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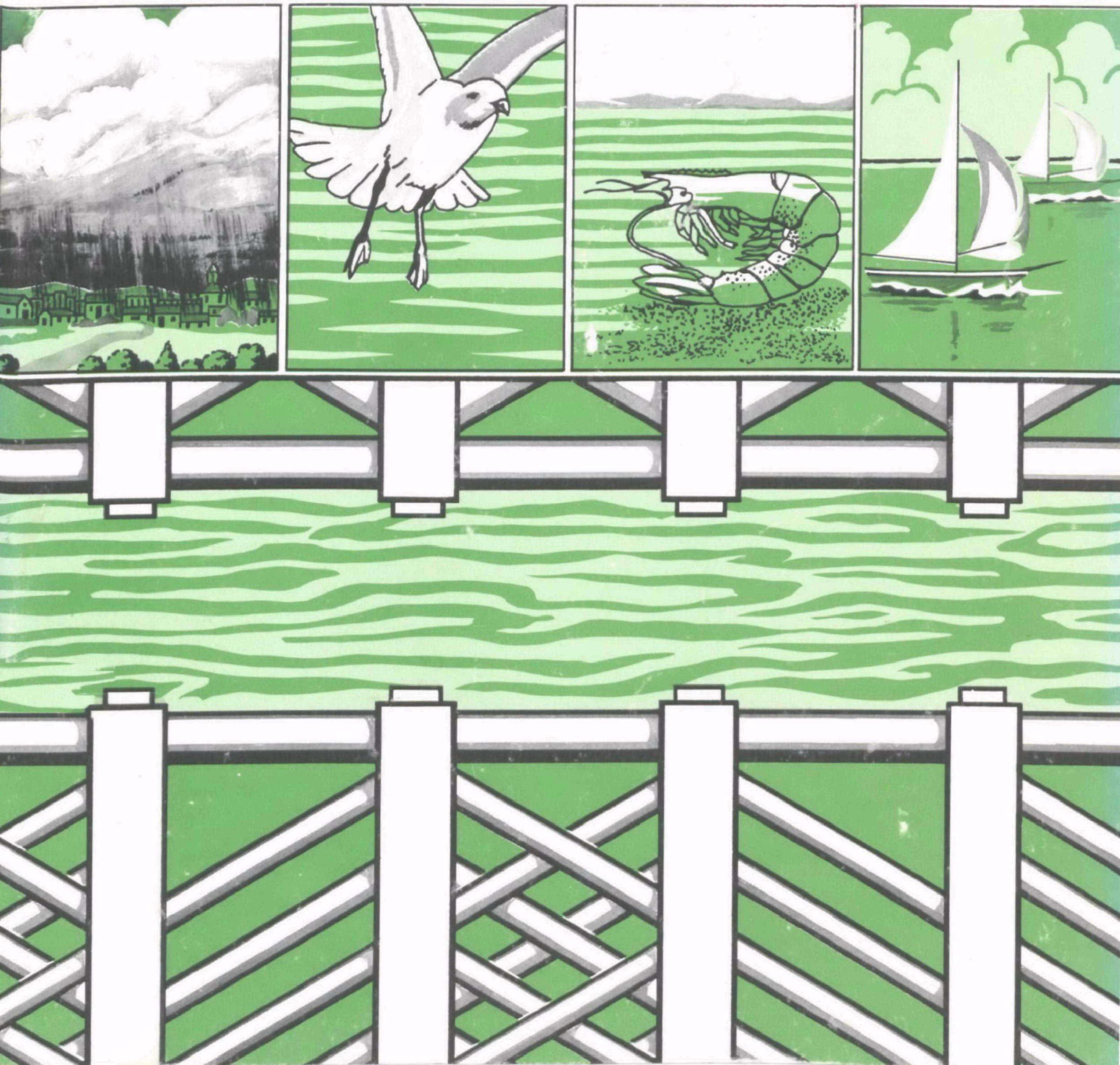
Benefit Analysis for Combined Sewer Overflow Control



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Benefit Analysis for Combined Sewer Overflow Control

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This seminar publication contains material prepared for the U.S. Environmental Protection Agency Technology Transfer Program and has been presented at Technology Transfer seminars on combined sewer overflow assessment and control procedures throughout the United States during 1978.

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Chapter I

Introduction

With each passing year, the number of publicly owned sewage treatment plants and industrial dischargers of waste water that are not in compliance with the national effluent guidelines set by the Federal Water Pollution Control Act Amendments of 1972[1] grows smaller. At the same time, there have been noticeable, often dramatic improvements in the quality of our streams and lakes. Fish kills caused by discharges of inadequately treated sewage were once common summer events in urban or industrialized areas; they have become infrequent. Waters that were once unappealing aesthetically are now attractive components of the urban landscape.

