveness of CSO control undertaken in the late 1970s. The analysis examined alternative standards of 2, 4, 6, 8, 10, and 16 overflows per year. The study indicated that for overflows to the Pacific, control costs under standards more stringent than eight overflows per year increased rapidly, with little commensurate beneficial impact on water quality. Control costs varied for CSOs discharging to the Bay, as did the sensitivity of receiving waters near the outfalls. The varying design standards for San Francisco Bay reflect the effort to establish cost-effective limits consistent with the sensitivity and beneficial uses of the receiving waters.

Illinois

Illinois' Water Pollution Regulations (Section 303.305: Treatment of Overflows and Bypasses) require all combined sewer overflows and treatment plant bypasses to be given sufficient treatment to prevent pollution or the violation of applicable water quality standards. Unless an exception for an alternative treatment program is granted, sufficient treatment is defined as follows:

(a) All dry weather flows, and the first flush of storm flows as determined by the [State], shall meet the applicable effluent standards; and

(b) Additional flows, as determined by the [State] but not less than ten times the average dry weather flow for the design year, shall receive a minimum of primary treatment and disinfection with adequate retention time; and

(c) Flows in excess of those described in subsection (b) shall be treated, in whole or in part, to the extent necessary to prevent accumulations of sludge deposits, floating debris and solids...and to prevent depression of oxygen levels.

Illinois' approach requires CSSs to treat the "first flush" of storm flows in accordance with applicable effluent standards because pollutant loadings from CSSs are likely to be greatest in a storm's early stages, when wet weather flow acts to scour deposits of sewage and other matter that may have accumulated in the system. The requirement that primary treatment be provided for wet weather flows up to ten times the dry weather flow is an extension of this concept, and was based on an analysis of empirical data that indicated that flows above "10X" were often so diluted with storm water that the water quality impacts were less severe than at lower flows.

<u>Massachusetts</u>

The Massachusetts Department of Environmental Protection (DEP) released its "Implementation Policy for the Abatement of Pollution from Combined Sewer Overflows" on May 24, 1990. EPA Region I has conditionally approved this policy, pending resolution of a disagreement over the wet weather design standard the policy employs.

DEP's policy establishes a design standard based on "a three month design storm as a minimum technology-based effluent limitation" that "will result in untreated overflows on an average of four (4) times a year." Massachusetts' rationale for this proposal rests on an analogy to the suspension of state water quality standards under dry weather, low flow conditions. Like most states, Massachusetts determines whether a discharge to a river or stream requires a water quality-limited permit by analyzing whether operation under technology-based limits during low flow conditions would lead to a violation of state water quality standards. For the purpose of such analyses, Massachusetts uses 7Q10 (the lowest stream flow for seven consecutive days over a 10 year period) as its low flow condition. Statistically, flows lower than 7Q10 occur on average about four days per year, or about one percent of the time. On this basis, Massachusetts argues that wet weather discharges should also be allowed to violate water quality standards about one percent of the time; hence, the state proposes a wet weather standard of four overflows per year.

EPA Region 1 has questioned the logic underlying Massachusetts' policy, arguing that the analogy to low flow conditions does not hold because one overflow may cause water quality standards to be violated for many days. This disagreement has yet to be resolved.[2]

Michigan

Michigan's CSO policy recommends (1) storage for secondary treatment of all CSO flows up to the 1-year/1-hour storm and (2) equivalent primary treatment (skimming, 30 minutes of sedimentation, and disinfection with 30 minutes of contact time) of all CSO flows up to the 10-year/1-hour storm. This standard is coupled with a provision that alternative treatment meeting Michigan water quality standards is permissible.

Michigan's choice of the 1-year/1-hour storm and the 10-year/1-hour storm as design standards was based on regulatory precedent and typical sewer system design. In the early 1970s, a number of storm water detention facilities were built in Michigan. Permits established at that time on the basis of Best Professional Judgment stipulated the 1-year/1-hour storm as the design standard. When the Michigan Department of Natural Resources (DNR) was developing its CSO policy, DNR considered it reasonable to apply this limit as the secondary treatment flow standard for combined sewer systems as well. The selection of the 10-year/1-hour storm as the design standard for wet weather flows requiring equivalent primary treatment was based at least in part on the fact that many Michigan sewer systems were designed to convey flows up to this magnitude; the policy now requires that these flows receive at least primary treatment.

Oregon

Oregon's CSO Policy was developed by the state's Department of Environmental Quality (DEQ) in response to EPA's National CSO Policy, and evolved in part from a 1981 policy requiring that:

> "Sewerage Construction programs should be designed to eliminate raw sewage bypassing during the summer recreation season (except for a storm event greater than the 1 in 10 year 24 hour storm) as soon as practicable. A program and timetable should be developed through negotiation with each affected source. Bypasses which occur during the remainder of the year should be eliminated in accordance with an approved longer term maintenance based correction program. More stringent schedules may be imposed as necessary to protect drinking water supplies and shellfish growing areas." (OAR 340-41-034(3)(f))

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[2] EPA Region I has established its own CSO guidance policy. Among other features, this policy calls for the elimination of CSO discharges from critical use areas (e.g., beaches and shellfishing areas) and implementation of sufficient treatment to comply with water quality standards whenever technically and economically feasible. The policy does not stipulate a technology-based wet weather standard.

The current CSO policy, which was adopted in February 1991, specifies that CSOs will be required "to meet the minimum technology-based limitations as set forth in the National CSO Control Strategy." The policy also states that "the Department will require whatever level of controls including separation of sewers is necessary to achieve water quality standards[,]" including a fecal coliform limit of 200/100 ml, to be met at the end of the pipe with no mixing zone. Although the CSO policy statement does not mention a wet weather design standard, only storms with rainfall greater than the 10-year event are expected to be sufficient to dilute raw sewage fecal coliform levels (about 8,000,000/100ml) to the 200/100 ml limit.[3]

The DEQ currently is applying this policy in an enforcement order against the City of Portland, where 60 percent of the sewer system is combined. This order will require elimination of all discharges that violate applicable water quality standards for

- o all flows between May 1 and Oct. 31 up to the 10-year storm event, and
- o all flows between Nov. 1 and April 30 up to the 5-year storm event.

Since the 10-year storm event will cause an overflow on average every ten years, this standard is equivalent to one permitting untreated overflows to occur an average of once every ten summers. Similarly, the standard would permit untreated overflows to occur an average of once every five winters.

Rhode Island

In March of 1990 the Rhode Island Department of Environmental Management (DEM) established a CSO policy requiring primary treatment for all flows equivalent to that associated with the 1-year/6-hour storm event (DEM, "Combined Sewer Overflow Policy", March 1990). Rhode Island defines primary treatment as 50 percent removal of total suspended solids and 35 percent removal of BOD loadings, or 100 percent removal of all settleable solids, whichever provides the greater improvement in water quality. The policy is flexible in that it allows municipalities to provide storage for less than the 1-year/6-hour flow provided that overall treatment is sufficiently stringent to achieve a reduction in pollutant loadings equivalent to the standard defined above.

In developing its policy, DEM analyzed an available set of data on the 300 largest storms in Rhode Island from 1949 to 1982. The depth of both the mean and median storms was approximately that of the state's 1-year/12-hour storm. The average duration of these storms was six hours. DEM chose the 1-year/6-hour storm rather than the 1-year/12-hour storm as its design standard after discussions with the regulated community suggested that the larger volume of rain associated with a 1-year/12-hour standard would make storing combined sewage prohibitively expensive, and therefore would compel communities to employ relatively less effective pass-through treatment technologies (e.g., swirl concentrators and chlorination). Under the 1-year/6-hour storm standard, it would be more feasible to store wet weather flows off-line until treatment capacity at POTWs -- where a higher degree of control could be attained -- became available.

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[3] The "ten-year event" refers to the greatest amount of rain expected, on average, from any one storm over a ten-year period. Such events are defined without reference to duration.

Washington

In Washington, a 1986 state law requires the "greatest reasonable reduction of CSOs at the earliest possible date," which the state's Department of Ecology (DOE) has defined in regulations as an average of one overflow per outfall per year. The selection of this standard was based on an analysis, completed in the late 1970s, of the impact of Seattle's CSOs on Lake Washington. This study suggested that a standard of one overflow per outfall per year would be sufficiently stringent to achieve the fishable/swimmable goals of the Clean Water Act.

Wisconsin

Wisconsin has not developed a uniform statewide CSO standard, but has developed a standard likely to be included in an NPDES permit for Milwaukee, the state's largest city. This standard would limit Milwaukee to an average of 1.7 overflows per year. This limit was arrived at post hoc, and has its origins in the design of improvements to Milwaukee's sewer systems.

In the 1970s the state of Illinois sued the City of Milwaukee and the Milwaukee Metropolitan Sewer District over CSO pollution of Lake Michigan and degradation of water quality in Illinois waters. An initial Federal court ruling favored Illinois and required Milwaukee to eliminate overflows from both its separate and combined sewer systems.[4] An appeal to the U.S. Supreme Court overturned the lower court ruling. The Wisconsin Department of Natural Resources (DNR) then interceded in the dispute, requiring Milwaukee in a stipulated agreement to attain zero discharge of its separate storm sewers. No agreement was reached on the level of protection for combined sewers; instead, a third party, the Southern Wisconsin Regional Planning Commission (SWRPC), was charged with studying water quality problems in the receiving waters and recommending a level of protection.

Construction began in the mid-1980s on a deep tunnel to provide 650 acre-feet of storage to handle overflows from the separate storm sewer system. This volume of storage was considered adequate to prevent overflow from the "worst storm on record in the last 40 years." A decision not to line the tunnel with concrete, coupled with the use of a larger tunnel bore than originally planned (smaller boring equipment was unavailable), increased the tunnel's storage capacity to 1140 acre-feet. Studies of the combined sewer overflow problem indicated that this additional storage would be sufficient to limit combined sewer overflows to an average of 1.7 per year, and the SWRPC recommended that this standard be adopted. Wisconsin DNR has conditionally approved the standard in a permit, although the DNR has not approved the water quality study conducted by the SWRPC.[5]

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[4] Approximately seven-eighths of the Milwaukee system consists of separate storm and sanitary sewers; the remaining eighth of the system consists of combined sewers.

[5] The cost of the Milwaukee project is estimated at $500 million for control of separate sewer overflows and $300 million for control of combined sewer overflows.

Vermont

Vermont's State Water Quality Standards (revised April 1990) propose elimination of CSO discharges to Class A (drinking water without filtration) and B waters (full body contact and drinking water with filtration/disinfection) and require that all water quality standards be met for all CSO discharges to Class C waters for all flows up to the 24 hour/2.5 inch rainfall. This standard embodies the approach developed to resolve CSO problems in Burlington, Vermont's largest city. Burlington's combined sewer overflows frequently violated state bacteria standards, forcing Lake Champlain beaches to close (Class B waters). Pressure from citizen's groups, EPA, and the U.S. Attorney's Office led to a consent decree in 1989 requiring control of CSOs. The facilities plan developed under this decree includes separation of some combined sewers and consolidation of some CSOs, with capacity for treatment and discharge through an extended outfall to Class C waters beyond the city's Lake Champlain breakwater.

As with Massachusetts, reference to the 7Q10 low flow condition guided Vermont's selection of a CSO wet weather standard. Analysis of 4,974 rainfall events at the Burlington airport indicated that only one percent of area storms exceed 2.0 inches; therefore, Vermont concluded, the probability of a storm that exceeds the depth of the 2.5-inch/24-hour event (less than one percent) is comparable to the probabilty of experiencing a low flow (7Q10) event (also less than one percent).

It is interesting to note that although both Vermont and Massachusetts draw an analogy to 7Q10 in defining CSO standards, they come to different conclusions about the implications of this analogy. In Vermont, a 2.5-inch storm event occurs on average only once in two years; therefore, storms greater than the design storm -- those that would cause uncontrolled overflows -- are likely to occur on average only once every two years. In contrast, the Massachusetts standard would allow uncontrolled overflows to occur eight times as frequently. This difference is a result of differing interpretations of rainfall data and the 7Q10 analogy.

INTRODUCTION

An understanding of design storm concepts and of the implications of alternative wet weather standards for controlling CSOs requires an understanding of the underlying rainfall data. This chapter briefly discusses key storm parameters, the collection and maintenance of rainfall data to describe these parameters, and how the data are used to analyze the characteristics of storm events.[1]

STORM PARAMETERS

Many structures, such as dams and storm sewers, must be designed with sufficient capacity to withstand or operate during severe storms. As a consequence, an important branch of meteorology concerns itself with the analysis of so-called "extreme rainfall events." The characteristics commonly used in describing such events are:

- Depth - the amount of rain that falls during a storm, typically measured in inches.
- Duration storm length, typically measured in minutes or hours.
- Intensity - the amount of rain that falls in a given time, typically measured in inches per hour.
- Frequency - the average number of storms of a given characteristic (e.g., depth or duration) that occur within a specified period of time at a particular location; alternatively, frequency can be expressed as the return period (average interval between expected occurrences) of a given rainfall event.

[1] This chapter is based upon Eugene D. Driscoll and Joan M. Kersnar, Woodward-Clyde Consultants, "The 1-Year, 6-Hour Design Storm and its Use in Legislative and/or Regulatory Approaches for Controlling Pollution from Combined Sewer Overflows," August 20, 1991.

Note that these characteristics are measured and defined with reference to a particular place (where the measurements are made). The depth, duration, or intensity of a given storm may vary significantly at different locations in the storm's path.

COLLECTION AND MAINTENANCE OF RAINFALL DATA

The U.S. Department of Commerce's National Weather Service operates thousands of weather monitoring stations nationwide. Since 1910, the Service or its predecessor, the U.S. Weather Bureau, has maintained 200 stations that record rainfall for periods ranging from 30 minutes to 24 hours. In addition, the Service or Bureau has collected data since approximately 1910 at more than 1400 sites where rainfall readings are made once every 24 hours. In combination, this network of over 1600 stations provides the Weather Service with 80 years of rainfall data from across the U.S., giving weather researchers a foundation for analyzing the characteristics of relatively rare storm events.

In the 1940s, the Weather Bureau established an additional network of over 2000 recording gauges, each of which provides hourly data on rainfall events. This network has now gathered over 40 years of hourly readings, providing comprehensive national coverage and a firmer basis for analyzing and understanding variations in rainfall parameters within relatively fine time intervals.[2]

The accuracy of the Weather Service's data is limited to some extent by the methodology used to gather the data. Rainfall events often overlap clock hour or calender day intervals; however, some stations record data only within these intervals. A more precise record is required to ensure that storm duration and intensity are accurately described.[3] Since 1948, many weather stations have recorded rainfall data in 15-minute increments, thereby increasing the precision with which events are measured and characterized.

The National Climatic Data Center (NCDC) maintains all weather data collected by the Weather Service. Data from the Weather Service's rain gauge network are available for analysis in computer-readable form.[4]

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[2] Some cities also maintain local rain gauge networks.

[3] For example, a storm that begins on March 31 at 23:30 and ends on April 1 at 00:30 would be recorded under a strict clock/calender system as two 30 minute storms. Under a duration system, the same storm would more accurately be recorded as a one-hour storm.

[4] NCDC's electronic data base contains data from approximately 17,000 previously and 8,000 currently operating stations throughout the 50 states. These data include hourly rainfall records from over 5,500 stations, and 15-minute data from over 2,700 stations.

ANALYZING THE CHARACTERISTICS OF STORM EVENTS

The rainfall data collected by the Weather Service provide the basis for determining national patterns of rainfall depth, duration, intensity, and frequency. These patterns form the basis for describing "typical" storm events for a given location.

The following discussion describes how the rainfall data are used to analyze and characterize storm events.

Typical Rainfall Patterns

Exhibit 3-1 illustrates typical data from an hourly rain gauge. This particular plot shows the pattern of rainfall for three separate storm events. As the exhibit shows, for each clock hour in which a measurable amount of rain falls, the quantity is recorded.[5] Each bar on the plot indicates both the amount of rain recorded in that hour (in inches), and the average intensity of rainfall during that hour (in inches per hour). The plot also illustrates the duration of each storm and the interval between storms (in hours). The total depth for each rainfall event is the sum of the individual hourly values, and the average intensity of each storm is this sum divided by the storm's duration. Note that a storm's intensity at any given time may vary considerably from its average intensity.

A plot of storm depths at a particular site, showing the relative frequency of each depth, tends to follow a log-normal distribution. As illustrated in Exhibit 3-2, such a distribution is skewed to the right, where the extreme rainfall events fall. Transforming these data into logarithms yields a normal distribution, which has more attractive statistical properties. Because statistical analysis is simplified by working with a normal distribution, engineers, hydrologists and meteorologists typically work with rainfall data in logarithmic form.

Analysis of Storm Frequency

Exhibit 3-3 shows data on all rainfall events for a site in the San Francisco Bay area over a 39-year period, transformed to logarithmic form and converted to a cumulative frequency distribution. Distributions like this are employed to analyze the probability that a storm of a given depth is likely to occur, and to calculate storm return periods. In the distribution shown, approximately five percent of the rainfall events on record exceed 1.3 inches. Thus, the probability that a storm will exceed 1.3 inches is 0.05. Given a total of 827 storms in the 39-year period, one would expect 41.4 storms (.05 x 827) to equal or exceed 1.3 inches, an average of about one per year. The "1-year storm" for this location is therefore approximately 1.3 inches. Working in the opposite direction, one can similarly determine the depth of the 2-year storm. Recognizing that approximately 19.5 such storms (39/2) will occur in a 39-year period, the probability that any given storm will equal or exceed the 2-year storm is approximately 0.02 (19.5/827), or two percent.

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[5] The minimum measurable quantity of rain in any hour is usually 0.01 inches.

Referring again to the cumulative frequency distribution, about two percent of all storms equal or exceed two inches. Thus, the 2-year storm for this location is approximately two inches.[6]

Annual vs. Partial-Duration Series

Engineers employ two methods to evaluate storm frequencies: the use of annual data series and partial-duration data series. Annual series select the largest rainfall event of a given duration in each year and rank the resulting set of events by depth. A partial-duration series ranks all rainfall events of a given duration by their depth, regardless of the year in which they occurred; this approach recognizes that the largest storm in some years may be smaller than the secondary storms in others. Before the widespread use of computers, the analysis of a complete set of rainfall events was generally impractical. As a result, annual series were commonly used. Today, the availability of computers has made use of partial-duration series more common.

The largest storm in a partial-duration series will be the same as the largest storm in an annual series taken from the same set of data; however, the tenth-ranked storm of the partial-duration series is likely to exceed the equivalent storm of the annual series, and the magnitude of such differences is likely to increase as one proceeds down the ranking to storms that occur more frequently. To correct this possible source of error, standard multipliers have been developed to convert findings based on annual series to a partial-duration equivalent. Table 3-1 lists several of these conversion factors.

Table 3-1

ANNUAL TO PARTIAL-DURATION SERIES CONVERSION FACTORS

Return Period	Conversion Factor
2 Year	1.14
5 Year	1.04
10 Year	1.01

General Method for Calculating Return Periods

Once rainfall events for a given location are ranked by depth, one can use the following formula to estimate return periods for different size storms:

Return Period = (Years of data + 1)/Ranking.

[6] The analysis above includes data on all storms, regardless of the storm's length. Hence, the 1-year or 2-year storm is described without reference to duration.

Thus, if there are 39 years of data, the largest rainfall event is the 40-year storm, the second-largest is the 20-year storm, and the 40th largest is the 1-year storm. Through regression analysis, analysts can also use these data to project the depth of 100- and 200-year events.