However, as the most obvious water pollution problems are abated, others become visible. In some urban areas, providing the required treatment for continuous point source discharges has not yielded the desired or mandated improvements in water quality. Attention has naturally turned to storm-related pollution in the form of storm sewer discharges and especially combined sewer overflows.

This publication is intended for the use of elected officials of municipalities served by combined sewers, their technical staff members, and their consultants. The report concerns an analysis of the benefits anticipated from control of combined sewer overflows. A number of references are available on combined sewer problems, their assessment and control technologies. They are cited in this publication, and some discussion of those topics is necessarily included here. But the subject of benefit analysis is uniquely important to anyone contemplating combined sewer overflow controls because of the nature of the overflows themselves, the distribution of combined sewer systems in the nation, the regulations governing the use of U.S. Environmental Protection Agency (EPA) construction grant moneys for this purpose, and the potentially high cost of corrective measures.

A clear understanding of the material in this publication will help any municipality, small or large, to avoid numerous and costly pitfalls and to take full advantage of opportunities for assistance in planning and implementing a combined sewer overflow control program.

The Nature of Combined Sewer Overflows

Combined sewers are, by definition, collection systems that convey both sanitary sewage and stormwater. They are typically found in older cities. Regulators in the sewers channel dry-weather flows (primarily sanitary sewage) into interceptors and thence to the sewage treatment plant. These regulators are set so that the excessive flows that enter the system through street inlets during storms are allowed to overflow to some receiving stream or lake rather than overloading the plant or the collection system with stormwater or backing up in sewers and causing localized flooding.

Combined sewer overflows can be characterized in several ways. First, they occur during or after storm events (unless regulators malfunction and allow continuous discharges), and their volumes and frequency are thus related to the rainfall patterns in the locality. Second, they occur at discrete overflow points. Third, they contain the constituents found in urban stormwater as well as those in sanitary sewage, often in higher concentrations as shown in Figure 1.

The result of an overflow can be a significant discharge of organic material, nutrients, sediment, microorganisms, oil and grease, and metals and other potentially toxic substances into the receiving water. In some cases, concentrations are higher at the beginning of the overflow – the so-called first flush of material accumulated in the sewer. Depending on the characteristics and sensitivity of the receiving water, the overflow can have a variety of effects, ranging from serious to negligible. Benefit analysis is in part concerned with identifying those effects and the anticipated results of effecting changes in them.

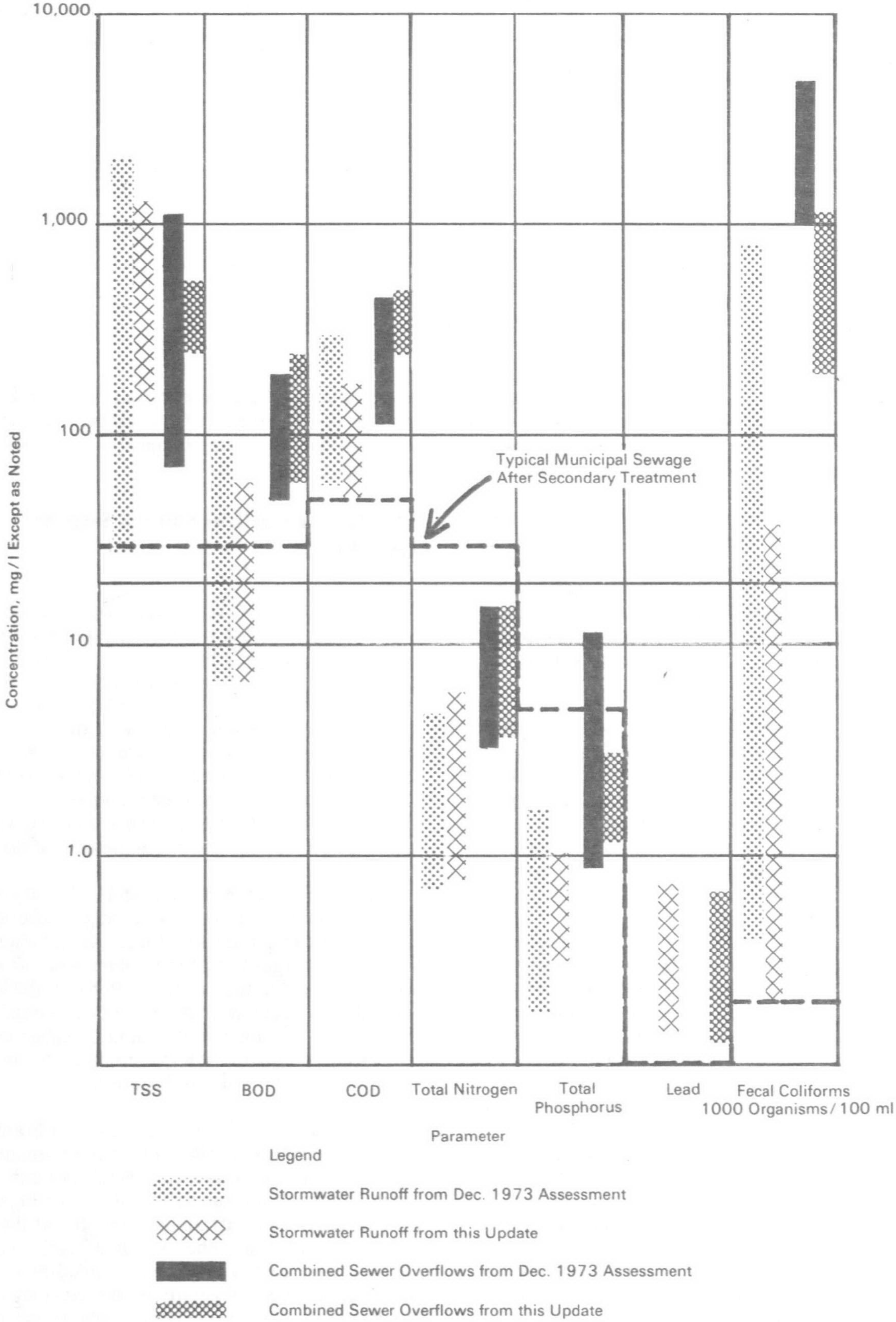

Figure 1. Representative Stormwater Discharge Quality.

Source: Lager, A., W. G. Smith, W. G. Lynard, R. M. Finn, and E. J. Finnemore, *Urban Stormwater Management and Technology: Update and User's Guide*, U.S. EPA Report, EPA 600/8-77-014, p. 10, September 1977.

Distribution of Combined Sewer Systems

Approximately 40 million people (one-fifth of the nation's population) are served by combined sewers. There are between 1,100 and 1,300 combined sewer systems, covering an area of more than 2 and one half million acres. Seventy-seven major cities, including 10 of the country's 14 largest have combined sewer overflow control needs of $50 million or more. They account for 96 percent of urbanized area combined sewer overflow control needs and 64 percent of national needs. The remaining control needs are shown in Figure 2.[2]

Regulations Governing Combined Sewer Overflow Control Projects

Combined sewer overflow control projects are eligible for federal assistance covering 75 percent of costs for feasibility studies, design and construction. However, the requirements for approval and funding are very different from those that apply to sewage treatment facilities. In the case of the latter, federal law requires at least secondary treatment. Facilities that have not achieved that level must do so, and when they are high enough on the state priority list, they can receive federal funding.