General Method for Calculating the Probability of Experiencing the N-Year Storm

It is important to emphasize that storms with a given return period will not necessarily occur within that period. The return period (n) merely indicates that a storm of a given depth is likely to occur, on average, once every n years. For storms with a return period of more than one year, the probability of occurrence within the return period (e.g., the probability that the two-year storm will occur in the next two years) can be calculated using the following formula:

$$P = 1 - (1 \quad 1/n)^n,$$

where P is the probability of occurrence and n is the return period, in years. Thus, the probability of experiencing a storm within two years that is greater than or equal to the two-year storm is 0.75. For longer return periods the probability declines until, as n becomes very large, P approaches a limit of 0.632.[7]

Rainfall Frequency/Duration Data

Employing the procedure described above to calculate return periods for rainfall events of a given duration -- and repeating the procedure for many locations -- makes it possible to create maps that define rainfall contours (isopluvials) for specified storm frequencies and durations across a geographic area. In the 1950s, the U.S. Army Corps of Engineers' demand for information to support flood-control planning led to analysis of long-term rainfall data to develop isopluvial maps for the entire United States. The Weather Bureau and the Soil Conservation Service published the results of this analysis in the Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years (Hershfield, Technical Paper No. 40, 1961). This publication includes maps for return periods of 1, 2, 5, 10, 25, 50, and 100 years and durations of 0.5, 1, 2, 3, 6, 12, and 24 hours. Exhibit 3-4 shows an example, illustrating isopluvials for the 1-year/6-hour storm in the 48 contiguous states. Subsequent publications cover Puerto Rico, Hawaii, and Alaska, and provide additional detail on rainfall in mountainous regions. Although somewhat dated, these documents continue to serve as primary references for information on the frequency and depth of extreme rainfall events throughout the U.S.

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[7] Thus, if you live to be 100, you have only a 63.2 percent chance of experiencing the 100-year storm.

Exhibit 3-1

SAMPLE HOURLY RAINFALL DATA

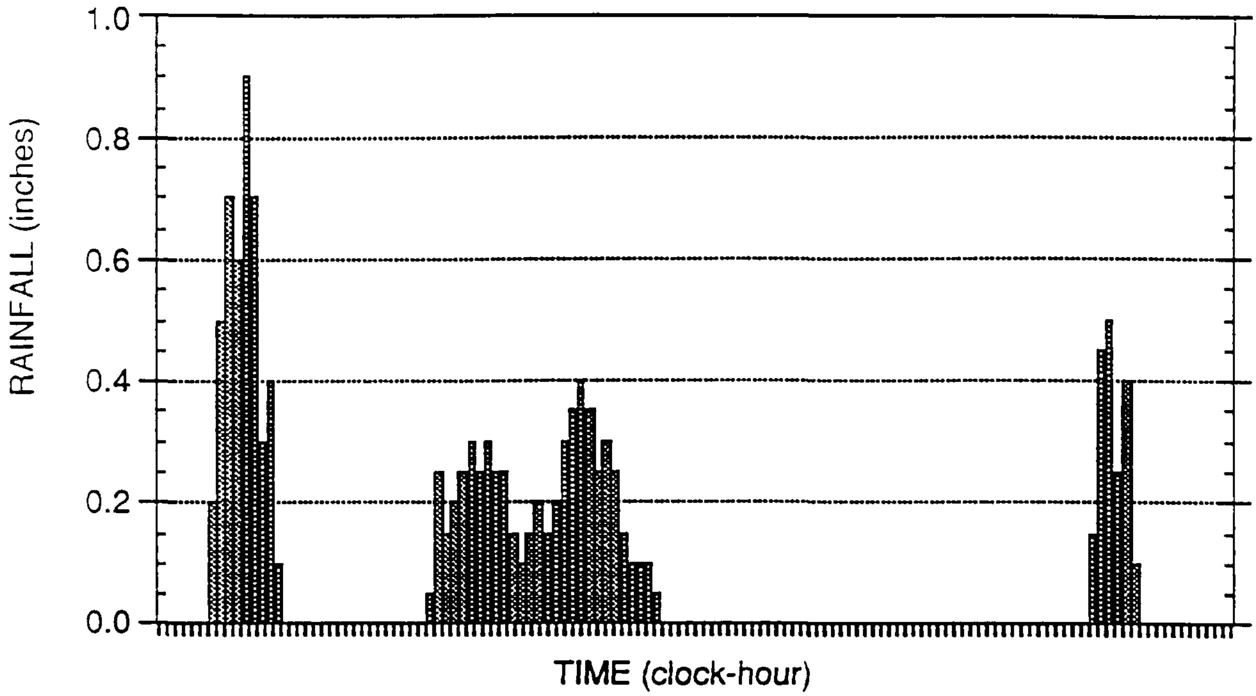


Exhibit 3-2

EXAMPLE OF A LOGNORMAL DISTRIBUTION

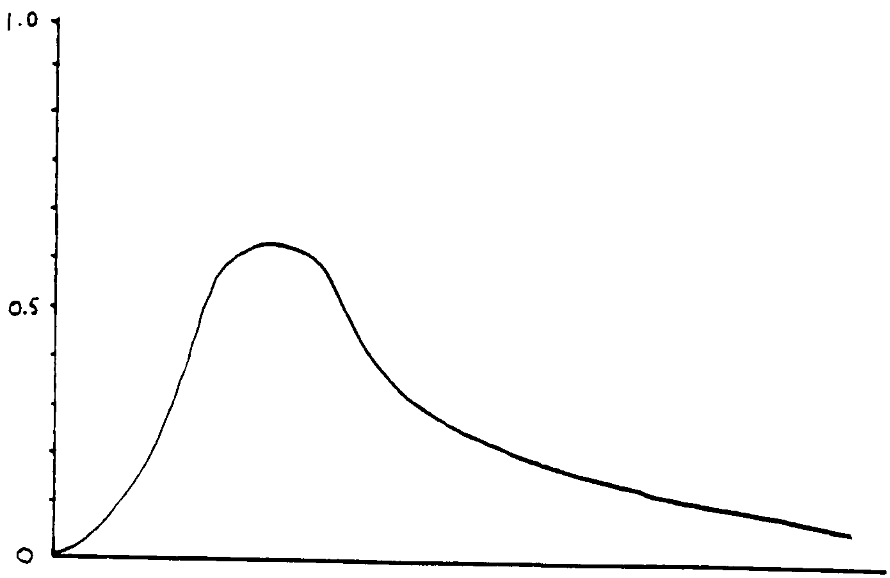


Exhibit 3-3

FREQUENCY DISTRIBUTION OF STORM EVENT VOLUMES

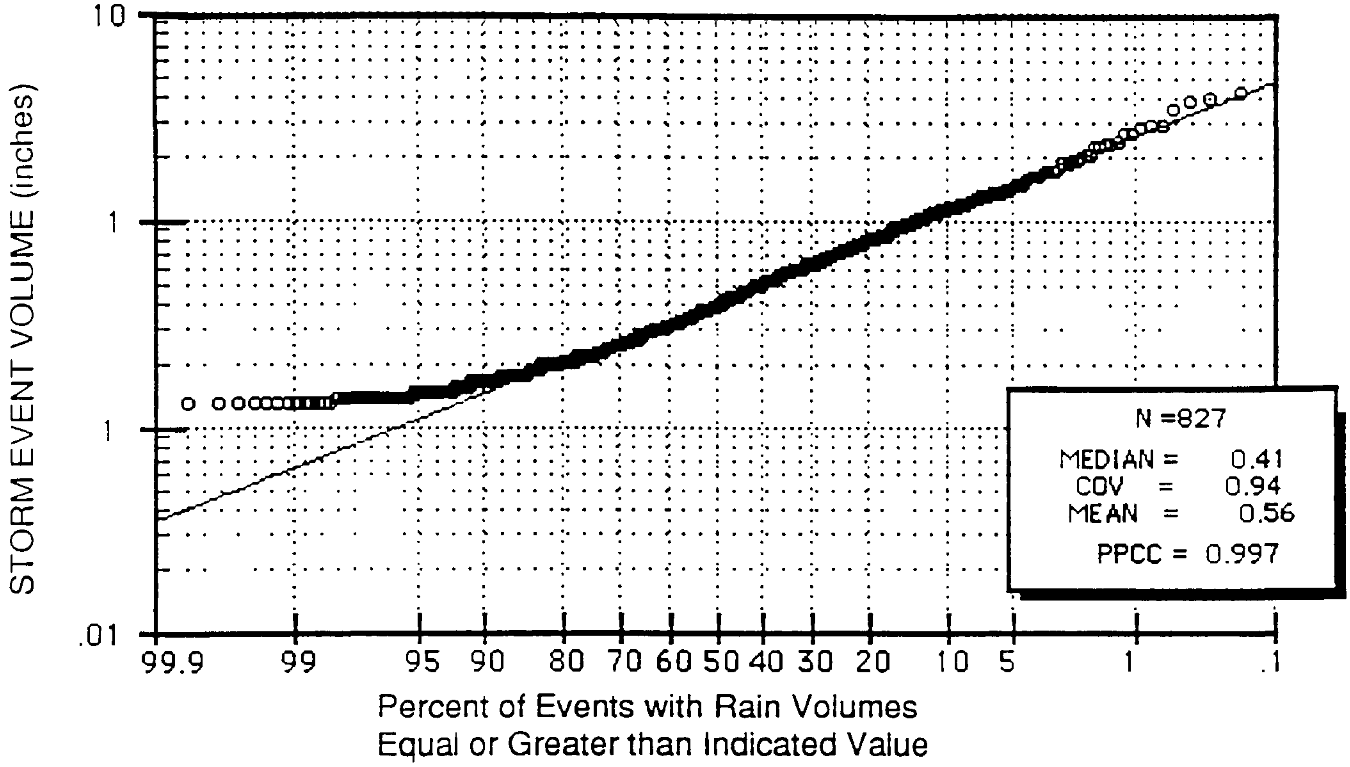
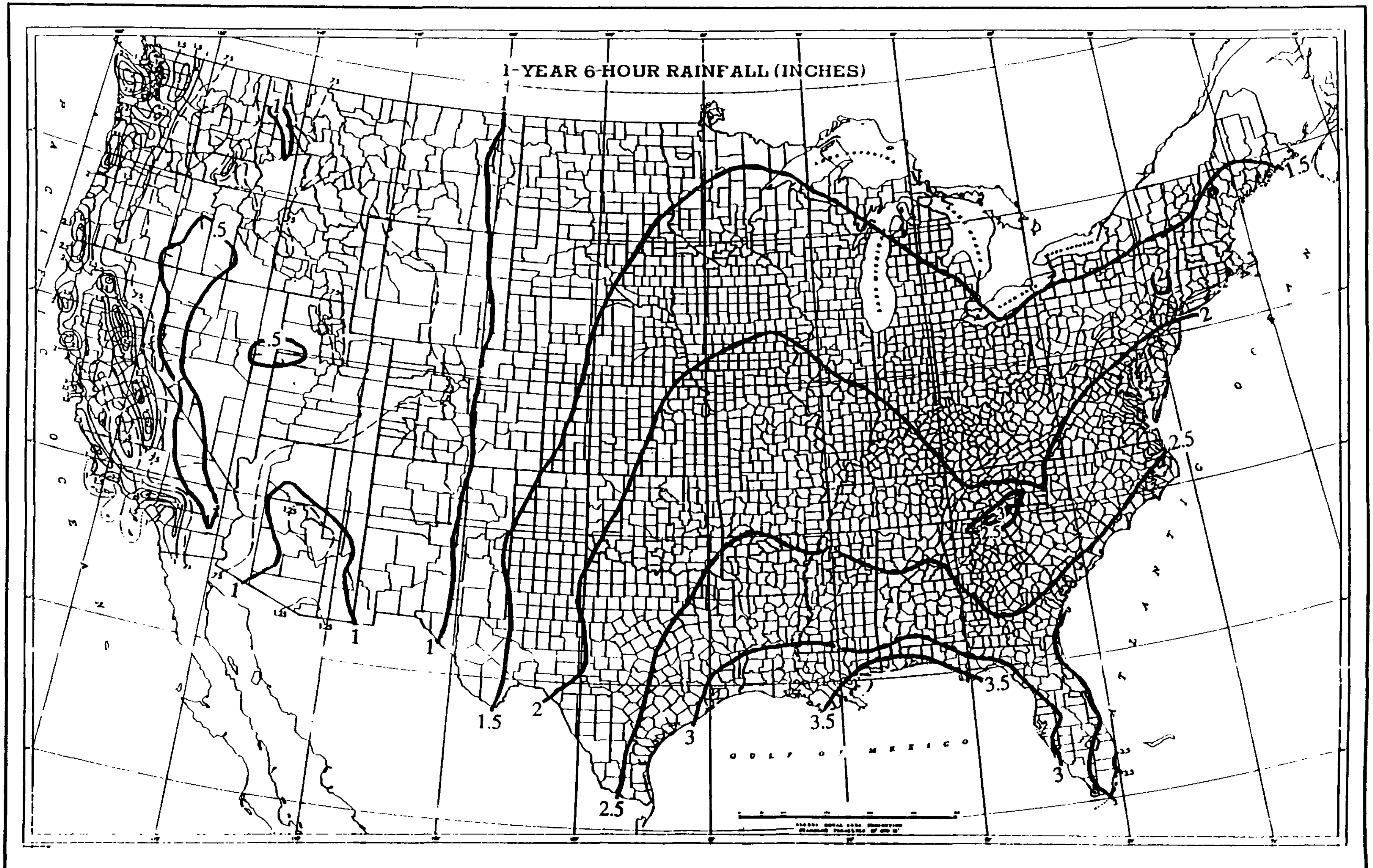


Exhibit 3-4

RAINFALL FREQUENCY/DURATION MAP



Source: Reduced copy from Hershfield, D.M. 1961. Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years. Technical Paper 40. Weather Bureau, U.S. Department of Commerce, Washington, D.C.

INTRODUCTION

The debate over regulatory or legislative initiatives to improve CSO control has focused to date on proposals to reduce the frequency with which untreated discharges occur. In some instances, including Senate Bill 1081 (filed in the Spring of 1991), these proposals call for a standard that would require communities to design and construct facilities to control wet weather discharges for all storm events smaller than a specified design storm. Other approaches under discussion would expressly limit the number of untreated CSO discharges that would be permitted each year, or would require control of wet weather flow up to a specified multiple of dry weather flow.

This chapter describes and compares four general approaches that have been proposed in Congress or employed by States or Regions to set CSO control standards:

(1) Requiring control of wet weather discharges based on a frequency/duration design storm, such as the 1-year/6-hour event proposed in S. 1081;

(2) Requiring control of wet weather discharges based on a depth/duration design storm, such as a 2.5-inch/24-hour event;

(3) Requiring control of wet weather discharges up to some multiple of dry weather flow, such as a factor of 10 (the "factor of flow" standard); and,

(4) Specifying an average or maximum number of allowable overflows per system or outfall each year.

Evaluation of the advantages and disadvantages of these wet weather standards requires careful consideration of a variety of factors, including their cost, relative effectiveness, enforceability, administrative feasibility, and resulting ecological, human health, and welfare benefits. In the absence of specific, detailed proposals and more complete information on the charateristics of the nation's combined sewer systems, these factors cannot be fully evaluated. For each general approach, however, it is possible to identify the underlying conditions likely to influence its practical impacts, and to use these insights to compare the implications of the approaches for different regions or different types of systems. This chapter develops such a comparison.

The following discussion focuses in particular on the effect of alternative approaches on three parameters:

(1) The frequency of uncontrolled overflows;

(2) The volume of wet weather discharge that must be controlled; and

(3) The wet weather flow for which treatment must be provided.

We focus on the frequency of uncontrolled overflows as an indicator of the potential environmental benefits of a wet weather standard. All other things equal, approaches that reduce the frequency of uncontrolled overflows more than others would be expected to provide greater environmental benefits.[1] We focus on the design standards' volume and flow management requirements as indicators of potential CSO control costs.[2] CSS's may employ a range of techniques to reduce pollutant discharges from overflows. A design standard is unlikely to influence the cost of some of these approaches (e.g., reducing infiltration and inflow, or repairing regulators to avoid dry weather overflows). A design standard, however, has direct implications for the cost of treatment devices, which are sized on the basis of flow, and for the cost of storage devices, which are sized on the basis of volume. All other things equal, the greater the wet weather volume and/or flow that must be controlled, the greater the expected cost of compliance.

CAVEATS

We emphasize that the conclusions we reach in analyzing alternative CSO design standards frequently rest on the implicit or explicit assumption, "all other things equal." A wide range of factors may influence the cost or effectiveness of a particular approach in a specific locale. For example, differences in the proportion of rainfall that ultimately enters a CSS as storm water runoff may cause compliance costs for two otherwise identical cities -- subject to the same standard and to identical rainfall conditions -- to differ significantly. Many other site-specific factors can have similar effects. The use of the assumption "all other things equal" is not meant to imply that no local variation exists; rather, it is employed specifically to control for the important influence of such factors, allowing us to illustrate the practical similarities and differences among alternative standards and to demonstrate more clearly how the impact of a particular standard may vary due to underlying differences in a specific parameter of interest.

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[1] The actual benefits of any wet weather design standard would also depend upon such factors as the nature of the receiving waters, the pollutants present in the combined sewer discharge, and the quality of treatment provided.

[2] The terms flow and volume are not interchangeable. Volume refers to the total quantity of wet weather discharge for which storage and treatment must be provided, and is typically measured in gallons. Flow refers to the volume of wastewater per unit of time for which conveyance and treatment systems must be designed, and is typically measured in gallons per minute.

DESIGN STORM STANDARDS

A design storm standard for CSOs would require combined sewer systems to be modified to control wet weather discharges associated with storms smaller than or equal to the design event. To enable engineers to determine the volume and flow of runoff associated with a design storm, at least two of three storm parameters -- depth, duration, and frequency -- must be defined. It is then possible to determine the value of the third, unspecified parameter, and ultimately -- given data on local runoff and combined sewer system conditions -- to calculate the associated wet weather volume and flow the system must control. The following discussion describes two approaches for specifying a design storm: a frequency/duration standard and a depth/duration standard.

Frequency/Duration Design Standard

Design storms can be defined with respect to frequency and duration. Specification of such a standard would require combined sewer systems to control wet weather discharges during all events smaller than or equivalent to the design event -- e.g., events smaller than or equal to the 1-year/6-hour storm, the greatest amount of rainfall, on average, expected to occur during six contiguous hours in a 365-day period.

The impact of a frequency/duration standard on the control of combined sewer overflows would depend upon the storm frequency and duration specified. Table 4-1 indicates, for the Cleveland area, how changes in storm frequency and/or duration affect rain depth. As the table shows, rain depth increases as the return period or duration of the design storm increases. This relationship suggests that the greater the duration or return period of the design storm, the greater the volume of rain that must be controlled.

Table 4-1

APPROXIMATE DEPTH OF SELECTED FREQUENCY/DURATION STORMS: CLEVELAND (INCHES)

Duration	Return Period	
	1 Year	25 Years
2 Hours	1.2	2.5
6 Hours	1.5	3.0
24 Hours	2.0	4.0

Increases in design storm return period and duration have conflicting effects on storm intensity. Using Cleveland once again as an example, Table 4-2 shows that the average intensity of design storms increases as the return period increases, but decreases as the duration of the storm increases.[3] These relationships suggest that increasing a design storm's return period (e.g., from 1 year to 25 years) would require CSSs to develop capacity to treat larger wet weather flows, but that increasing the design storm's duration (e.g., from 6 hours to 24 hours) would have the opposite effect on the treatment capacity required.

Table 4-2

AVERAGE INTENSITY OF SELECTED FREQUENCY/DURATION STORMS: CLEVELAND (INCHES PER HOUR)

	Return Period	
Duration	**1 Year**	**25 Years**
2 Hours	0.60	1.25
6 Hours	0.25	0.50
24 Hours	0.08	0.17

Depth/Duration Design Standard

Design storms can also be characterized by depth and duration; e.g., the 2.5-inch/24-hour storm. Specification of such a standard would require combined sewer systems to control wet weather discharges during all events smaller than or equal to a 2.5-inch/24-hour storm.

For a given location, the frequency with which a depth/duration design storm would occur varies with the depth and duration specified. Table 4-3 illustrates this effect, using Chicago as an example.[4] As the table indicates, return periods lengthen as the specified depth increases, indicating that for a given duration, the greater the depth of the design storm, the less frequently it will occur. For example, in Chicago, a 2-inch/2-hour storm would occur on average once in 5 years, but a 2.5-inch/2-hour storm would occur on average only once in 25 years. From the standpoint of CSO control, this suggests that for a given duration (e.g., 2 hours), the greater the depth of the design storm specified, the greater the storage and/or treatment capacity required to comply with the standard, and the lower the frequency of untreated overflows. Conversely, increasing the duration of a depth/duration design storm while holding depth constant shortens the return period. In Chicago, for instance, moving from a 2-inch/2-hour storm to a 2-inch/6-hour storm reduces the expected return period from 5 years to 1.5 years. This suggests that

[3] In other words, the shorter the design storm (for a given return period), the greater its intensity.

[4] The return periods shown in Table 4-3 are estimates that we have developed based upon a review of the rainfall frequency/duration maps presented in Hershfield's Rainfall Atlas. The precise values for Chicago may differ slightly from these estimates.

the longer the duration of a depth-duration design storm, the less stringent the level of control achieved and the greater the expected frequency of uncontrolled CSO discharges.

Table 4-3

APPROXIMATE RETURN PERIOD OF SELECTED DEPTH/DURATION STORMS: CHICAGO (YEARS)

Duration	Rain Depth		
	2 Inches	**2.5 Inches**	**3 Inches**
2 Hours	5	25	50
6 Hours	1.5	2	10
24 Hours	<1	1	3

The intensity of rainfall associated with a depth/duration design storm will also vary with the parameters employed. As Table 4-4 shows, increasing the depth of the design storm while holding duration constant increases not only the total amount of rainfall, but also the average intensity of the event. Thus, increasing the design storm's depth increases not only the volume but also the flow of rain that must be controlled. In contrast, increasing the design storm's duration while holding depth constant decreases the average intensity of the event. Such a change has no effect on the total volume of rain that must be controlled, but does reduce the average wet weather flow for which conveyance and treatment capacity must be provided.

Table 4-4

AVERAGE INTENSITY OF SELECTED DEPTH/DURATION STORMS (INCHES PER HOUR)

Duration	Rain Depth		
	2 Inches	**2.5 Inches**	**3 Inches**
2 Hours	1.00	1.25	1.50
6 Hours	0.33	0.42	0.50
24 Hours	0.08	0.10	0.13

Evaluation of Design Storms as a CSO Control Standard

Because of variation in regional rainfall, the use of a design storm as a national CSO wet weather standard would likely have different cost or pollution control implications for systems in different parts of the country. The nature of these differences would depend upon whether a frequency/duration or depth/duration design standard were employed.

As described in Chapter 3, the amount of rain associated with a given frequency/duration event varies with location. Exhibit 4-1 illustrates the extent of this variation for the 1-year/6-hour storm.[5] As the exhibit indicates, the 1-year/6-hour storm ranges from less than 0.5 inches in parts of the Southwest to greater than 3.5 inches along the Gulf Coast; in the Northeast and Midwest, where most CSSs are located, the range extends from roughly 1.0 to 2.0 inches. This variation indicates that the storage, conveyance and treatment capacity necessary to meet a frequency/duration standard is likely to differ somewhat from state to state, and therefore that systems located in states subject to larger storms probably would face higher compliance costs. This standard, however, would offer inter-regional consistency in controlling the frequency of combined sewer overflows, since the likelihood of experiencing a storm greater than a specified frequency/duration storm is roughly similar in all parts of the country. Thus, all other factors being equal, systems complying with the same frequency/duration standard should experience roughly the same number of uncontrolled overflows.

Table 4-5 further illustrates how control requirements might vary under a frequency/duration standard. The table shows that both the volume and rate of runoff from an impervious acre increase in proportion to the depth of the 1-year/6-hour storm. As a result, control requirements -- measured either with respect to the storage volume or the treatment capacity required to control the runoff from an impervious acre -- also increase proportionately. Thus, all other things equal, a 1-year/6-hour design storm would require some cities, such as Savannah and Wilmington, North Carolina, to provide greater wet weather control capacity than others, such as Boston and Buffalo.

In contrast to a frequency/duration standard, a depth/duration design storm would impose similar control capacity requirements on CSSs nationwide, but could in turn lead to wider variation in the frequency of uncontrolled overflows. Under a depth/duration standard, all systems would be required to provide capacity to control the runoff from a storm of the same depth and duration (and, therefore, the same average intensity). Although site-specific hydrologic and system conditions would influence the ultimate combined sewer volume and flow associated with a given depth/duration storm, this approach to setting a national CSO standard would imply less inter-regional variation in storage and treatment requirements than would a frequency/duration standard; therefore, it would imply greater similarity in compliance costs.[6] Because of inter-regional variations in rainfall, however, this approach would yield differences in the frequency with which untreated discharges would occur. Exhibit 4-2 gives some sense of the possible degree of variation, showing the return period for a 2-inch/6-hour storm in each of the 48 contiguous states. As this exhibit suggests, a standard depth/duration storm is likely to be exceeded

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[5] The exhibit includes data for the 48 contiguous states covered by Hershfield's Rainfall Atlas.

[6] This conclusion holds only under the assumption that all other factors that may influence compliance costs are equal. In practice, of course, complicating factors would likely lead to differences among systems. It may be the case, for example, that systems in areas with higher rainfall will require less additional construction than systems in areas with lower rainfall, as the systems in wetter areas already may be designed with relatively greater capacity to manage excess wet weather flow. Without a more detailed understanding of the particular systems in question, such relationships are not easily deduced.

with greater frequency in some states than others, leading to a disparity in the frequency of untreated discharges from combined sewer systems.

Table 4-5

THE EFFECT OF VARIATION IN THE 1-YEAR/6-HOUR STORM ON CSO CONTROL REQUIREMENTS

Depth (inches)	Runoff per Impervious Acre		Control Capacity Required		Example CSO Cities
	Volume (cubic feet)	Rate (cfs)	Storage (gallons/acre)	Treatment (MGD/acre)	
1.5	5,445	0.25	40,731	0.16	Boston; Buffalo; Cleveland; Detroit; Milwaukee
2.0	7,260	0.34	54,309	0.22	Des Moines; Louisville; Nashville; New York; Philadelphia; Washington
2.5	9,075	0.42	67,886	0.27	Savannah; Wilmington, North Carolina

As the discussion above suggests, specification of a uniform national design storm standard would not ensure uniformity in CSO control costs and performance. All other things equal, a frequency/ duration standard (e.g., the 1-year/6-hour storm) would tend to equalize the frequency of uncontrolled overflows from different systems, but would likely impose higher costs in rainier regions. In contrast, establishing a depth/duration standard (e.g., the 2.5-inch/24-hour storm) would tend to equalize wet weather capacity requirements -- and hence, control costs -- across systems, but would do so while allowing variations among systems in the frequency with which uncontrolled discharges occur.

Regardless of how it is specified, a design storm standard would be implemented and enforced as part of the development, review, and approval of CSS facility plans. To demonstrate compliance with the standard, combined sewer operating authorities would need to characterize hydrologic conditions throughout the system's service area and describe in depth the calculations employed to determine the storage and treatment capacity needed under design storm conditions. EPA and state regulators would probably require substantial time to review these plans and calculations, request changes, and certify compliance.

FACTOR OF DRY WEATHER FLOW

An alternative to the design storm approach to establishing a CSO standard is to specify the wet weather flow to be controlled as a multiple of the CSS's dry weather flow (i.e., the flow in the system due to sanitary, commercial, and industrial waste water). As described in Chapter 2, Illinois has adopted this approach, requiring primary treatment of all flows up to 10 times the design dry weather flow (the "10X" approach). Illinois' selection of this standard was based upon (1) the state's interest in controlling the "first flush" from CSOs during storm events, which typically contains the highest concentrations of pollutants, and (2) a state analysis that indicated that wet weather flows greater than ten times the dry weather flow tend to dilute pollutant concentrations to such an extent that water quality impacts are less severe than occur at lower flows. This section examines the implications of the factor of flow approach as a CSO control standard.

The practical implications of setting a CSO standard as a factor of dry weather flow would vary by location, depending on design flows, system characteristics, and hydrology. All other things equal, a higher multiplier would imply more stringent regulation, higher compliance costs (due to the need for greater storage and/or treatment capacity), and a higher standard of environmental protection. In practice, however, systems differ considerably. As a result, compliance costs and the standard of control achieved under a single multiplier would likely differ for different systems and regions.

Under a factor of flow approach, the cost of compliance is likely to vary with conditions that influence base flow, such as population and the mix of residential, commercial, and industrial dischargers a system serves. Consider, for example, two systems subject to identical rainfall and runoff, each serving small towns with identical populations and drainage areas. Due to the presence of a single industrial user -- e.g., a food processing plant -- System A receives twice the dry weather flow of System B. Under the factor of flow approach, System A would be required to provide twice the wet weather control capacity of System B, despite the fact that each system is subject to identical runoff volumes and flows. As a result, compliance costs would likely be higher for System A.

The degree of control offered by the factor of flow approach would vary with rainfall conditions. Again, consider two systems, A and B, each receiving identical dry weather flows and each serving identically-sized areas with identical surface runoff conditions. Because their base flows are identical, the systems would be required to provide similar wet weather storage and treatment capacity. If, however, System A were located in a rainier area, it would experience more frequent uncontrolled wet weather discharges than would System B. The compliance requirements for the two systems would be identical, but the practical standard of control achieved would differ.

The factor of flow approach would not explicitly tie wet weather storage and treatment requirements to receiving water quality. It would, however, control the first flush of pollutants and guarantee that uncontrolled discharges from combined sewer systems would be diluted by some minimum percentage of runoff; for example, a 10X factor of flow standard would ensure that the ratio of storm water to base flow in any uncontrolled discharge would be at least ten to one. If this ratio were sufficient under most circumstances to avoid water quality violations from CSOs, and also could be shown to be economically achievable, the approach might prove an attractive alternative for a uniform national standard. However, variation in receiving waters and in the concentration of pollutants in both base flow and runoff would make it difficult to derive a uniform, environmentally acceptable and economically achieveable standard. Moreover, attempting to set a standard based on a dilution factor would ignore the potential long-term build-up of persistent and bioaccumulative pollutants in aquatic ecosystems.

Like the design storm approach, implementation of a factor of flow approach would require engineers to modify facilities to control and treat a given quantity of runoff. As under the design storm approach, implementation and enforcement would entail the development and review of detailed facilities plans. In contrast, however, these plans would not require detailed analysis to predict the volume and flow of runoff associated with a rainfall event; instead, greater attention would be devoted to quantifying the system's dry weather flow, the factor that ultimately would determine wet weather storage and treatment requirements. Specification of storage and treatment requirements might be simplified if the standard were based on design rather than actual dry weather flow, since information on design flow may be available from historical records. Determination of actual dry weather flow would likely require some form of monitoring and development of mutually agreed upon procedures for averaging variations in actual flow.

OVERFLOW FREQUENCY

A fourth approach to setting a CSO standard is to directly specify a limit on the number of overflows that a system would be allowed in a given time period; e.g., four overflows per year. As noted in Chapter 2, several states have adopted some form of overflow frequency limit. This approach is similar to the use of a frequency/duration design storm in that both would tend to equalize the level of control across systems, but would likely cause compliance costs to vary with differences in regional rainfall. In contrast to a frequency/duration standard, however, an overflow frequency limit expresses the wet weather standard in terms that are likely to be less subject to debate and confusion. The relative stringency of alternative overflow frequency limits can be readily compared and understood by laymen, while the stringency of alternative design storms -- e.g., a 5-year/2-hour storm versus a 1-year/6-hour storm -- cannot be discerned without reference to rainfall data. In addition, an overflow frequency limit lends itself more readily to flexible application. It would be possible, for example, to set overflow limits on an outfall-by-outfall basis, depending upon the nature of the waters to which the outfalls discharge.

Because some years will be rainier than others, we assume that an overflow frequency design standard would be specified as a long-run average, rather than as a maximum never to be exceeded in any year (it would be statistically impossible to demonstrate perfect compliance with a standard that made no allowance for chance variations in rainfall). It would be necessary, however, to specify whether the limit applies to the entire system or to each outfall; in the latter case, the standard would also need to state whether it is necessary to demonstrate compliance outfall-by-outfall, or whether it is permissible to average the predicted number of overflows across all outfalls.

The cost of complying with a uniform overflow frequency limit would vary across regions. Holding other factors constant, systems located in regions with greater rainfall would probably face greater compliance costs. Other factors that affect runoff to combined sewer systems, such as the runoff coefficient in the drainage area, would also influence costs. In contrast, however, the approach would provide a consistent standard of performance, since all systems would be held to the same overflow limit.

As with the approaches previously discussed, an overflow frequency limit would be implemented and enforced at the design stage.[7] Under this approach, however, facilities plans would be required to focus particular attention on the relationship between rainfall events and overflows. Demonstrating compliance could possibly require sophisticated modeling of system performance under a range of storm conditions. As with the other approaches, development, review and approval of this analysis could prove time-consuming.

Like the other approaches, an overflow frequency limit would be incorporated as part of a minimum technology-based standard for CSOs. More stringent limits, including the prohibition of all uncontrolled overflows, could still be mandated for situations in which technology-based requirements proved inadequate to achieve applicable water quality standards.

INTERRELATIONSHIPS

Given detailed information on a specific location's meteorology, hydrology, and sewer system, it would be possible to compare the stringency of specific CSO regulatory alternatives, both with respect to the frequency of overflows allowed and the costs of compliance. Such a detailed analysis is beyond the scope of this report. It is possible, however, to develop a simple comparison of the relative stringency of some alternatives. For purposes of this discussion, we define the stringency of the options according to the wet weather volume and flow they would require to be controlled. If on-line flow-through treatment (e.g., screening, filtration, etc.) is the preferred technological option, the flow requiring treatment determines the stringency of the standard. If storage prior to treatment is the preferred control technique, the volume of water that must be controlled is the primary indicator of the standard's stringency.

The following discussion compares the stringency of alternative CSO design standards for a city on the Ohio River. The standards compared include a 1-year/6-hour storm, a 10X factor of flow, and a 2.5-inch/24-hour standard. Due to the lack of detailed information needed to translate each of these standards to an estimate of the number of uncontrolled overflows, no quantitative comparison of these standards with an overflow frequency limit is possible.

Flow Control Requirements

In the city chosen for our example, the 1-year/6-hour storm yields about two inches of rainfall. Therefore, the storm's average intensity is 0.33 inches per hour. Assuming a runoff coefficient of 0.7, this translates to a runoff rate of approximately 105 gallons per acre per minute. In comparison, the estimated dry weather flow for the city's system is approximately 150 gallons per capita per day. Assuming a population density of 15 persons per acre, this per capita flow translates to about 1.6 gallons per acre per minute. Thus, for this city, the flow associated with the 1-year/6-hour design storm is about

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[7] While it is theoretically possible to impose an overflow frequency limit as a performance standard, such an approach would be impractical. Given the detailed study and large, long-term investment in sewers and treatment plants that may be required to address the CSO problem, it is difficult to justify any standard that would not be enforced at the design stage, before construction begins.

67 times the dry weather flow, or roughly seven times greater than the flow subject to treatment under the 10X factor of flow standard.[8]

In comparison to the city's 1-year/6-hour storm, a 2.5-inch/24-hour design storm is much less intense -- only 0.1 inches per hour. Using the same assumptions employed above, the runoff rate for this storm would be approximately 33 gallons per acre per minute, or about 21 times the dry weather flow. Thus, for this location, a 2.5-inch/24-hour design storm would prove roughly twice as stringent with respect to flow as the 10X factor, but only a third as stringent as the 1-year/6-hour storm.

Volume Control Requirements

As noted above, the parameter of interest for evaluating wet weather storage requirements is the volume of water that must be controlled. The implications of a factor of flow standard for storage requirements is unclear, since the standard is articulated solely with respect to flow. It is possible, however, to compare the relative stringency of the two design storms with respect to volume, simply by comparing rain depth for the two storms: the quantity of rain that falls in a 2.5-inch/24-hour storm is 25 percent greater than the 2 inches that fall in the city's 1-year/6-hour storm. Thus, for the sample site, a 2.5-inch/24-hour design storm implies more stringent storage requirements than a 1-year/6-hour design storm.

COMPARISON AND CONCLUSIONS

As noted earlier in this report, in the absence of specific CSO design proposals it is difficult to compare in detail the relative cost, effectiveness, and environmental benefits of alternative CSO design standards. As described below, however, the preceding discussion offers some general insights regarding administrative and operational similarities and differences among the four approaches.

First, from an administrative perspective, the four alternatives analyzed above are quite similar. Each would be implemented and enforced as a design standard. Each would require detailed study to demonstrate compliance, although the analysis needed to demonstrate compliance with an overflow frequency limit might prove more complex and statistically sophisticated than that required under the other approaches. Because CSO projects in general already rely on detailed facility plans -- technical documents that include data on CSO frequency, volume, duration, and pollutant loads; evaluations of receiving water impacts; and assessments of the cost and effectiveness of CSO pollution abatement alternatives -- these requirements seem unlikely to pose a significantly greater analytic burden on CSO permittees. The implementation of a uniform national standard, however, is likely to increase the degree of regulatory oversight exercised by the States and EPA. To date, oversight of the recommendations proposed by permittees in facilities plans has been very limited, and in the absence of specific guidance or design criteria the CSO controls adopted have varied greatly. Implementation of a uniform national

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[8] In practice, the multiplier employed in the factor of flow approach could be applied to the system's design dry weather flow, rather than the average dry weather flow used in these calculations. If design flow were greater than average flow, a factor of flow standard would control a correspondingly larger wet weather flow than our calculations indicate.

standard for CSOs would ensure greater consistency in CSO abatement, but would require EPA and state regulators to devote substantial time to review facility plans, request changes, and certify compliance.

Second, from an operational standpoint, the four regulatory approaches evaluated fall into two general categories. The first category consists of alternatives that would consistently limit the frequency of overflows across systems regardless of likely differences in compliance costs; it includes approaches that would specify a frequency/duration design storm or an overflow frequency limit. The second category consists of alternatives that would require comparable wet weather storage and treatment capacity for systems that are otherwise similar but, because of differences in rainfall and/or runoff, might differ markedly with respect to the frequency of overflows. It includes approaches that would specify a depth/duration design storm or set control requirements based on a factor of dry weather flow. Thus, these two categories reflect fundamentally different means of defining a "uniform" wet weather design standard. The first would set a standard that aims to achieve uniform performance, as measured by the frequency of untreated overflows. The second would set a standard that tends to equalize control capacity and, hence, compliance costs, regardless of resulting differences in the frequency with which untreated discharges would occur.