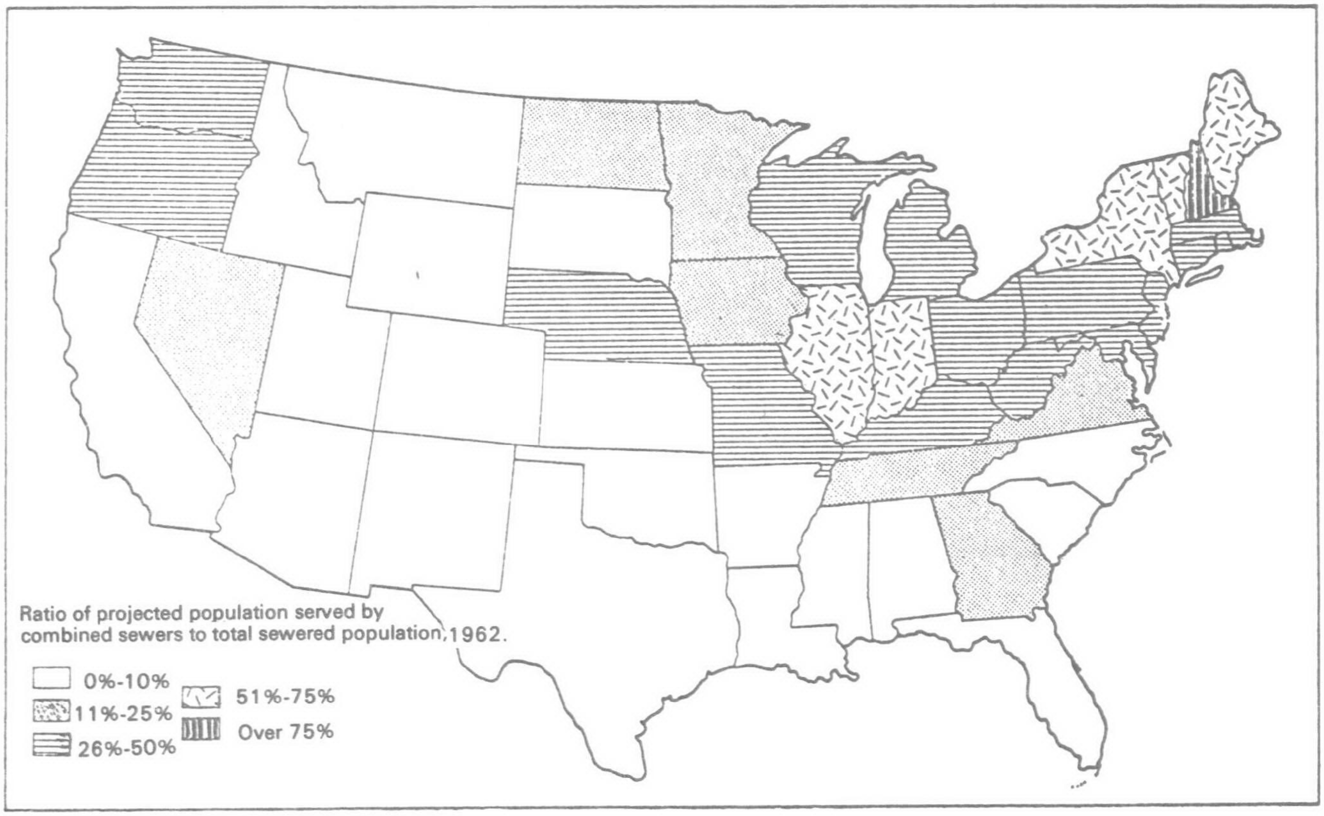

Figure 2. Geographic Distribution of Population Served by Combined Sewer Systems.
Source: U.S. Environmental Protection Agency, *Report to Congress on Control of Combined Sewer Overflows in the United States*, MCD-50, p. 6-2, 1978.

These statistics reveal another important characteristic of combined sewers: They are concentrated in some of our most heavily populated urban centers. In fact, the average population density of combined sewer service areas is 16.7 persons per acre. Consequently, when overflows occur, they affect relatively short reaches of surface waters, but millions of people feel the impact on water quality.[3]

There is no such technology-based treatment requirement for combined sewer overflows. Benefit analysis must be performed to demonstrate that the proposed level of overflow control or treatment will result in some tangible improvement in water-quality-related benefits. This is the same kind of requirement faced by states wishing to set water quality standards which require higher than secondary treatment; the state must show the connection between the water quality criterion and some beneficial use to be protected.

Other regulations governing combined sewer overflows require permits for each outfall. However, they differ from the National Pollutant Discharge Elimination System (NPDES) permits for treatment plants, which specify effluent limitations based on technology or water quality standards. NPDES permits for combined sewer overflows contain no effluent limitations, though they do usually require monitoring and data collection.

The Cost of Combined Sewer Overflow Control

Some of the options for controlling combined sewer overflows, especially those involving the division of the combined sewers into separate storm and sanitary systems, necessitate monumental expenditures that severely strain local budgets and state construstion grant allocations. On a nationwide basis, the EPA *1976 Needs Survey*[4] estimated that more than $18 billion ($21 billion in 1978 dollars) would be needed for control of pollution from combined sewer overflow, compared to $13 billion for secondary treatment and $21 billion for more stringent treatment of sanitary sewage. The *1978 Needs Survey*[5] contains a revised estimate of $25.7 billion for combined sewer overflow control. This estimate is based on optimum or least-cost alternative to provide certain minimum benefits. If sewer separation were arbitrarily carried out for all combined systems, the cost w;uld be an estimated $104 billion.

As a tool to relate proposed expenditure to anticipated benefit, a properly executed benefit analysis helps a municipality, and thus the U.S. government, avoid unnecessary costs. A benefit analysis provides justification for funding requested from the state and EPA, and it demonstrates to the taxpayers that their tax dollars are being used to achieve desirable objectives.