Ultimately, the choice need not be limited to the four options this chapter describes. One alternative is to continue to rely on best professional judgment to establish technology-based requirements for CSOs on a permit-by-permit basis. While this approach to date has not satisfactorily addressed the CSO problem nationwide, EPA's renewed efforts under the National CSO Strategy suggest that progress will be made. Another alternative -- albeit inconsistent with the standard NPDES approach of the Clean Water Act -- would be to forego a technology-based standard entirely, and instead tailor CSO permit requirements on a case-by-case basis according to the level of control needed to comply with water quality standards. In theory, this approach would offer the greatest economic efficiency in achieving water quality goals. In practice, however, setting CSO control standards based solely on water quality requirements has proved to be quite difficult, and the lack of a technology-based requirement for CSOs has been and remains a major factor in making their regulation complicated and their abatement elusive. In general, the development of water quality-based permits has been hampered by:

(1) The lack of comprehensive monitoring data on CSO discharges;

(2) Lack of detailed analysis relating CSO discharges to the nature and extent of water quality violations;

(3) Extreme difficulty and uncertainty in translating water quality criteria and standards into numeric effluent limits for CSOs;[9]

[9] A particular difficulty in developing water quality-based permits for CSOs is the stochastic nature of the storm events that trigger CSO discharges. Given the narrative criteria prohibiting discharges of floatables, oil and grease, solids, etc., a strict interpretation of most state water quality standards would hold that any untreated CSO discharge -- even overflows caused by the 100-year storm -- would constitute a violation. Compliance with this strict interpretation would in all probability require communities to separate their sewer and storm water systems. As an alternative, some states (Indiana, New Hampshire, North Carolina, Vermont, and the District of Columbia) have included provisions in their water quality standards that allow for exceedences if caused by CSOs during specified high flow conditions.

(4) The lack of adequate water quality criteria for nutrients, many toxic pollutants, and contaminated sediments; and,

(5) Inconsistent water quality standards from state to state, particularly for pathogens.

These obstacles have slowed improvements in CSO control substantially, and in the absence of a national technology-based standard could continue to do so. Moreover, it is likely to be administratively infeasible to set water quality-based permit limits for each of the thousands of combined sewer outfalls nationwide. In light of these concerns, the establishment of a state or national technology-based standard that relates to water quality goals could prove to be essential to timely progress.

Should Congress or EPA determine that it is necessary to set a design standard for CSOs, the issue returns again to how best to balance cost, administrative feasibility and other concerns against environmental goals. One means of doing so would be to consider a targeted, risk-based approach that combines aspects of the alternatives described above. For example, the stringency of the design standard might be linked to the aquatic resources affected by CSOs: discharges to high priority or high use waters (e.g., discharges that damage a shellfish bed or swimming beach) could be prohibited, while discharges to lower priority waters could be held to a non-zero overflow frequency limit. Such an approach might prove a viable means of establishing a technology-based standard without (1) ignoring situations in which the cost of meeting that standard is disproportionately high relative to water quality benefits, or (2) imposing similar treatment requirements regardless of need. Such targeted flexibility could help make a technology-based standard for CSOs more efficient, equitable, and affordable.

Exhibit 4-1

MAGNITUDE OF THE 1-YEAR/6-HOUR STORM, BY STATE

EPA Region	State	Number of Combined Sewer Systems	1-Year/6-Hour Rainfall Low (Inches)	1-Year/6-Hour Rainfall High (Inches)
1	Connecticut	13	1.50	1.50
	Maine	61	1.00	1.50
	Massachusetts	26	1.50	1.50
	New Hampshire	22	1.00	1.50
	Rhode Island	3	1.50	1.50
	Vermont	31	1.00	1.50
	SUBTOTALS	**156**	**1.00**	**1.50**
2	New Jersey	28	1.50	2.00
	New York	90	1.00	2.00
	Puerto Rico	NA	NA	NA
	Virgin Islands	NA	NA	NA
	SUBTOTALS	**118**	**1.00**	**2.00**
3	Delaware	3	2.00	2.00
	Dist. of Columbia	1	2.00	2.00
	Maryland	7	1.50	2.00
	Pennsylvania	140	1.50	2.00
	Virginia	4	1.50	2.00
	West Virginia	50	1.50	1.50
	SUBTOTALS	**205**	**1.50**	**2.00**
4	Alabama	0	2.00	3.50
	Florida	0	2.50	3.50
	Georgia	5	2.00	2.50
	Kentucky	22	1.50	2.00
	Mississippi	0	2.00	3.50
	North Carolina	0	1.50	2.50
	South Carolina	0	2.00	3.00
	Tennessee	3	1.50	2.00
	SUBTOTALS	**30**	**1.50**	**3.50**
5	Illinois	135	1.50	2.00
	Indiana	141	1.50	2.00
	Michigan	85	1.00	1.50
	Minnesota	6	1.00	1.50
	Ohio	109	1.50	1.50
	Wisconsin	2	1.50	1.50
	SUBTOTALS	**478**	**1.00**	**2.00**

Exhibit 4-1
(continued)

EPA Region	State		Number of Combined Sewer Systems	1-Year/6-Hour Rainfall Low (Inches)	1-Year/6-Hour Rainfall High (Inches)
6	Arkansas		1	2.00	2.50
	Louisiana		0	2.50	3.50
	New Mexico		1	0.75	1.00
	Oklahoma		0	1.00	2.50
	Texas		0	0.75	3.00
	SUBTOTALS		**2**	**0.75**	**3.00**
7	Iowa		19	1.50	2.00
	Kansas		3	1.00	2.00
	Missouri		14	2.00	2.00
	Nebraska		3	1.00	2.00
	SUBTOTALS		**39**	**1.00**	**2.00**
8	Colorado		1	0.75	1.00
	Montana		1	0.75	1.00
	North Dakota		0	1.00	1.00
	South Dakota		1	1.00	1.50
	Utah		0	0.50	0.75
	Wyoming		0	0.75	1.00
	SUBTOTALS		**3**	**0.50**	**1.50**
9	Arizona		0	0.75	1.25
	California	North	1	1.00	3.00
		South	1	0.50	2.00
	Hawaii		0	NA	NA
	Nevada		0	0.50	0.75
	SUBTOTALS		**2**	**0.50**	**3.00**
10	Alaska		0	NA	NA
	Idaho		2	0.75	1.00
	Oregon	East	0	0.50	0.75
		West	4	0.75	3.00
	Washington		11	0.50	3.00
	SUBTOTALS		**17**	**0.50**	**3.00**
	US TOTALS		**1050**	**0.50**	**3.50**

Sources: EPA, "Status of Strategy Approvals," January 16, 1992.

Hershfield, D.M., "Rainfall Frequency Atlas of the US," Weather Bureau Technical Paper No. 40, Washington, DC, GPO, 1961.

Exhibit 4-2

RETURN PERIOD FOR THE 2-INCH/6-HOUR STORM, BY STATE

EPA Region	State	Number of Combined Sewer Systems	2-Inch/6-Hour Storm Return Period (years)
1	Connecticut	13	2
	Maine	61	2-50
	Massachusetts	26	2
	New Hampshire	22	2-25
	Rhode Island	3	2
	Vermont	31	5
	SUBTOTALS	**156**	**2-50**
2	New Jersey	28	2-25
	New York	90	1-2
	Puerto Rico	NA	NA
	Virgin Islands	NA	NA
	SUBTOTALS	**118**	**1-25**
3	Delaware	3	1-2
	Dist. of Columbia	1	1-2
	Maryland	7	1-2
	Pennsylvania	140	2-5
	Virginia	4	1-2
	West Virginia	50	2-5
	SUBTOTALS	**205**	**1-5**
4	Alabama	0	1
	Florida	0	<1
	Georgia	5	1
	Kentucky	22	1-2
	Mississippi	0	1
	North Carolina	0	1-2
	South Carolina	0	1
	Tennessee	3	1-2
	SUBTOTALS	**30**	**<1-2**
5	Illinois	135	1-2
	Indiana	141	1-2
	Michigan	85	5-50
	Minnesota	6	2-50
	Ohio	109	2-25
	Wisconsin	2	2-5
	SUBTOTALS	**478**	**1-50**

Exhibit 4-2
(continued)

EPA Region	State		Number of Combined Sewer Systems	2-Inch/6-Hour Storm Return Period (years)
6	Arkansas		1	1
	Louisiana		0	<1
	New Mexico		1	5-50
	Oklahoma		0	1-2
	Texas		0	1-50
	SUBTOTALS		**2**	**<1-50**
7	Iowa		19	1-2
	Kansas		3	1-5
	Missouri		14	1
	Nebraska		3	2-25
	SUBTOTALS		**39**	**1-25**
8	Colorado		1	5-50
	Montana		1	10-50
	North Dakota		0	5-50
	South Dakota		1	2-25
	Utah		0	25-100
	Wyoming		0	10-50
	SUBTOTALS		**3**	**2-100**
9	Arizona		0	5-50
	California	North	1	1-100
		South	1	1-100
	Hawaii		0	NA
	Nevada		0	25-100
	SUBTOTALS		**2**	**1-100**
10	Alaska		0	NA
	Idaho		2	25-100
	Oregon	East	0	10-100
		West	4	1-50
	Washington		11	100
	SUBTOTALS		**17**	**1-50**
	US TOTALS		**1050**	**<1-100**

Note: The return periods shown above are approximate. They have been estimated based on the maps presented in the "Rainfall Frequency Atlas of the US."

Sources: EPA, "Status of Strategy Approvals," January 16, 1992.

Hershfield, D.M., "Rainfall Frequency Atlas of the US," Weather Bureau Technical Paper No. 40, Washington, DC, GPO, 1961.

Appendix A

COMMUNITIES WITH COMBINED SEWER SYSTEMS: DATA FROM THE 1980 NEEDS SURVEY'S SUPPLEMENTARY DATABASE

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
AK	CORDOVA	PRINCE WILLIAM SOUND	60	2,110
AK	JUNEAU	GASTINEAU CHANNEL	4,800	26,751
CA	BLYTHE	CITY STP POND	11,000	8,428
CA	BRAWLEY	NEW RIVER	14,000	18,923
CA	SACRAMENTO	SACRAMENTO RIVER	96,119	369,365
CA	SAN FRANCISCO	SAN FRANCISCO BAY	473,000	723,959
CA	SAN FRANCISCO	PACIFIC OCEAN	258,000	723,959
CO	DELTA		4,500	3,789
CO	GRAND JUNCTION	COLORADO RIVER	37,600	29,034
CO	LA JARA		781	725
CO	PUEBLO	ARKANSAS RIVER	107,800	98,640
CO	SPRINGFIELD		1,660	1,475
CO	TRINIDAD	PURGATOIRE RIVER	0	8,580
CT	BRIDGEPORT	BRIDGEPORT HARBOR	50,000	141,686
CT	DERBY	HOUSATONIC R	11,000	12,199
CT	GRISWOLD	QUINEBAUG R	3,250	10,384
CT	HARTFORD	CONNECTICUT R	110,000	139,739
CT	MIDDLETOWN	COGINCHAUG R	8,014	42,762
CT	NEW HAVEN	NEW HAVEN HARBOR	84,300	130,474
CT	NORWALK	NORWALK HARBOR	15,800	78,331
CT	NORWICH	THAMES R	23,000	37,391
CT	PORTLAND	CONNECTICUT RIVER	150	5,645
CT	SHELTON	HOUSATONIC RIVER	8,800	35,418
CT	STAFFORD SPRINGS	WILLIMANTIC RIVER	80,056	4,100
CT	THOMPSONVILLE	CONNECTICUT R	9,900	8,458

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
CT	WATERBURY	NAUGATUCK RIVER	6,947	108,961
CT	WEST HARTFORD	CONNECTICUT RIVER	4,000	60,110
DC	WASHINGTON	POTOMAC RIVER	489,093	606,900
DE	WILMINGTON	BRANDYWINE CREEK	80,368	71,529
DE	BRIDGEVILLE	NANTICOKE RIVER	1,400	1,210
DE	LEWES	LEWES–REHOBOTA CANAL	2,820	2,295
DE	MILFORD	MISPILLION RIVER	4,880	6,040
DE	SEAFORD	NANTICOKE RIVER	600	5,689
FL	SANFORD	LAKE MONROE	4,370	32,387
GA	ALBANY	FLINT RIVER	60,000	78,122
GA	ATLANTA	UTOY CREEK	195,775	394,017
GA	ATLANTA	SOUTH RIVER	51,900	394,017
GA	ATLANTA	CHATAHOOCHEE RIVER	63,900	394,017
GA	AUGUSTA	SAVANNAH RIVER	54,863	44,639
GA	COLUMBUS	CHATAHOOCHEE RIVER	22,970	178,681
GA	ROME	COOSA RIVER	5,400	30,326
GA	SAVANNAH	VERNON RIVER	18,210	137,560
IA	ADEL	NORTH RACCON RIVER	675	3,304
IA	ALBIA	CEDAR CREEK	1,300	3,870
IA	BURLINGTON	MISSISSIPPI	32,645	27,208
IA	CLINTON	MISSISSIPPI	34,000	29,201
IA	COUNCIL BLUFFS	MISSOURI	62,397	54,315
IA	DAVENPORT	MISSISSIPPI RIVER	60,000	95,333

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
IA	DES MOINES	DES MOINES RIVER	100,000	193,187
IA	EAGLE GROVE	BOONE RIVER	4,519	3,671
IA	FORT MADISON	MISSISSIPPI	15,500	11,618
IA	GOWRIE	WEST BUTTERICK CREEK	1,294	1,028
IA	KEOKUK	MISSISSIPPI	14,091	12,451
IA	MONTROSE	MISSISSIPPI RIVER	838	957
IA	MOUNT PLEASANT	BIG CREEK	7,303	8,027
IA	MUSCATINE	MAD CREEK	24,083	22,881
IA	OLIN	WALNUT CREEK	700	663
IA	OTTUMWA	DES MOINES RIVER	30,000	24,488
IA	RINGSTEAD	BLACK CAT CREEK	50	481
IA	SIOUX CITY	MISSOURI RIVER	4,000	80,505
IA	WASHINGTON	W FORK CROOKED CREEK	3,675	7,074
IA	WEBSTER CITY	BOONE RIVER	8,488	7,894
ID	BLACKFOOT	SNAKE RIVER	3,716	9,646
ID	BONNERS FERRY	KOOTENAI RIVER	2,700	2,193
ID	BOVILL	POTLATCH RIVER	358	256
ID	GENESEE	COW CREEK	741	725
ID	IDAHO FALLS	SNAKE RIVER	31,500	43,929
ID	MOUNTAIN HOME	PAYETTE RIVER	0	7,913
ID	NEW PLYMOUTH	PAYETTE RIVER	1,089	1,313
ID	OROFINO	CLEARWATER RIVER	2,000	2,868
ID	PRIEST RIVER	PEND OREILLE RIVER	286	1,560
ID	RUPERT	SNAKE RIVER	482	5,455
ID	SPIRIT LAKE	SPIRIT LAKE	75	790
ID	ST ANTHONY	HENRYS FORK	2,810	3,010
ID	ST MARIES	ST JOESPH RIVER	20	2,442

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
ID	WALLACE	COVER D'ALENE RIVER	235	1,010
IL	ADDISON	SALT CREEK	3,000	32,058
IL	ALTON	WOOD RIVER	39,700	32,905
IL	ASSUMPTION	BIG GEORGE CREEK	1,500	1,244
IL	AURORA	FOX RIVER	60,000	99,581
IL	BATAVIA	FOX RIVER	4,760	17,076
IL	BEARDSTOWN	ILLINOIS RIVER	6,700	5,270
IL	BELLEVILLE	RICHLAND CREEK	39,709	42,785
IL	BENLD	CAHOKIE CREEK	1,780	1,604
IL	BLOOMINGTON	SUGAR CREEK	11,200	51,972
IL	BLUE ISLAND		0	21,203
IL	BRADLEY	KANKAKEE RIVER	10,276	10,792
IL	BRADLEY	KANKAKEE RIVER	5,000	10,792
IL	BUREAU JUNCTION	ILL & MISS CANAL	420	350
IL	BYRON	ROCK RIVER	1,900	2,284
IL	CAIRO	OHIO RIVER	6,500	4,846
IL	CANTON	SPOON RIVER	15,000	13,922
IL	CARLINVILLE	MACOUPIN CREEK	5,765	5,416
IL	CARMI	LITTLE WABASH RIVER	780	5,564
IL	CASEY	TRIB TO EMBARRAS RIVE	300	2,914
IL	CHARLESTON	TRIB TO KICKAPOO CRK	26,403	20,398
IL	CHICAGO	LITTLE CALUMET RIVER	563,344	2,783,726
IL	CHICAGO	NORTH SHORE CHANNEL	1,406,255	2,783,726
IL	CHICAGO	CHICAGO SAN & SHIP CA	2,423,431	2,783,726
IL	CHICAGO	WILLIAM HIGGINS CRK	66,200	2,783,726
IL	CHICAGO	SALT CREEK	0	2,783,726
IL	CHRISMAN	BROUILLETTS	850	1,136

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
IL	CLINTON	SALT CREEK	7,604	7,437
IL	COWDEN	KASKASKIA RIVER	517	599
IL	DALZELL	SPRING CREEK	20	587
IL	DECATUR	STEVENS CK/SANGAMON	40,000	83,885
IL	DIXON	ROCK RIVER	6,800	15,144
IL	DOLTON		0	23,930
IL	DWIGHT	GOOSEBERRY CREEK	650	4,230
IL	EARLVILLE	INDIAN CREEK	1,400	1,435
IL	EAST ST LOUIS	MISSISSIPPI RIVER	70,169	40,944
IL	EDWARDSVILLE	CAHOKIA CREEK	4,000	14,579
IL	EFFINGHAM	TRIB TO SALT CREEK	10,000	11,851
IL	ELGIN	FOX RIVER	40,600	77,010
IL	ELLSWORTH	TRIB TO SANGAMON RIV	25	224
IL	FAIRBURY	INDIAN CREEK	2,450	3,643
IL	FARMER CITY	SALT CREEK	1,211	2,114
IL	GALESBURG	CEDAR FORK CREEK	30,000	33,530
IL	GALESBURG	CEDAR FORK CREEK	30,000	33,530
IL	GEORGETOWN	LITTLE VERMILLION	4,100	3,678
IL	GIBSON	DRUMMER CREEK	1,000	3,396
IL	GRANITE CITY	MISSISSIPPI RIVER	13,333	32,862
IL	HARRISBURG	MIDDLE FORK CREEK	9,500	9,289
IL	HARTFORD	MISSISSIPPI RIVER	2,300	1,676
IL	HAVANA	ILLINOIS RIVER	4,450	3,610
IL	HIGHWOOD	LAKE MICHIGAN	0	5,331
IL	HINSDALE	FLAGG CREEK	12,000	16,029
IL	JACKSONVILLE	MAUVAISTERRE CREEK	5,500	19,324
IL	JERSEYVILLE	DEARCY CREEK	6,240	7,382
IL	JOLIET	DES PLAINES RIVER	12,000	76,836

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
IL	JOLIET	HICKORY CREEK	71,000	76,836
IL	KANKAKEE	KANKAKEE RIVER	15,000	27,575
IL	KENILWORTH		3,000	2,402
IL	KINCAID	SO FORK SANGAMON RIV	1,500	1,353
IL	LA SALLE	ILLINOIS RIVER	1,000	9,717
IL	LADD	SPRING CREEK	1,400	1,283
IL	LEMONT	CHGO SAN & SHIP CANAL	5,120	7,348
IL	LEROY	SALT CREEK	2,630	2,777
IL	LINCOLN	SALT CREEK	21,700	15,418
IL	LITCHFIELD	LAKE LOU YAEGER	7,340	6,883
IL	LOCKPORT	DEEP RUN CREEK	6,437	9,401
IL	LOMBARD	E BRANCH–DUPAGE RIV	32,000	39,408
IL	MARSHALL	LITTLE CREEK	1,079	3,555
IL	MARSHALL	EAST MILL CREEK	1,066	3,555
IL	MASON	SALT CREEK	3,000	2,323
IL	MATTON	KICKAPOO CREEK	13,500	18,441
IL	METROPOLIS	OHIO RIVER	2,100	6,734
IL	MINONK	LONG POINT CREEK	2,366	1,982
IL	MOMENCE	KANKAKEE RIVER	2,000	2,968
IL	MONMOUTH	CEDAR CREEK	14,000	9,489
IL	MORRIS	NETTLE CREEK	9,000	10,270
IL	MORRISON	ROCK CREEK	42,000	4,363
IL	MORTON GROVE		0	22,408
IL	MT OLIVE	UNNAM TRIB – SUGAR CR	1,533	2,126
IL	MT VERNON	CASEY FORK	20,000	16,988
IL	NORTH UTICA	ILLINOIS RIVER	1,100	848
IL	OGLESBY	VERMILLION RIVER	4,000	3,619
IL	OLNEY	FOX RIVER	1,000	8,664

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
IL	OREGON	ROCK RIVER	3,700	3,891
IL	OTTAWA	ILLINOIS RIVER	18,048	17,451
IL	PARIS	SUGAR CREEK	10,000	8,987
IL	PEKIN	ILLINOIS RIVER	29,000	32,254
IL	PEORIA	ILLINOIS RIVER	77,000	113,504
IL	PEOTONE	BLACK WALNUT CREEK	600	2,947
IL	PERU	ILLINOIS RIVER	11,300	9,302
IL	PLAINFIELD	DUPAGE RIVER	3,300	4,557
IL	PONTIAC	VERMILION RIVER	1,250	11,428
IL	QUINCY	MISSISSIPPI RIVER	50,288	39,681
IL	RANKIN	PIGEON CREEK	750	619
IL	ROCK ISLAND	MISSISSIPPI RIVER	47,000	40,552
IL	ROCKDALE	I & M CANAL	1,600	1,709
IL	ROSSVILLE	N FORK OF VERMILION R	1,340	1,334
IL	RUSHVILLE	CRANE CREEK	3,300	3,229
IL	SAUGET	MISSISSIPPI RIVER	200	197
IL	SHEFFIELD	COAL CREEK	1,000	951
IL	SHELBYVILLE	KASKASKIA	5,000	4,943
IL	SPRING VALLEY	ILLINOIS RIVER	5,605	5,246
IL	SPRINGFIELD	SUGAR CREEK	60,000	105,227
IL	SPRINGFIELD	SPRING CREEK	15,000	105,227
IL	ST ANNE	LITTLE BEAVER CREEK	1,300	1,153
IL	STAUNTON	CAHOKIA CREEK	500	4,806
IL	STERLING	ROCK RIVER	7,000	15,132
IL	STREATOR	VERMILION RIVER	15,000	14,121
IL	TAYLORVILLE	PANTHER CREEK	11,182	11,133
IL	TAYLORVILLE	PANTHER CREEK	12,000	11,133
IL	THORNTON	THORN CREEK	375	2,778

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
IL	TOLUCA	NO BR CROW CREEK	1,200	1,315
IL	VANDALIA	KASKASKIA RIVER	3,000	6,114
IL	VENICE	MISSISSIPPI RIVER	4,600	3,571
IL	VILLA PARK	SALT CREEK	15,000	22,253
IL	WASHINGTON	TRIB TO FARM CREEK	946	10,099
IL	WATSEKA	SUGAR CREEK	7,202	5,424
IL	WAUKEGAN	LAKE MICHIGAN	1,320	69,392
IL	WELLINGTON	GAY CREEK	321	294
IL	WENONA	SANDY CREEK	1,100	950
IL	WESTVILLE	GRAPE CREEK	5,450	3,387
IL	WHITE HALL	WOLF RUN CREEK	3,000	2,814
IL	WILMETTE		0	26,690
IL	WOOD RIVER	MISSISSIPPI RIVER	13,000	11,490
IL	YORKVILLE	FOX RIVER	1,000	3,925
IN	AKRON	CHIPPEWANUK CREEK	1,776	1,001
IN	ALBANY	MISSISSINEWA RIVER	2,350	2,357
IN	ALBION	CROFT DITCH0000000	1,780	1,823
IN	ALEXANDRIA	PIPE CREEK	3,000	5,709
IN	ANDERSON	WHITE RIVER	67,080	59,459
IN	ANGOLA	MUD CREEK	0	5,824
IN	ATTICA	HONEY CREEK	707	3,457
IN	AUBURN	CEDAR CK	8,000	9,379
IN	AVILLA	KING LAKE	1,438	1,366
IN	BERNE	HABEGGER-DITCH	2,988	3,559
IN	BLUFFTON	WABASH RIVER	9,000	9,020
IN	BRAZIL	UNNAMED CREEK WABASHR	192,000	7,640
IN	BUTLER	BIG RUN CREEK	2,475	2,601

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
IN	CHESTERFIELD	WHITE RIVER	2,580	2,730
IN	CHESTERTON AND PORTER	LITTLE CALUMET RIVER	21,504	9,124
IN	CICERO	MORSE RESERVOIR	1,378	3,268
IN	CLARKSVILLE	CANE RUN TO OHIO RIVE	14,000	19,833
IN	CLINTON	WABASH RIVER	1,740	5,040
IN	COLFAX	WITHE DITCH	0	727
IN	COLUMBUS	EAST FK,WHITE RIVER	26,457	31,802
IN	CONNERSVILLE	WEST FK WHITEWATER R	42,840	15,550
IN	CRAWFORDSVILLE	SUGAR CREEK	5,029	13,584
IN	CROTHERSVILLE	MUSCATATUCK RIVER	0	1,687
IN	CROWN POINT	BEAVER DAM DITCH	4,020	17,728
IN	DECATUR	ST MARYS RIVER	10,440	8,644
IN	DUNKIRK	DULIKIRK-DRAIN	3,354	2,739
IN	DYER	PLUM CREEK(HART DITCH	6,985	10,923
IN	EAST CHICAGO	GRAND CALUMET RIVER	45,483	33,892
IN	EAST GARY	L CALUMET RIVER	30,000	0
IN	EATON	MISSISSINEWA RIVER	1,594	1,614
IN	EDINBURG	BIG BLUE RIVER	4,063	4,536
IN	ELKHART	ST JOSEPH RIVER	44,000	43,627
IN	ELWOOD	DUCK CREEK	27,000	9,494
IN	EVANSVILLE	PIGEON CREEK	50,425	126,272
IN	FAIRMOUNT	BACK CREEK	3,600	3,130
IN	FLORA	BACHELOR RUN	2,000	2,179
IN	FORT WAYNE	MAUMEE RIVER	177,671	173,072
IN	FORTVILLE	FLAT FORK CREEK	2,000	2,690
IN	FOWLER	HUMBERT DITCH	2,631	2,333
IN	FRANKFORT	PRAIRIE CREEK	20,000	14,754
IN	FRANKLIN	YOUNG'S^"CREEK	11,411	12,907

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
IN	FRANKTON	PIPE CREEK	1,584	1,736
IN	GARRETT	GARRETT CITY DITCH	7,800	5,349
IN	GARY	LAKE MICHIGAN	300,000	116,646
IN	GAS CITY	MISSISSINEWA RIVER	6,000	6,296
IN	GENEVA	LOBLOLLY CREEK	1,100	1,280
IN	GOSHEN	ELKHART RIVER	48,000	23,797
IN	GREENFIELD	BRANDYWINE CREEK	10,000	11,657
IN	GREENTOWN	WILDCAT CR	0	2,172
IN	GREENTOWN	WILDCAT CREEK	4,236	2,172
IN	GREENWOOD	PLEASANT RUN CREEK	7,680	26,265
IN	GRIFFITH	CALUMET RIVER	1,500	17,916
IN	HAMMOND	LITTLE CALUMET	28,054	84,236
IN	HARTFORD CITY	BIG LICK CREEK	3,789	6,960
IN	HARTFORD CITY	LITTLE LICK CREEK	4,418	6,960
IN	HIGHLAND	CALUMET RIVER	13,000	23,696
IN	HOBART	DEEP RIVER	26,160	21,822
IN	HUNTINGTON	LITTLE RIVER	16,500	16,389
IN	INDIANAPOLIS	WHITE RIVER WEST FORK	323,557	731,327
IN	INDIANAPOLIS	WHITE RIVER	205,516	731,327
IN	JASPER	PATOKA	1,000	10,030
IN	JEFFERSONVILLE	OHIO RIVER	25,200	21,841
IN	JONESBORO TOWN OF	MISSISSINEWA RIVER	0	2,073
IN	KENDALLVILLE	HENDERSON LAKE	750	7,773
IN	KOKOMO	WILDCAT CREEK	70,000	44,962
IN	LA GRANGE	FLY CREEK	2,100	2,382
IN	LAFAYETTE	WABASH RIVER	47,805	43,764
IN	LAPORTE	TRAVIS DITCH	28,000	21,507
IN	LIBERTY	TOWN RUN	1,831	2,051

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
IN	LIGONIER	ELKHART RIVER	3,000	3,443
IN	LINN GROVE	TRIB UPPER WABASH	0	3,559
IN	LOGANSPORT	WABASH RIVER	18,500	16,812
IN	MARION	MISSISSINEWA RIVER	47,052	32,618
IN	MARKLE	WABASH RIVER	1,029	1,208
IN	MERRILLVILLE	TURKEY CREEK	26,000	27,257
IN	MICHIGAN CITY	TRAIL CREEK	35,000	33,822
IN	MIDDLETOWN	SUGAR CREEK	2,267	2,333
IN	MILAN	SOUTH HOGAN CREEK	1,210	1,529
IN	MISHAWKA	ST JOSEPH RIVER	25,900	42,608
IN	MONTICELLO	LAKE FREEMAN	5,074	5,237
IN	MONTPELIER	SALAMONIE RIVER	2,800	1,880
IN	MT VERNON	OHIO RIVER	6,914	7,217
IN	MUNCIE	WHITE RIVER	162,960	71,035
IN	MUNSTER	L CALUMET RIVER	7,600	19,949
IN	NAPPANEE	BERLINCOURT DITCH	415	5,510
IN	NEW CARLISLE	HIESPOOZIANCY DITCH	1,434	1,446
IN	NEW CASTLE	BIG BLUE RIVER	20,825	17,753
IN	NEW HAVEN	MARTIN DITCH	5,877	9,320
IN	NOBLESVILLE	WHITE RIVER	45,000	17,655
IN	NORTH LIBERTY	POTATO-CREEK"	1,259	1,366
IN	NORTH VERNON, VERNON	MUSCATTATUCK R VERNON	7,457	370
IN	OAKLAND CITY	TURKEY CREEK	1,800	2,810
IN	OLDENBURG	HARVEY DITCH	150	715
IN	OSSIAN	EIGHT MILE CREEK	1,735	2,428
IN	OTTERBEIN	OTTERBEIN DITCH	0	1,291
IN	OXFORD	MUD PINE CREEK	1,200	1,273
IN	PATOKA	PATOKA RIVER	0	704

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
IN	PENDLETON	FALL CREEK	3,600	2,309
IN	PERU	WABASH RIVER	14,000	12,843
IN	PLAINFIELD	WHITE LICK CREEK	8,650	10,433
IN	PLYMOUTH	YELLOW RIVER	4,175	8,303
IN	PORTLAND	SALAMONIE RIVER	7,700	6,483
IN	REDKEY	REDKEY RUN	840	1,383
IN	REMINGTON	CARPENTER CREEK	343	1,247
IN	RENSSELAER	IROQUOIS RIVER	4,000	5,045
IN	RICHMOND	WHITEWATER RIVER	5,500	38,705
IN	ROANOKE	LITTLE RIVER	0	1,018
IN	ROSSVILLE	SILVERTHORN CREEK	1,004	1,175
IN	RUSHVILLE	FLAT ROCK CREEK	8,340	5,533
IN	SALEM	WEST FORK BLUE RIVER	780	5,619
IN	SCOTTSBURG	STUCKER FORK	3,800	5,334
IN	SEYMOUR	EAST FORK]WHITE RIVER	13,352	15,576
IN	SHERIDAN	SYMONS DITCH	4,800	2,046
IN	SHIRLEY	SIX MILE CREEK	360	817
IN	SOUTH BEND	ST JOSEPH RIVER	100,000	105,511
IN	SOUTH WHITLEY	EEL RIVER	1,600	1,482
IN	SPEEDWAY	EAGLE CREEK	9,000	13,092
IN	SULLIVAN	BUSSERON CREEK	7,860	4,663
IN	SUMMITVILLE	MUD CREEK	1,000	1,010
IN	TERRE HAUTE	WABASH RIVER	40,860	57,483
IN	THORNTOWN	PRAIRE CREEK	1,399	1,506
IN	TIPTON	CICERO CREEK	5,300	4,751
IN	TOWN OF LAPEL	STONY CREEK	2,616	1,742
IN	UNION	LITTLE MISSINEWA	3,401	3,612
IN	VALPARAISO	SALT CREEK	20,544	24,414

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
IN	VINCENNES	WABASH RIVER	29,376	19,859
IN	WABASH	WABASH RIVER	11,300	12,127
IN	WAKARUSA	WERNTZ DITCH	1,323	1,667
IN	WASHINGTON	HAWKINS CREEK	12,000	10,838
IN	WATERLOO	CEDAR CREEK	1,584	2,040
IN	WEST LAFAYETTE	WABASH RIVER	22,000	25,907
IN	WESTERN-WAYNE-RSD	W FORK WHITEWATER R	1,240	2,091
IN	WESTFIELD	COAL CREEK	0	3,304
IN	WHITING	GRAND CALUMET RIVER	7,200	5,155
IN	WOLCOTTVILLE	NORTH BRANCH ELKART	800	879
IN	YORKTOWN	W FL WHITE RIVER	1,277	4,106
KS	ATCHISON	MISSOURI RIVER	5,000	10,656
KS	KANSAS CITY	MISSOURI RIVER	339,000	149,767
KS	TOPEKA	KANSAS RIVER	120,000	119,883
KY	ASHLAND	OHIO RIVER	0	23,622
KY	BROMLEY	OHIO RIVER	177,000	1,137
KY	CARROLLTON	KENTUCKY RIVER	5,475	3,715
KY	FRANKFORT	KENTUCKY RIVER	18,700	25,968
KY	HARLAN	CUMBERLAND RIVER	0	2,686
KY	HENDERSON	OHIO RIVER	25,150	25,945
KY	JACKSON	N FORK KENTUCKY RIVER	800	2,466
KY	LOUISVILLE	OHIO RIVER	457,450	269,063
KY	LOUISVILLE	OHIO RIVER	13,110	269,063
KY	LOYALL	CUMBERLAND RIVER	3,000	1,100
KY	MAYSVILLE	OHIO RIVER	7,650	7,169
KY	MORGANFIELD	OHIO RIVER	2,625	3,776

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
KY	OWENSBORO	OHIO RIVER	33,600	53,549
KY	PADUCAH	OHIO RIVER	14,400	27,256
KY	PIKEVILLE	LEVISA FORK	3,821	6,324
KY	PINEVILLE	CUMBERLAND RIVER	4,125	2,198
KY	VANCEBURG	OHIO RIVER	1,650	1,713
MA	BOSTON		692,200	574,283
MA	AMESBURY	MERRIMACK RIVER	8,800	12,109
MA	BROOKLINE	CHARLES R	58,200	54,718
MA	CAMBRIDGE	CHARLES R	55,000	95,802
MA	CHELSEA	MYSTIC R	30,600	28,710
MA	CHICOPEE	CONN – CHICOPEE RIVER	31,020	56,632
MA	ERVING	MILLERS RIVER	367	1,372
MA	FALL RIVER	MOUNT HOPE BAY	92,600	92,703
MA	FITCHBURG	NASHUA RIVER	41,800	41,194
MA	GLOUCESTER	GLOUCESTER HARBOR	15,500	28,716
MA	GREAT BARRINGTON	HOUSATONIC RIVER	4,500	2,810
MA	HATFIELD	CONNECTICUT RIVER	1,500	1,234
MA	HAVERHILL	MERRIMACK RIVER	44,600	51,418
MA	HOLYOKS MASS	CONNECTICUT RIVER	22,000	43,704
MA	HULL	MASSACHUSETTS BAY	4,500	10,466
MA	HUNTINGTON	WESTFIELD RIVER	800	1,987
MA	LAWRENCE	SPICKETT RIVER	45,000	70,207
MA	LEOMINSTER	NASHUA RIVER	35,000	38,145
MA	LUDLOW	CONNECTICUT RIVER	8,000	0
MA	MONTAGUE	CONNECTICUT RIVER	6,500	8,316
MA	NEW BEDFORD	BUZZARDS BAY	104,000	99,922
MA	NORTHAMPTON	CONNECTICUT RIVER	22,000	29,289

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
MA	NORTHFIELD	CONNECTICUT RIVER	2,000	1,322
MA	ORANGE	MILLERS RIVER	2,750	3,791
MA	PALMER	CHICOPEE RIVER	19,400	4,069
MA	SOMERVILLE	MYSTIC R	80,890	76,210
MA	SOUTH DARTMOUTH	BUZZARDS BAY	2,000	0
MA	SOUTH HADLEY	CONNECTICUT RIVER	16,180	16,685
MA	SPENCER	CRANBERRY BROOK	4,500	6,306
MA	SPRINGFIELD	CONNECTICUT RIVER	160,000	156,983
MA	TAUNTON	TAUNTON RIVER	24,200	49,832
MA	WARREN	QUABOAG RIVER	260	1,516
MA	WEST SPRINGFIELD	CONNECTICUT RIVER	28,289	27,537
MA	WESTFIELD	WESTFIELD RIVER	20,200	38,372
MA	WORCESTER	BLACKSTONE RIVER	182,000	169,759
MD	CAMBRIDGE	CHOPTANK RIVER	2,100	11,514
MD	CENTREVILLE	GRAVEL RUN	2,000	2,097
MD	CUMBERLAND	NORTH BR OF POTOMAC	16,000	23,706
MD	ELKTON	BIG ELK CREEK	7,000	9,073
MD	FROSTBURG	WILLS-CREEK	7,330	8,075
MD	HAVRE DE GRACE	SUSQUEHANNA RIVER	11,000	8,952
MD	MILLINGTON	CHESTER RIVER	475	409
MD	POCOMOKE CITY	POCOMOKE RIVER	3,825	3,922
MD	SALISBURY	N BR WICOMICO RIVER	900	20,592
MD	SNOW HILL	POCOMOKE RIVER	456	2,217
MD	WESTERNPORT	NTH BR-OF POTOMAC RV	2,800	2,454
ME	ANSON	CARABASETT RIVER	740	2,382
ME	AUBURN	ANDROSCOGGIN R	19,000	24,309

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
ME	AUGUSTA	KENNEBEC R	41,000	21,325
ME	BANGOR	PENOBSCOT R	25,000	33,181
ME	BAR HARBOR	ATLANTIC OCEAN	2,775	2,768
ME	BATH	KENNEBEC ESTUARY	9,500	9,799
ME	BELFAST	ATLANTIC OCEAN	600	6,355
ME	BIDDEFORD	ATLANTIC OCEAN	12,000	20,710
ME	BREWER	PENOBSCOT R	8,900	9,021
ME	BRUNSWICK	ANDROSCOGGIN RIVER	9,700	14,683
ME	BUCKSPORT	PENOBSCOT R	2,150	2,989
ME	CALAIS	ST CROIX R	3,000	3,963
ME	CAMDEN	ATLANTIC OCEAN	4,000	4,022
ME	CAPE ELIZABETH	ATLANTIC0OCEAN	5,400	8,854
ME	CARIBOU	AROOSTOOK RIVER	750	9,415
ME	CORINNA	SEBASTICOOK R	1,000	2,196
ME	DANFORTH	BASKAHEGAN STREAM	105	710
ME	DEXTER	SEBASTICOOK RIVER	2,700	2,650
ME	DOVER FOXCROFT	PISCATAQUIS RIVER	2,500	3,077
ME	EASTPORT	ATLANTIC OCEAN	1,500	1,965
ME	ELLSWORTH	UNION BAY	3,000	5,975
ME	FALMOUTH	ATLANTIC OCEAN	340	1,708
ME	FORT KENT	FISH RIVER	750	2,123
ME	GARDINER	KENNEBEC RIVER	4,700	6,746
ME	GORHAM	PRESUMPSCOT RIVER	100	3,618
ME	HALLOWELL	KENNEBEC RIVER	2,500	2,534
ME	HOWLAND	PISCATAQUIS RIVER	1,300	1,304
ME	KENNEBUNK	MOUSAM RIVER	5,000	4,206
ME	KINGFIELD	CARRABASSETT RIVER	200	1,114
ME	KITTERY	PISCATAQUA R	1,100	5,151

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
ME	LEWISTON	ANDROSCOGGIN R	32,300	39,757
ME	LINCOLN	PENOBSCOT RIVER	3,500	3,399
ME	LISBON FALLS	ANDROSCOGGIN RIVER	5,100	4,674
ME	LIVERMORE FALLS	ANDROSCOGGIN RIVER	2,180	1,935
ME	MACHIAS	MACHIAS RIVER	3,000	1,773
ME	MARS HILL	PRESTILE STREAM	200	1,717
ME	MECHANIC FALLS	LITTLE ANDROSCOGGIN R	1,550	2,388
ME	MEDWAY	PENOBSCOT RIVER	0	1,922
ME	MILFORD	PENOBSCOT RIVER	600	2,228
ME	MILLINOCKET	MILLINOCKET STREAM	800	6,922
ME	NEWPORT	SEBASTICOOK RIVER	1,300	1,843
ME	OAKLAND	MESSALONSKEE STREAM	3,000	3,510
ME	OLD ORCHARD BEACH	ATLANTIC OCEAN	875	7,789
ME	OLD TOWN	PENOBSCOTT RIVER	6,500	8,317
ME	PITTSFIELD	SEBASTICOOK R	150	3,222
ME	PORTLAND	ATLANTIC OCEAN	58,000	64,358
ME	PRESQUE ISLE	AROOSTOOK RIVER	9,000	10,550
ME	RANDOLPH	KENNEBEC RIVER	1,600	1,949
ME	RICHMOND	KENNEBEC ESTUARY	12,000	1,775
ME	ROCKLAND	ROCKLAND HARBOR	6,675	7,972
ME	SACO	SACO RIVER	7,500	15,181
ME	SANFORD	MOOSAM RIVER	14,900	10,296
ME	SKOWHEGAN	KENNEBEC R	5,000	6,990
ME	SO BERWICK	SALMON FALLS RIVER	200	0
ME	SOUTH PARIS	LITTLE ANDROSCOGGIN R	2,700	2,320
ME	SOUTH PORTLAND	ATLANTIC OCEAN	14,000	23,163
ME	STRONG	VALLEY BROOK	21	1,217
ME	THOMASTON	ST GEORGE RIVER	750	2,445

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
ME	VAN BUREN	ST JOHN RIVER	3,565	2,759
ME	VEAZIE	PENOBSCOT RIVER	200	33,181
ME	WASHBURN	SALMON BROOK STREAM	600	1,880
ME	WATERVILLE	KENNEBEC R	22,000	17,173
ME	WESTBROOK	PRESUMPSCOT R	3,500	16,121
MI	ADRIAN	RAISIN RIVER	20,400	22,097
MI	ALPENA	THUNDER BAY	2,988	11,354
MI	ALPENA	LAKE HURON	3,100	11,354
MI	ARMADA	COON CREEK	2,688	1,548
MI	BAY CITY	SAGINAW RIVER	25,000	38,936
MI	BELDING	FLAT RIVER	0	5,969
MI	BELLEVILLE	HURON RIVER	1,152	3,270
MI	BENTON HARBOR	ST JOSEPH RIVER	62,000	12,818
MI	BERKLEY	RIVER ROUGE	21,879	16,960
MI	BESSEMER	BLACK RIVER	820	2,272
MI	BIG RAPIDS	MUSKEGON RIVER	13,875	12,603
MI	CAPAC	LEMON DRAIN	260	1,583
MI	CASPIAN	IRON RIVER	384	1,031
MI	CHEBOYGAN	CHEBOYGAN RIVER	3,228	4,999
MI	COOPERSVILLE	DEER CREEK	1,000	3,421
MI	CROSWELL	BLACK RIVER	957	2,174
MI	CRYSTAL FALLS	PAINT RIVER	0	1,922
MI	DAVISON	BLACK CREEK	24,434	5,693
MI	DETROIT	DETROIT RIVER	1,017,880	1,027,974
MI	DETROIT	ROUGE RIVER	458,320	1,027,974
MI	DOWAGIAC	DOWAGIAC CREEK	6,880	6,409
MI	DUNDEE	RAISIN RIVER	500	2,664

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
MI	EAST LANSING	RED CEDAR RIVER	35,000	50,677
MI	EATON RAPIDS	GRAND RIVER	1,560	4,695
MI	ECORSE	ECORSE CREEK	16,000	12,180
MI	ESSEXVILLE	SAGINAW RIVER	5,000	4,088
MI	FARMINGTON	UPPER ROUGE RIVER	5,000	10,132
MI	FERNDALE	RIVER ROUGE	30,850	25,084
MI	FLINT	FLINT RIVER	2,400	140,761
MI	FRANKFORT	BETSIE LAKE	1,800	1,546
MI	GLADWIN	CEDAR RIVER	1,926	2,682
MI	GRAND RAPIDS	GRAND RIVER	25,789	189,126
MI	GROSSE ISLE	DETROIT RIVER	2,100	9,781
MI	HANCOCK	PORTAGE LAKE SHIP CAN	4,977	4,547
MI	HART	S BRANCH PENTWATER RI	0	1,942
MI	HOUGHTON	PORTAGE LAKE SHIP CAN	6,904	7,498
MI	HUBBELL	PORTAGE LAKE	1,425	1,174
MI	HUDSON	BEAN CREEK	1,000	2,580
MI	HUNTINGTON		0	6,419
MI	IMLAY	BELLE RIVER	100	2,921
MI	IRON RIVER	IRON RIVER	2,694	2,095
MI	IRONWOOD	MONTREAL RIVER	2,818	6,849
MI	ISPHEMING	CARP RIVER	8,800	7,200
MI	KINGSFORD	NENOMINEE RIVER	24,000	5,480
MI	LAINGSBURG		1,050	1,148
MI	LAKE LINDEN	TORCH LAKE	2,464	1,203
MI	LANSING	GRAND RIVER	50,000	127,321
MI	LAPEER	FLINT RIVER	4,735	7,759
MI	LESLIE	HUNTOON CREEK	2,400	1,872
MI	MANCHESTER	RIVER RAISEN	2,880	1,753

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
MI	MANISTIQUE	MANISTIQUE RIVER	4,550	3,456
MI	MARINE CITY	BELLE RIVER	1,920	4,556
MI	MARLETTE	DUFF DRAIN	1,706	1,924
MI	MARQUETTE	LAKE SUPERIOR	21,800	21,977
MI	MARSHALL	KALAMAZOO RIVER	40,440	6,891
MI	MARYSVILLE	ST CLAIR RIVER	6,000	8,515
MI	MIDLAND	TITTABAWASSEE RIVER	7,200	38,053
MI	MILAN	SALINE RIVER	540	4,040
MI	MONROE	RAISEN RIVER	2,500	22,902
MI	MORENCI	BEAN CREEK	2,135	2,342
MI	MOUNT CLEMENS	CLINTON RIVER	4,608	18,405
MI	MT CLEMENS	CLINTON RIVER	20,300	18,405
MI	NEGAUNEE	CARP RIVER	5,165	4,741
MI	NEW HAVEN	SALT RIVER	184	2,331
MI	NILES	ST JOSEPH RIVER	13,000	12,458
MI	NORWAY	WHITE CREEK	1,440	2,910
MI	OAK PARK	DETROIT RIVER	36,762	30,462
MI	OAKLAND	CLINTON RIVER	222,480	71,166
MI	PALMER	WARNER CREEK	690	0
MI	PLEASANT	DETROIT RIVER	3,989	2,775
MI	PONTIC	UPPER RIVER ROUGE	26,920	71,166
MI	PORT HURON	LAKE HURON	588	33,694
MI	RICHMOND	COON CREEK	960	4,141
MI	ROYAL OAK	RIVER ROUGE	0	65,410
MI	SAGINAW	SAGINAW RIVER	90,000	69,512
MI	SAGINAW	TITTABAWASSEE RIVER	2,710	69,512
MI	SANDUSKY	DWIGHT CREEK	240	2,403
MI	SAULT STE MARIE	ST MARYS RIVER	14,200	14,689

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
MI	SHEPHERD	LITTLE SALT RIVER	1,723	1,413
MI	SOUTH RANGE VILLAGE		193	745
MI	SOUTHFIELD	DETROIT RIVER	46,080	75,728
MI	ST CLAIR	ST CLAIR RIVER	3,600	5,116
MI	ST CLAIR SHORES	LAKE ST CLAIR	49,510	68,107
MI	STOCKBRIDGE	PORTAGE CREEK	1,047	1,202
MI	TRENTON	DETROIT RIVER	2,688	20,586
MI	TROY	DETROIT RIVER	3,840	72,884
MI	WYANDOTTE	DETROIT RIVER	63,600	30,938
MN	AITKIN	MISSISSIPPI RIVER	40	1,698
MN	APPLETON	POMME DE TERRE RIVER	1,400	1,552
MN	BIRD ISLAND	BUFFALO CREEK	1,400	1,326
MN	BRAINERD	MISSISSIPPI RIVER	13,900	12,353
MN	BRAINERD	MISSISSIPPI RIVER	0	12,353
MN	BUFFALO LAKE	BUFFALO CREEK	0	734
MN	CARLTON	ST LOUIS RIVER	884	923
MN	DANUBE	BEAVER CREEK	0	562
MN	HECTOR	BUFFALO CREEK	1,178	1,145
MN	HERON LAKE	HERON LAKE	777	730
MN	MAHNOMEN	WILD RICE RIVER	1,313	1,154
MN	NEW ULM	MINNESOTA RIVER	4,800	13,132
MN	RED WING	MISSISSIPPI RIVER	8,000	15,134
MN	RICHMOND	SAUK RIVER	866	965
MN	ST CLOUD	MISSISSIPPI RIVER	4,000	48,812
MN	ST PAUL	MISSISSIPPI RIVER	204,913	272,235
MN	ST PETER	MINNESOTA RIVER	6,375	9,421
MN	WATSON	CHIPPEWA RIVER	200	211

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
MN	WHEATON	MUSTINKA RIVER	2,009	1,615
MO	CAPE GIRARDEAU	CADE LACROUIX CREEK	3,500	34,438
MO	CHILLICOTHE	GRAND RIVER	8,296	8,804
MO	CHULA	NEDECINE CREEK	25	183
MO	JEFFERSON CITY	MISSOURI RIVER	4,500	35,481
MO	KANSAS CITY	MISSOURI RIVER	92,000	435,146
MO	KANSAS CITY	BLUE RIVER	200,000	435,146
MO	MACON	MIDDLEFORK SALT RIVER	5,500	5,571
MO	MOBERLY	ELK FORK SALT RIVER	8,670	12,839
MO	MOBERLY	SWEET SPRING CREEK	4,700	12,839
MO	POPLAR BLUFF	BLACK RIVER	22,500	16,996
MO	SAINT JOSEPH	MISSOURI RIVER	78,750	71,852
MO	SEDALIA	MUDDY CREEK	240	19,800
MO	ST LOUIS	MISSISSIPPI RIVER	336,000	396,685
MO	ST LOUIS	MISSISSIPPI RIVER	109,620	396,685
MS	PASCAGOULA	EAST PASCAGOULA RIVER	18,000	25,899
MS	SUMNER	CASSIDY BAYOU	500	368
MS	WEBB	CASSIDY BAYOU	600	605
MT	ALBERTON	CLARK FORT RIVER	428	354
MT	BAINVILLE		214	165
MT	BRIDGER		0	692
MT	CULBERTSON		849	796
MT	EKALAKA		619	439
MT	FORT BELKNAP		0	422
MT	FORT BENTON	MISSOURI RIVER	2,000	1,660

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
MT	GLASGOW	MILK RIVER	5,302	3,572
MT	GLENDIVE	YELLOWSTONE RIVER	6,272	4,802
MT	GREAT FALLS	MISSOURI RIVER	62,006	55,097
MT	HAVRE	MILK RIVER	10,683	10,201
MT	HAVRE	MILK RIVER	10,683	10,201
MT	HELENA	PRICKLY PEAR CREEK	27,123	24,569
MT	LODGE GRASS	LITTLE BIG HORN RIVER	675	517
MT	MALTA	MILK RIVER	2,243	2,340
MT	PLENTYWOOD	BIG MUDDY CREEK	2,241	2,136
MT	SIDNEY	YELLOWSTONE RIVER	4,736	5,217
MT	WHITEFISH	WHITEFISH RIVER	5,700	4,368
NC	LUMBERTON	LUMBER RIVER	8,000	18,601
NC	WARSAW	OATHA CREEK	3,675	2,859
NC	WILMINGTON	CAPE FEAR RIVER	29,450	55,530
ND	CITY OF FARGO	RED RIVER	2,300	197
ND	EDGELEY	MAPLE CREEK	890	680
ND	ELM CITY		900	0
ND	ENDERLIN		1,133	997
ND	FAIRMOUNT	BOIS DE SIOUX RIVER	203	427
ND	FORBES		72	56
ND	GRAFTON	PARK RIVER	6,450	4,840
ND	GRAND FORKS	RED RIVER	11,280	49,425
ND	LIDGERWOOD		966	799
ND	STARKWEATHER	DRAINAGE DITCH	200	197
ND	WEST FARGO		15,500	12,287

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
NE	OMAHA	PAPILLION CREEK	24,000	335,795
NE	OMAHA	MISSOURI RIVER	167,505	335,795
NE	PLATTSMOUTH	MISSOURI RIVER	7,900	6,412
NH	CENTER HARBOR	LAKE WINNIPESAUKEE	200	996
NH	COLEBROOK	MOHAWK RIVER	300	2,444
NH	CONCORD	MERRIMACK R	3,700	36,006
NH	CONCORD	MERRIMACK R	16,000	36,006
NH	EXETER	SQUAMSCOTT RIVER	9,080	9,556
NH	FRANKLIN	MERRIMACK RIVER	500	8,304
NH	GORHAM	ANDROSCOGGIN RIVER	2,550	1,910
NH	GROVETON	UPPER AMMONOOSOC RIV	1,550	1,255
NH	LANCASTER	CONNECTICUT RIVER	2,000	1,859
NH	LEBANON	MASCOMA RIVER	9,000	12,183
NH	LINCOLN	PEMIGEWASSET RIVER	1,300	1,229
NH	LITTLETON	AMMONOOSUC RIVER	5,400	4,633
NH	MANCHESTER	MERRIMACK RIVER	84,400	99,567
NH	MILFORD	SOUHEGAN RIVER	6,250	8,015
NH	MILTON	SALMON FALLS RIVER	540	3,691
NH	NASHUA	MERRIMACK RIVER	54,400	79,662
NH	NEWBURY	SUNAPEE LAKE	60	1,347
NH	PLYMOUTH	PEMIGEWASSET RIVER	2,076	3,967
NH	PORTSMOUTH	PISCATAQUA RIVER	16,000	25,925
NH	SOMERSWORTH	SALMON FALLS RIVER	65,000	11,249
NH	WALPOLE	CONNECTICUT RIVER	400	3,210
NH	WHITEFIELD	ST JOHNS RIVER	1,450	1,041
NH	WINCHESTER	ASHUCLOT RIVER	500	1,735
NH	WOODSVILLE	CONNECTICUT RIVER	1,200	1,122

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
NJ	BAYONNE	KILL VAN KULL	72,000	61,444
NJ	CAMDEN	DELAWARE RIVER	17,000	87,492
NJ	CAMDEN	NEWTON CREEK	86,500	87,492
NJ	CLIFFSIDE PARK		0	20,393
NJ	ELIZABETH	ELIZABETH RIVER	115,000	110,002
NJ	GLOUCESTER	LITTLE TIMBER CREEK	15,000	12,649
NJ	GUTTENBERG	HUDSON RIVER	18,551	8,268
NJ	HOBOKEN	HUDSON RIVER	83,120	33,397
NJ	JERSEY CITY	NEWARK BAY	91,313	228,537
NJ	JERSEY CITY	HUDSON RIVER	157,914	228,537
NJ	LIBERTY CORNER	DEAD RIVER	8,000	6,597
NJ	LITTLE FERRY	HACKENSACK RIVER	106,467	9,989
NJ	NEW BRUNSWICK	LOWER RARITAN RIVER	54,500	41,711
NJ	NEWARK	UPPER NEW YORK BAY	539,731	275,221
NJ	PAULSBORO	DELAWARE RIVER	33,230	6,577
NJ	PERTH AMBOY	RARITAN RIVER	40,000	41,967
NJ	RAHWAY	ARTHUR KILL	31,000	25,325
NJ	SOUTH KEARNY	HACKENSACK RIVER	19,000	34,874
NJ	TRENTON	DELAWARE RIVER	105,600	88,675
NY			13,000	1,753
NY	ALBANY	HUDSON RIVER	91,600	101,082
NY	AMSTERDAM	MOHAWK R	25,872	20,714
NY	ANDS	HUDSON RIVER	98,747	4,333
NY	ASTORIA	UPPER EAST RIVER	680,000	7,322,564
NY	AUBURN	OWASCO LAKE OUTLET	36,800	31,258
NY	BALDWINSVILLE	SENECA RIVER	0	6,591

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
NY	BEACON	HUDSON RIVER	11,200	13,243
NY	BINGHAMTON	SUSQUEHANNA RIVER	64,123	53,008
NY	BOONVILLE	MILL CREEK	2,200	2,220
NY	BROOKLYN	ROCKAWAY INLET	600,000	7,322,564
NY	BROOKLYN	UPPER BAY	800,000	7,322,564
NY	BROOKLYN	HENDRIX CANAL	350,000	7,322,564
NY	BROOKLYN	XDST RIVER	275,000	7,322,564
NY	BUFFALO	NIAGARA RIVER	762,768	328,123
NY	CANASTOTA	COWASELOW CREEK	18,200	4,673
NY	CANTON	GRASSE RIVER	0	6,379
NY	CARTHAGE	BLACK RIVER	0	4,344
NY	CASTLETON-ON-HUDSON	HUDSON RIVER	2,400	1,491
NY	CATSKILL	HUDSON RIVER	5,317	4,690
NY	COHOES	HUDSON RIVER	18,635	16,825
NY	COXSACKIE	HUDSON RIVER	3,095	2,789
NY	ELMIRA	CHEMUNG RIVER	81,500	33,724
NY	ELMIRA	CHEMUNG RIVER	37,500	33,724
NY	ENDICOTT	SUSQUEHANA RIVER	46,000	13,531
NY	ENDICOTT	SUSQUEHANA RIVER	46,000	13,531
NY	FORT EDWARD	HUDSON RIVER	3,750	3,561
NY	GLEN FALLS	HUDSON RIVER	17,000	3,561
NY	GOUVERNEUR	OSWEGATCHIE RIVER	4,600	4,604
NY	GRANVILLE		0	2,646
NY	GREEN ISLAND	HUDSON RIVER	3,297	2,490
NY	HUDSON	HUDSON RIVER	9,000	8,034
NY	HUDSON FALLS	HUDSON RIVER	8,000	7,651
NY	HUNTS POINT	UPPER EAST RIVER	750,000	7,322,564
NY	JOHNSON CITY	SUSQUEHANNA RIVER	19,000	16,890

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
NY	KINGSTON	RONDOUT CREEK	25,000	23,095
NY	LEWISTON	NIAGARA RIVER	312	3,048
NY	LEWISTON	EIGHTEEN MILE CREEK	43,000	3,048
NY	LOCKPORT		0	24,426
NY	MASSENA	GRASS RIVER	14,000	11,719
NY	MEDINA	OAK ORCHARD CK	14,800	6,686
NY	NEW YORK	EAST RIVER	1,250,000	7,322,564
NY	NEW YORK	HUDSON RIVER	156,390	7,322,564
NY	NEWBURG	HUDSON RIVER	26,000	26,454
NY	NIAGARA FALLS	NIAGARA RIVER	85,400	61,840
NY	NORTH TONAWANDA	NIAGARA RIVER	49,000	34,989
NY	OGDENSBURG	ST LAWRENCE RIVER	14,500	13,521
NY	ONEONTA	SUSQUEHANNA RIVER	17,000	13,954
NY	OSWEGO	OSWEGO RIVER	24,000	19,195
NY	OWEGO	SUSQUEHANNA RIVER	4,800	4,442
NY	PLATTSBURG	SARANAC RIVER	30,000	21,255
NY	POTSDAM	RAQUETTE RIVER	13,000	10,251
NY	POUGHKEEPSIE	HUDSON RIVER	33,270	28,844
NY	QUEENS	EAST RIVER	1,500,000	7,322,564
NY	RENSSELAER	HUDSON RIVER	25,220	8,255
NY	ROCHESTER	GENESEE–RIVER	166,500	231,636
NY	SALAMANCA	ALLEGHENY R	8,000	6,566
NY	SAUGERTIES	ESOPUS CREEK	4,100	3,915
NY	SCHENECTADY	MOHAWK RIVER	71,332	65,566
NY	SIDNEY	SUSQUEHANNA RIVER	4,800	4,720
NY	STATEN ISLAND	KILL VAN KULL	155,000	7,322,564
NY	STOCKPORT	HUDSON RIVER	625	8,034
NY	SYRACUSE	ONONDAGA LAKE	288,000	163,860

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
NY	TROY	HUDSON RIVER	174,200	54,269
NY	TROY	HUDSON RIVER	174,200	54,269
NY	TUPPERLAKE	RAQUETTE POND	5,604	4,087
NY	UTICA	MOHAWK RIVER	130,000	68,637
NY	UTICA	MAHAWK RIVER	142,402	68,637
NY	VILL OF WEEDSPORT	COLD SPRINGS BROOK	3,000	1,996
NY	WADDINGTON		0	944
NY	WATERFORD	HUDSON RIVER	17,188	2,370
NY	WATERFORD	MOHAWK RIVER	2,340	2,370
NY	WATERLOO		0	5,116
NY	WATERTOWN	BLACK RIVER	32,037	29,429
NY	WATSRVLIET	HUDSON RIVER	12,464	11,061
NY	YONKERS	HUDSON RIVER	130,000	188,082
OH		POE DITCH	24,000	8,348
OH	ADA	GRASS RUN CREEK	6,300	949
OH	AKRON	LITTLE CUYAHOGA RIVER	254,000	223,019
OH	ALLIANCE	MAHONING RIVER	625	23,376
OH	ANSONIA	NORTH FORK STILLWATER	1,053	1,279
OH	ARCANUM	SYCAMORE DITCH	2,996	1,953
OH	ASHTABULA	LAKE ERIE	2,160	21,633
OH	AUSEON	BRANCH DITCH	5,945	364,040
OH	AVON LAKE	LAKE ERIE	13,000	15,066
OH	BEDFORD	TINKERS CREEK	384	505,616
OH	BELLAIRE	OHIO RIVER	10,000	6,028
OH	BLOOMVILLE	HONEY CREEK	967	949
OH	BLUFFTON	RILEY CREEK	2,400	3,367
OH	BRADFORD	BALLINGER RUN	2,300	2,005

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
OH	BRIDGEPORT	WHEELING CREEK	2,000	2,318
OH	BROOKSIDE	OHIO RIVER	939	703
OH	BRYAN	PRAIRIE CREEK	6,954	8,348
OH	BUCYRUS	SANDUSKY RIVER	13,000	13,496
OH	CAMPBELL	MAHONING RIVER	250	10,038
OH	CINCINNATI	OHIO RIVER	146,000	364,040
OH	CINCINNATI	OHIO RIVER	30,000	364,040
OH	CINCINNATI	OHIO RIVER	358,100	364,040
OH	CITY OF WILLARD	JACOBS CREEK	5,965	4,297
OH	CLEVELAND EASTERLY AREA	LAKE ERIE	255,000	505,616
OH	CLEVELAND SOUTHERLY AREA	CUYAHOGA RIVER	223,000	505,616
OH	CLEVELAND WESTERLY AREA	LAKE ERIE	151,600	54,875
OH	CLYDE	UNNAMED CREEK	4,930	5,776
OH	COLUMBUS GROVE	PLUM CREEK	2,000	2,231
OH	COLUMBUS JACKSON PIKE	SCIOTO RIVER	227,500	632,910
OH	COLUMBUS SOUTHERLY	SCIOTO RIVER	122,500	2,849
OH	CONTINENTAL	COUNTY DITCH # 322	1,200	1,214
OH	CONVOY	HAGERMAN CREEK	1,100	1,200
OH	CRESTLINE	PARAMOUR CREEK	3,300	4,934
OH	DEFIANCE	MAUMEE RIVER	9,500	16,768
OH	DELPHOS	JENNINGS CREEK	7,639	7,093
OH	DELTA	BAD CREEK	2,880	2,849
OH	ELMORE	PORTAGE RIVER	1,300	1,334
OH	ELYRIA	BLACK RIVER	25,400	56,746
OH	ERIE	HURON RIVER	694	1,953
OH	EUCLID	LAKE ERIE	5,376	54,875
OH	FAYETTE	DEER CREEK	1,200	3,557
OH	FINDLAY	BLANCHARD RIVER	10,980	35,703

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
OH	FOREST VILLAGE OF	TRIB BLANCHARD RIVER	1,155	2,443
OH	FOSTORIA	EAST BRANCH PORTYAGE→	1,700	14,983
OH	FREDRICKTOWN	KOKOSING RIVER	2,000	1,442
OH	FREMONT	SANDUSKY RIVER	39,600	17,648
OH	GENOA	TOUSSAINT CREEK	2,000	2,262
OH	GIBSONBURG	PORTAGE RIVER	2,648	2,579
OH	GREEN SPRINGS	FLAG RUN CREEK	1,350	1,446
OH	GREENWICH	VERMILLION RIVER	1,500	1,442
OH	HASKINS	MAUMEE RIVER	647	549
OH	HICKSVILLE	MILL CREEK	3,900	3,664
OH	HURON	HURON RIVER	1,700	7,030
OH	IRONTON	OHIO RIVER	15,700	12,751
OH	KENTON	SCIOTO RIVER	6,000	8,356
OH	KINGSTON	BLACKWATER CREEK	1,400	1,153
OH	LAKEWOOD	ROCKY RIVER	40,000	59,718
OH	LANCASTER	HOCKING RIVER	36,000	34,507
OH	LIMA	AUGLAIZE RIVER	55,200	21,633
OH	LINDSEY	MUDDY CREEK	675	529
OH	LISBON	LITTLE BEAVER CREEK	3,500	3,037
OH	MARIETTA	OHIO RIVER	6,960	15,026
OH	MARION	OLENTANGY RIVER	39,357	34,075
OH	MARSHALVILLE	RED RUN	255	3,367
OH	MARTINS FERRY	OHIO RIVER	1,100	7,990
OH	MARTINS FERRY–BELLAIRE	OHIO RIVER	27,500	6,028
OH	MAUMEE	MAUMEE RIVER	159	15,561
OH	MCCOMB	ALGIRE CREEK	1,500	1,544
OH	MCCONNELSVILLE	MUSKINGUM RIVER	3,000	1,804
OH	MIDDLEPORT	OHIO RIVER	1,716	2,725

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
OH	MIDDLETOWN	MIAMI RIVER	14,724	46,022
OH	MILAN	HURON RIVER	1,300	1,464
OH	MILFORD	LITTLE MIAMI RIVER	75,000	5,660
OH	MINGO JUNCTION	CROSS CREEK	5,200	4,297
OH	MONROEVILLE	HURON RIVER	1,500	1,381
OH	MONTPELIER	ST JOSEPH	3,360	4,299
OH	NAPOLEON	MAUMEE RIVER	5,850	8,884
OH	NEW BOSTON	OHIO RIVER	2,500	2,717
OH	NEW BREMEN	WIERTH DITCH	2,500	2,558
OH	NEW LEXINGTON	LITTLE RUSH CREEK	4,500	5,117
OH	NEWARK	LICKING RIVER	42,000	44,389
OH	NEWTON FALLS	MAHONING RIVER	6,000	4,866
OH	NILES	MAHONING RIVER	500	21,128
OH	NORTH BALTIMORE	ROCKY FORD CREEK	3,200	3,139
OH	NORWALK	RATTLESNAKE CREEK	13,500	14,731
OH	OAK HARBOR	PORTAGE RIVER	3,000	2,637
OH	OHIO CITY	PRAIRIE DITCH	630	899
OH	PANDORA	RILEY CREEK	1,300	1,009
OH	PAULDING	FLATROCK CREEK	3,300	2,605
OH	PAYNE	FLATROCK CREEK	1,350	1,244
OH	PEMBERVILLE	PORTAGE RIVER	1,400	1,279
OH	PERRYSBURG	MAUMEE RIVER	9,500	12,551
OH	POMEROY	OHIO RIVER	600	2,259
OH	PORT CLINTON	LAKE ERIE	7,400	7,106
OH	PORTSMOUTH	OHIO RIVER	3,300	22,676
OH	PORTSMOUTH	LAWSON RUN	11,400	22,676
OH	ROCKFORD	ST MARY RIVER	960	1,119
OH	ROSSFORD	MAUMEE RIVER	200	5,861

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
OH	SANDUSKY	SANDUSKY BAY	38,000	34,507
OH	SPRINGFIELD	MAD RIVER	95,000	70,487
OH	STEUBENVILLE	OHIO RIVER	133,000	22,125
OH	STOCKPORT	MUSKINGUM RIVER	56	462
OH	STRUTHERS	MAHONING RIVER	28,000	12,284
OH	SWANTON	AI CREEK	3,000	3,557
OH	TIFFIN	SANDUSKY RIVER	24,000	18,604
OH	TOLEDO	MAUMEE RIVER	196,000	332,943
OH	TORONTO	OHIO RIVER	5,353	6,127
OH	UPPER SANDUSKY	SANDUSKY RIVER	18,000	5,906
OH	VAN WERT	TOWN CREEK	11,300	10,891
OH	VILLAGE OF PUT IN BAY	LAKE ERIE	430	2,605
OH	WAPAKONETA CITY OF	AUGLAIZE RIVER	3,650	9,214
OH	WARREN	MAHONING RIVER	35,000	4,866
OH	WASHINGTON	PAINT CREEK	12,910	12,983
OH	WESTON	TONTOGANY CREEK	1,146	1,716
OH	WILLISTON		17,405	0
OH	WILSHIRE	ST MARY RIVER	720	15,026
OH	WOODVILLE	PORTAGE RIVER	1,520	1,953
OH	WOOSTER	KILLBUCK CR	6,800	22,191
OH	YOUNGSTOWN	MAHONING RIVER	46,075	95,732
OH	ZANESVILLE	MUSKINGUM	3,330	26,778
OR		COQVILLE RIVER	1,200	163
OR	ALBANY	WILLAMETTE RIVER	2,971	29,462
OR	ASTORIA	YOUNGS BAY	6,103	10,069
OR	AUMSVILLE	BEAVER CREEK	213	1,650
OR	COOS BAY CITY	COOS BAY	3,553	15,076

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
OR	CORVALLIS	WILLAMETTE RIVER	5,684	44,757
OR	COTTAGE GROVE	WILLAMETTE RIVER	1,197	7,402
OR	CRESWELL	CAMAS SWALE	104	2,431
OR	DALLAS	RICKREALL CREEK	1,529	9,422
OR	GERVAIS	PUDDING RIVER	177	992
OR	GLADSTONE	WILLAMETTE RIVER	1,501	10,152
OR	GRANTS PASS	ROGUE RIVER	3,492	17,488
OR	HUNTINGTON	BURNT RIVER	270	522
OR	INDEPENDENCE	ASH CREEK	1,061	4,425
OR	JEFFERSON	SANTIAM RIVER	165	1,805
OR	KLAMATH FALLS	LAKE EWAUNA	2,759	17,737
OR	LA GRANDE	GEKELER SLOUGH	367	11,766
OR	LEBANON	SOUTH SANTIAM RIVER	883	10,950
OR	MCMINNVILLE	SOUTH YAMHILL RIVER	1,462	17,894
OR	MONMOUTH	NORTH FORK ASH CREEK	495	6,288
OR	MYRTLE CREEK	MYRTLE CREEK	900	3,063
OR	MYRTLE POINT	COQVILLE RIVER	750	2,712
OR	NEWPORT	PACIFIC OCEAN	3,252	8,437
OR	NORTH BEND	COOS BAY	2,243	9,614
OR	ONTARIO	MALHEUR RIVER	2,190	9,392
OR	OREGON CITY	WILLAMETTE RIVER	6,276	14,698
OR	PENDLETON	MCKAY CREEK	1,032	15,126
OR	PORTLAND	WILLAMETTE RIVER	317,574	437,319
OR	ROSEBURG	SOUTH UMPQUA RIVER	7,800	17,488
OR	SALEM	WILLAMETTE RIVER	60,187	107,786
OR	SILVERTON	SILVER CREEK	384	5,635
OR	ST HELENS	COLUMBIA RIVER	2,166	15,076
OR	THE DALLES	COLUMBIA RIVER	439	17,894

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
OR	WOODBURN	MILL CREEK	1,425	13,404
OR	WOODBURN	PUDDING RIVER	1,189	13,404
PA		LEGHIGH- RIVER	6,300	481,479
PA		TOWANDA CREEK	1,310	481,479
PA		QUEMAHONING CREEK	1,600	481,479
PA		OIL CREEK	7,331	(1)
PA		QUEMAHONING CREEK	1,600	21,923
PA			12,036	479
PA	CALIFORNIA	MONONGAHELA RIVER	7,800	5,748
PA	ALLENPORT	MONONGAHELA RIVER	6,417	595
PA	ALTOONA	LITTLE JUNIATA RIVER	45,000	51,881
PA	AMBRIDGE	OHIO RIVER	11,324	8,133
PA	APOLLO	KISKIMENTAS RIVER	40,546	1,895
PA	ARCHBALD	LACKAWANNA RIVER	210,255	6,291
PA	BALDWIN	SEE NOTE	27,000	21,923
PA	BARNESBORO	W BR SUSQUEHANA RIVER	4,882	2,530
PA	BEAVER FALLS	BEAVER RIVER	13,867	10,687
PA	BELLE VERNON	MONONGAHELA RIVER	1,496	1,213
PA	BENTLEYVILLE	SEE NOTE	714	2,673
PA	BERWICK	SUSQUEHANNA RIVER	12,274	10,976
PA	BLAIRSVILLE	CONEMAUGH RESERVOIR	4,447	3,595
PA	BRIDGEPORT	SCHUYLKILL RIVER	5,700	4,292
PA	BROWNSVILLE	MONONGAHELA RIVER	10,000	3,164
PA	CENTRAL CITY	DARK SHADE CREEK	600	1,246
PA	CENTRALIA	BIG MINE RUN CREEK	1,089	63
PA	CHARLEROI	MONONGAHELA RIVER	8,536	5,014
PA	CHESTER	DELAWARE RIV ESTUARY	35,926	7,216

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
PA	CLAIRTON	MONONGAHELAKRIVER	19,870	9,656
PA	COKEBURG	SEE NOTE	45	724
PA	CONFLUENCE	YOUGHIOGHENY RIVER	954	873
PA	CONNELLSVILLE	YOUGHIOGHENY RIVER	9,600	9,229
PA	CORAOPOLIS	OHIO RIVER	8,435	6,747
PA	CORRY	HARE CREEK	6,835	7,216
PA	COUDERSPORT	ALLEGHENY RIVER	3,000	2,854
PA	CREIGHTON	ALLEGHENY RIVER	14,256	0
PA	CREIGHTON	SEE NOTE	2,081	(1)
PA	CRESSON	LITTLE CONEMAUGH RIVE	2,412	2,003
PA	DAWSON	YOUGHIOGHENY RIVER	1,500	535
PA	DRAVOSBURG	MONONGAHELA RIVER	2,216	2,377
PA	DUQUESNE	MONONGAHELA RIVER	11,410	8,525
PA	EASTON	DELAWARE RIVER	8,000	26,276
PA	EDGEWORTH	SEE NOTE	2,200	1,670
PA	ELIZABETH	MONONGAHELA RIVER	2,100	1,387
PA	ELLSWORTH	SEE NOTE	733	1,048
PA	ELLWOOD CITY	CONNOQUENESSING CREEK	10,857	8,894
PA	ERIE	PRESQUE ISLE BAY	129,231	108,718
PA	FARRELL	SHENANGO RIVER	8,200	6,841
PA	FAYETTE CITY	MONONGAHELA RIVER	1,000	713
PA	FRANKLIN	ALLEGHENY RIVER	14,600	7,329
PA	FREELAND	POND CREEK	3,960	3,909
PA	GALETON	WEST BRANCH PINE CR	1,552	1,370
PA	GALLITZIN	BRADLEY RUN	2,406	2,003
PA	GREENSBURG	SEWICKLEY CREEK	20,388	16,318
PA	HARRISBURG	SUSQUEHANNA RIVER	69,350	52,376
PA	HAZELTON	N BR SUSQUEHANA RIVER	18,800	24,730

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
PA	HAZELTON	SEE NOTE	31,500	24,730
PA	HAZLETON	SEE NOTE	3,092	24,730
PA	HUNTINGDON	JUNIATA RIVER	11,000	6,843
PA	IRWIN	BRUSH CREEK	4,200	4,604
PA	JEANNETTE	BRUSH CREEK	15,809	11,221
PA	KANE	KINZUA-CREEK	5,000	4,590
PA	KEISER	SHAMOKIN CREEK	970	7,196
PA	LANCASTER	CONESTOGA CREEK	45,815	55,551
PA	LANCASTER	CONESTOGA CREEK	1,187	55,551
PA	LATROBE	LOYALHANNA CREEK	612	9,265
PA	LEETSDALE	OHIO RIVER	1,862	1,387
PA	LIGONIER	LOYALHANNA CREEK	2,408	1,638
PA	LILLY	LITTLE CONEMAUGH RIVE	1,436	1,162
PA	MANOR	BRUSH CREEK	1,700	2,627
PA	MARIANNA	TEN MILE CREEK	850	616
PA	MARYSVILLE	SUSQUEHANA RIVER	2,370	2,425
PA	MCKEESPORT	MONONGAHELA RIVER	74,991	26,016
PA	MEYERSDALE	CASSELMAN RIVER	3,000	2,518
PA	MIDLAND	OHIO RIVER	5,300	3,321
PA	MONACA	OHIO RIVER	7,350	6,739
PA	MONONGAHELA	MONONGAHELA	2,840	4,928
PA	MOOSIC	SEE NOTE	4,400	5,339
PA	MOOSIC	LACKAWANNA RIVER	40,993	5,339
PA	MOUNT CARMEL	SHAMOKIN CREEK	17,300	7,196
PA	MT PLEASANT	SHOPE RUN	3,537	4,787
PA	NESQUEHONING	NESQUEHONING CREEK	3,700	3,364
PA	NEW BETHLEHEM	RED BANK CREEK	1,300	1,151
PA	NEW KENSINGTON	BIG PUCKETAS	6,095	15,894

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
PA	NEWPORT	JUNIATA RIVER	3,000	1,568
PA	NORRISTOWN	SCHUYLKILL RIVER	4,800	30,749
PA	OAKMONT	ALLEGHENY RIVER	2,265	6,961
PA	OIL CITY	OIL CREEK	15,033	11,949
PA	OLD FORGE	LACKAWANNA RIVER	29,335	8,834
PA	OSBORNE	SEE NOTE	579	565
PA	PHILADELPHIA	DELAWARE RIVER	1,926,176	1,585,577
PA	PITTSBURGH	ALLEGHENY RIVER	7,900	369,879
PA	PITTSBURGH	OHIO RIVER	193,860	369,879
PA	PITTSBURGH	OHIO RIVER	518,300	369,879
PA	PITTSBURGH	SEE NOTE	12,036	369,879
PA	POTTSVILLE	SCHUYLKILL RIVER	27,000	16,603
PA	PUNXSUTAWNEY	MAHONING CREEK	7,700	6,782
PA	ROCHESTER	OHIO RIVER	8,255	4,156
PA	ROCKWOOD	CASSELMAN RIVER	1,019	1,014
PA	SCOTTDALE	JACOBS CREEK	2,900	5,184
PA	SCRANTON	LACKAWANNA RIVER	88,000	81,805
PA	SEWICKLEY	OHIO RIVER	8,439	1,821
PA	SHAMOKIN	SHAMOKIN CREEK	22,500	11,591
PA	SHEFFIELD	TIONESTA CREEK	1,564	1,294
PA	SHINGLEHOUSE	OSWAYO– CREEK	1,324	1,243
PA	SLIGO	LICKING CREEK	800	706
PA	SOUTH BETHLEHEM	RED BANK CREEK	500	479
PA	ST CLAIR	MILL CREEK	5,000	3,524
PA	STROUDSBURG	BRODHEADS CREEK	1,100	5,312
PA	SUNBURY	SHAMOKIN CREEK	12,703	11,591
PA	THROOP	LACKAWANNA RIVER	35,449	4,070
PA	UNIONTOWN	REDSTONE CREEK	16,280	12,034

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
PA	VERSAILLES	MONONGAHELA RIVER	2,754	1,821
PA	VINTONDALE	S BRANCH BLACKLICK CR	795	582
PA	WEST HAZLETON	SEE NOTE	6,200	4,136
PA	WEST NEWTON	YOUGHIOGHENY	3,700	3,152
PA	WILKES-BARRE	SUSQUEHANA	23,508	31,933
PA	WILLIAMSPORT	W BR SUSQUEHANA RIVER	35,000	31,933
PA	WINDBER	CONEMAUGH-RIVER	10,000	4,756
PR	PUERTO NUEVO	SAN JUAN BAY	600,000	0
RI	PAWTUCKET	BLACKSTONE R	77,000	72,644
RI	PROVIDENCE	PROVIDENCE R	113,550	160,728
SD	ARTESIAN	JIM CREEK	277	217
SD	CRESBARD	SNAKE CREEK TRIB.	224	185
SD	GROTON	MUD CREEK	1,200	1,196
SD	HIGHMORE	BRANCH OF WOLF CREEK	1,000	835
SD	HURON	JAMES RIVER	14,245	12,448
SD	LEAD	WHITEWOOD CREEK	9,063	3,632
SD	LEMMON	CEDAR CREEK,TRIB. OF	1,950	1,614
SD	LENNOX		1,700	1,767
SD	PINE RIDGE	WHITE RIVER	3,000	2,596
SD	REDFIELD	TURTLE CREEK	2,840	2,770
SD	SIOUX FALLS	BIG SIOUX FALLS	80,000	100,814
SD	TYNDALL	MISSOURI RIVER TRIB	0	1,201
SD	WAGNER	TRIB. OF CHOTEAU CK	1,800	1,462
TN	BRISTOL	SOUTHFORKHOLSTONRIVER	34,000	23,421

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
TN	CHATTANOOGA	TENNESSEE RIVER	15,600	152,466
TN	NASHVILLE	CUMBERLAND RIVER	100,900	488,374
TX	BEAUMONT	NECHES RIVER	35,000	114,323
UT	EUREKA		918	562
UT	TREMONTON	MALAD RIVER	3,818	4,264
VA	ALEXANDRIA	POTOMAC-RIVER	13,440	111,183
VA	ASHLAND	SOUTH ANNA RIVER	4,275	5,864
VA	BRISTOL	BRISTOL CITY	8,600	18,426
VA	CLIFTON FORGE	COWPASTURE-RIVER	5,100	4,679
VA	COVINGTON	JACKSON RIVER	9,760	6,991
VA	HOPEWELL	POYTHRESS CREEK	1,250	23,101
VA	LYNCHBURG	JAMES RIVER	85,800	66,049
VA	NEWPORT NEWS	JAMES RIVER	51,600	170,045
VA	RADFORD	NEW RIVER	3,000	15,940
VA	REMINGTON	RAPPAHANNOCK RIVER	450	460
VA	RICHMOND CITY	JAMES RIVER	352,775	203,056
VA	WAYNESBORO	SOUTH RIVER	1,300	18,549
VT	ALBURG	LAKE CHAMPLAIN	530	436
VT	BARTON VILLAGE	BARTON RIVER	1,050	908
VT	BELLOWS FALLS	CONNECTICUT RIVER	3,505	3,313
VT	BENNINGTON	WALLOOMSAC RIVER	12,460	9,532
VT	BETHEL		87	1,866
VT	BRANDON	SAVH	2,700	1,902
VT	BURLINGTON	LAKE CHAMPLAIN	20,000	39,127

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
VT	ENOSBURG FALLS	MISSISQUOI RIVER	1,266	1,350
VT	ESSEX JUNCTION VILLAGE	WINOOSKI R	4,000	8,396
VT	FAIRHAVEN	POULTNEY – RIVER	2,200	2,432
VT	HARDWICK	LAMOILLE RIVER	1,500	2,964
VT	HYDE PARK	LAMOILLE RIVER	318	457
VT	LUDLOW	BLACK RIVER	1,800	1,123
VT	LUNENBURG	CONNECTICUT RIVER	400	1,176
VT	LYNDON	PASSUMPSIC RIVER	4,080	1,255
VT	MIDDLEBURY	OTTER CREEK	2,000	6,007
VT	MONTPELIER	WINOOSKI RIVER	8,609	8,247
VT	NEWPORT	LAKE MEMPHREMAGOG	4,664	4,434
VT	NORTHFIELD	DOG RIVER	4,995	1,889
VT	ORLEANS	BARTON&WILLOUGHBY RVR	1,047	806
VT	POULTNEY	POULTNEY RIVER	1,874	1,731
VT	RANDOLPH	THIRD BRANCH OF WHITE	1,400	4,764
VT	RICHFORD	MISSISQUOI RIVER	75	1,425
VT	RUTLAND	OTTER CREEK	20,000	18,230
VT	SOUTH ROYALTON	WHITE RIVER	80	0
VT	SPRINGFIELD	BLACK RIVER	6,532	4,207
VT	ST ALBANS	STEVENS BRANCH	8,200	7,339
VT	ST JOHNSBURY	PASSUMPIC RIVER	7,000	6,424
VT	WILDER	CONNECTICUT RIVER	1,000	1,576
VT	WINDSOR	CONNECTICUT RIVER	2,940	3,714
VT	WINOOSKI	WINOOSKI RIVER	2,000	6,649
WA		YAKIMA RIVER	0	491
WA		SULFUR CREEK	0	491
WA		WILLAPA RIVER	0	(1)

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
WA		STILLAGUAMISH RIVER	502	491
WA	ABERDEEN	CHEHALIS RIVER	10,539	16,565
WA	ANACORTES	GUEMES CHANNEL	918	11,451
WA	BELLINGHAM	BELLINGHAM BAY	3,998	52,179
WA	BLAINE	DRAYTON HARBOR	814	2,489
WA	BREMERTON	PUGET SOUND	9,616	38,142
WA	CARBONADO	CARBON RIVER	400	495
WA	CATHLAMET	COLUMBIA RIVER	695	508
WA	CHENEY		6,820	7,723
WA	EDMUNDS		21,600	30,744
WA	ELLENSBURG	YAKIMA RIVER	1,585	12,361
WA	EVERETT	SKYKOMISH RIVER	264	69,961
WA	EVERETT	SNOHOMISH RIVER	31,680	69,961
WA	FERNDALE	NOOKSACK RIVER	38	5,398
WA	GOLDENDALE	LITTLE KLICKITAT RIV	0	3,319
WA	GRAND COULEE	CRESCENT BAY	490	984
WA	GRANITE FALLS	PILCHUCK RIVER	600	1,060
WA	HOQUIAM	CHEHALIS RIVER	1,000	8,972
WA	ILWACO		1,200	815
WA	KALAMA		1,200	1,210
WA	LACEY	BUDD INLET	10,817	19,279
WA	MARYSVILLE	EBEY SLOUGH	1,300	10,328
WA	METALINE FALLS		350	210
WA	MONROE	SKYKOMISH RIVER	2,400	4,278
WA	MOSES LAKE	MOSES LAKE	3,500	11,235
WA	MOUNT VERNON	SKAGIT RIVER	6,000	17,647
WA	MUKILTEO	PUGET SOUND	770	7,007
WA	OLYMPIA	BUDD INLET	6,500	33,840

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
WA	PASCO	SACAJAWEA LAKE	689	20,337
WA	PORT TOWNSEND	ST OF JUAN DE FUCA	137	7,001
WA	PT ANGELES	ST OF JUAN DE FUCA	6,116	17,710
WA	PUYALLUP		25,881	23,875
WA	REARDON		490	482
WA	ROSLYN		1,421	869
WA	SEATTLE	PUGET SOUND ET. AL.	330,000	516,259
WA	SNOHOMISH	SNOHOMISH RIVER	5,500	6,499
WA	SPOKANE	SPOKANE RIVER	160,700	177,196
WA	SUMNER	WHITE RIVER	1,080	6,281
WA	TACOMA	PUYALLUP RIVER	999	176,664
WA	VANCOUVER		44,000	46,380
WA	WALLA WALLA	MILL CREEK	23,000	26,478
WA	WENATCHEE		17,450	21,756
WI	CHIPPEWA FALLS	CHIPPEWA RIVER	7,378	12,727
WI	CLINTONVILLE	PIGEON RIVER	7,500	4,351
WI	EAU CLAIRE	CHIPPEWA RIVER	45,900	56,856
WI	KENOSHA	LAKE MICHIGAN	21,000	80,352
WI	MARINETTE	MENOMINEE RIVER	6,200	11,843
WI	MILWAUKEE	LAKE MICHIGAN	366,000	628,088
WI	NEKOOSA	WISCONSIN RIVER	150	2,557
WI	OCONTO CITY	OCONTO RIVER	2,500	4,474
WI	OSHKOSH	LAKE WINNEBAGO	3,150	55,006
WI	RACINE	LAKE MICHIGAN	118,000	84,298
WI	RICE LAKE	RED CEDAR RIVER	19	7,998
WI	SHOREWOOD	LAKE MICHIGAN	4,300	14,116
WI	SUPERIOR	LAKE SUPERIOR	30,100	27,134

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
WI	WISCONSIN	WISCONSIN RIVER	15,300	0
WV	BARBOURSVILLE	MUD RIVER	2,279	2,774
WV	BECKLEY	PINEY CREEK	25,000	18,296
WV	BELINGTON	TYGART RIVER	1,567	1,850
WV	BENWOOD	OHIO RIVER	1,866	1,669
WV	BETHANY	BUFFALO-CREEK	650	1,139
WV	BLUEVILLE	TYGART RIVER	6,433	5,524
WV	CAMERON	GRAVE CREEK	1,537	1,177
WV	CHARLESTON	KANAWHA RIVER	69,956	57,287
WV	CHESTER	OHIO RIVER	4,000	2,905
WV	CLARKSBURG	WEST FORK RIVER	30,137	18,059
WV	CLENDENIN	ELK RIVER	1,000	1,203
WV	EAST BANK	CHELYAN	1,465	892
WV	ELKINS		9,170	7,420
WV	FOLLANSBEE	OHIO RIVER	3,450	3,339
WV	HANDLEY	KANAWHA RIVER	450	334
WV	HINTON	NEW RIVER	4,400	3,433
WV	HUNTINGTON	OHIO RIVER	76,815	54,844
WV	HURRICANE		0	4,461
WV	KENOVA	OHIO RIVER	5,000	3,748
WV	KEYSER	NORTH BRANCH POTOMAC	7,000	5,870
WV	MALDEN	KANAWHA RIVER	12,000	0
WV	MARLINGTON	GREENBRIAR RIVER	1,500	1,148
WV	MARMET	KANAWHA RIVER	3,500	1,879
WV	MARTINSBURG	OPEQUON CREEK	14,626	14,073
WV	MCMECHEN	OHIO RIVER	2,080	2,130
WV	MONONGAH	WEST FORK RIVER	1,200	1,018

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
WV	MONTGOMERY	KANAWHA RIVER	2,275	2,449
WV	MORGANTOWN	MONONGAHELA RIVER	35,250	25,879
WV	MOUNDSVILLE	OHIO RIVER	25,000	10,753
WV	NEW CUMBERLAND	OHIO RIVER	575	1,363
WV	NITRO	KANAWHA RIVER	6,449	6,851
WV	NUTTER FORT	ELK CREEK	2,379	1,819
WV	PARKERSBURG	OHIO RIVER	0	33,862
WV	PARSONS	SHAVERS FORK	1,250	1,453
WV	PENNSBORO	BUNNELLS RUN STREAM	1,614	1,282
WV	PETERSBURG	S BRANCH POTOMAC RIVE	2,395	2,360
WV	PHILIPPI	TYGART RIVER	3,600	3,132
WV	POINT PLEASANT	OHIO RIVER	6,350	4,996
WV	RICHWOOD	CHERRY RIVER	4,000	2,808
WV	RIDGELEY	N BR POTOMAC RIVER	1,112	779
WV	ROWLESBURG	CHEAT RIVER	2,000	648
WV	SCOTT DEPOT	KANAWHA RIVER	1,398	0
WV	SHINNSTON	WEST FORK RIVER	2,516	2,543
WV	SISTERSVILLE		2,821	1,797
WV	SMITHERS	KANAWHA– RIVER	2,000	1,162
WV	SOUTH CHARLESTON	KANAWHA RIVER	17,050	13,645
WV	SPENCER	SPRING CREEK	3,800	2,279
WV	SUMMERSVILLE	ARBUCKLE–CREEK–	4,000	2,906
WV	TERRA ALTA	SNOWY CREEK	1,500	1,713
WV	WAYNE	TWELVE POLE CREEK	750	1,128
WV	WHEELING	OHIO RIVER	54,000	34,882
WV	WHITESVILLE	BIG COAL RIVER	781	486
WV	WILLIAMSON	TUG FORK OF BIG SANDY	5,700	4,154

COMMUNITIES WITH COMBINED SEWER SYSTEMS

STATE	COMMUNITY	PRIMARY RECEIVING WATER	1980 CSO POPULATION SERVED (1)	1990 TOTAL CITY POPULATION (2)
WY	SHERIDAN	GOOSE CREEK	14,645	13,900
US	TOTAL (3)		42,289,122	44,308,986

(1) Source: 1980 Needs Survey, U.S. EPA
(2) Source: 1990 U.S. Census of Population, Bureau of the Census.
(3) Double counting has been eliminated in city total.
Note: Service area of sewer utility for named community does not necessarily correspond with Census area associated with named community.

Appendix B

INFORMATION SOURCES FOR STATE CSO WET WEATHER STANDARDS

GENERAL INFORMATION

Work performed by Jeff Albert of The Bruce Company under separate contract to EPA provided general information for all of the state policies. Mr. Albert provided further information in a July 1991 telephone conversation (Natural Resources Defense Council, San Francisco, California, (415) 777-0220).

CALIFORNIA

State Water Resources Control Board, State of California Combined Sewer Overflow Control Strategy, State of California, Sacramento, California.

Stephen A. Hill, Environmental Specialist, California Regional Water Quality Control Board, San Francisco Bay Region, Oakland, California, (510) 464-0433. Telephone conversation, July 1991.

"City and County of San Francisco Wastewater Facility Improvements - Status Report," internal memorandum from Stephen Hill to Steven R. Ritchie, California Regional Water Quality Control Board, San Francisco Bay Region, August 23, 1991.

ILLINOIS

Tom McSwiggin, Manager, Water Pollution Permits Section, Illinois Environmental Protection Agency, (217) 782-0610. Telephone conversation, 1991.

MASSACHUSETTS

"Massachusetts Water Quality Standards: Implementation Policy for the Abatement of Pollution from Combined Sewer Overflows," May 24, 1990.

Glen Haas, Massachusetts Department of Environmental Protection, (617) 292-5500. Telephone conversations, 1991.

MICHIGAN

Jim Beaver, Water Administrator, City of Grand Rapids, Michigan, (616) 456-3257. Telephone conversation, July 1991.

Paul Blakesly, Michigan Department of Natural Resources, Lansing, Michigan, (517) 322-5755. Telephone conversation, December 1991.

OREGON

"Oregon's Strategy for Regulating Combined Sewer Overflows (CSOs)," State of Oregon Department of Environmental Quality, February 28, 1991.

"Department of Environmental Quality of the State of Oregon v. City of Portland," Stipulation and Final Order No. WQ-NWR-91-75, before the Environmental Quality Commission of the State of Oregon.

Barbara Burton, Department of Environmental Quality, State of Oregon, Salem, Oregon, (503) 229-6099. Telephone conversations, 1991.

RHODE ISLAND

"Combined Sewer Overflow Policy," Rhode Island Department of Environmental Management, Division of Water Resources, March 1990.

Save the Bay, Providence, Rhode Island, "A Raw Deal: Combined Sewer Overflow Pollution in Narragansett Bay," Draft.

Kevin Brubaker, Save the Bay, Providence, Rhode Island, (401) 272-3450. Telephone conversation, July 1991.

Jay Manning, Rhode Island Department of Environmental Management, (401) 277-3961. Telephone conversations, 1991.

WASHINGTON

Ed O'Brien, Supervisor, Storm Water/Municipal Unit, Water Quality Program, Washington Department of Ecology, (206) 438-7037. Telephone conversation, 1991.

WISCONSIN

Wayne Saint John, Milwaukee Metropolitan Sewage District, (414) 225-2141. Telephone conversation, July 1991.

Jim Koster, Sewer Services Engineer, Department of Street and Sewer Maintenance, City of Milwaukee, (414) 278-2160. Telephone conversation, July 1991.

VERMONT

Brian Kooiker, Chief of Direct Permits Section, Department of Environmental Conservation, Vermont Agency of Natural Resources, (802) 244-5674. Telephone conversation, July 1991.