References

[1]Federal Water Pollution Control Act Amendment of 1972, 33 U.S.C. 1251, et seq., P.L. 92-500.

[2]U.S. Environmental Protection Agency, *Report to Congress on Control of Combined Sewer Overflows in the United States* (MCD-50), 1978.

[3]*Ibid.*, p. 6-9.

[4]Turner, B., R. Holbrook, R. Corbitt, and R. Wysoff, *1976 Needs Survey: Summary of Technical Data for Combined Sewer Overflow and Stormwater Discharge*, U.S. EPA Report, EPA 430/9-76-012, February 1977.

[5]Wycoff, R. J., J. Scholl, and S. Kissoon, *1978 Needs Survey: Cost Methodology of Control of Combined Sewer Overflows and Stormwater Discharge*, U.S. EPA Report, EPA-430/9-79-003, February, 1979.

Chapter II

Legislation and Regulations

To succeed in obtaining approval and funding assistance for a combined sewer overflow (CSO) project, it is necessary to know the regulations and policies that have an impact on ultimate grant application approvals. A clear understanding should be developed at the beginning of the process, because the plans must provide special outputs and must meet a number of criteria peculiar to combined sewer overflow control planning. Thus, this chapter will review briefly the legislation under which combined sewer overflow control planning and construction may be funded, the regulations promulgated by EPA in response to that legislation, other laws and regulations having an impact on combined sewer overflow, and the policies developed to guide not only the planners, engineers and attorneys, but also the elected officials, state environmental agencies, and EPA itself.

Under Section 208 of the Clean Water Act of 1977 (P.L. 95-217)[1] which ammended the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500),[2] funds are provided for areawide waste treatment management planning. This planning must include:

> The identification of treatment works necessary to meet the anticipated municipal and industrial waste treatment needs of the area over a twenty-year period, annually updated . . . [and] the necessary wastewater collection and urban storm water runoff systems . . . [Section 208(b)(2)(A)]*

The rules and regulations for 208 planning (promulgated by the EPA in 1975) specifically require as a component of the areawide plan the identification of required improvements to existing urban and industrial stormwater systems (including combined sewer overflows) necessary to attain and maintain applicable water quality standards [40 CFR 131.11(1)(1)].

The EPA guidelines for completing this element of 208 planning spelled out the steps to be followed:

- Inventory existing combined sewer systems, including locations of intakes, bypasses, pipes, regulators, and outfalls;
- Assess system performance;
- Measure or estimate waste constituents and loads and wastewater flows;
- Project wasteloads and flows; and
- Develop and evaluate alternatives.

As a practical matter, few 208 agencies have been able to accomplish all of this work.

One of the greatest difficulties faced by 208 planners was determining the relative contribution of combined sewer overflow pollution to existing water quality problems. The necessary data and analytical tools were not available and could not be assembled within the limitations imposed by time or budget. This problem definition function remains an appropriate task for the areawide planning process. Ongoing initial 208 programs, as well as those in the continuing planning stage, should incorporate it to provide a general framework for more detailed planning and engineering studies, including benefit analysis, which must precede implementation of combined sewer overflow controls.

What has in fact happened to date is that whatever combined sewer overflow problem definition has been accomplished in specific areas has been done in connection with the more detailed planning process for sanitary sewer treatment facilities under Section 201 of the Clean Water Act. This has weakened the areawide and comprehensive emphasis of the Act. Section 201 authorizes the Administrator of EPA to make grants for the planning and construction of publicly owned wastewater treatment works. For the purpose of Section 201, the term "treatment works" is defined rather broadly and includes (Section 212):

- Liquid waste storage, treatment, recycling and reclamation systems and devices;

*For simplicity, all Act citations are from P.L. 95-217 to ensure that no amendments are omitted, although in many cases the language of P.L. 92-500 remained unchanged.

- Interceptor and outfall sewers, collection systems, and related equipment;
- Extensions, improvements, or alterations to existing systems; and
- Any other method or system for preventing, abating, reducing, storing, treating, separating or disposing of municipal waste (including storm water runoff) or industrial waste (including waste in combined storm water and sanitary sewer systems).

The grants are generally for 75 percent of the cost of construction of the most cost effective alternative that provides the necessary treatment.

Part 35 of Title 40 of the Code of Federal Regulations[3] covers EPA's treatment works construction grant program. Section 35.915 establishes the state priority system used to allocate federal grant moneys. It specifies that projects are to be rated by the states on the basis of:

- Severity of the pollution problem;
- Population affected;
- Need for preservation of high quality waters; and
- At the state's option, the category of need addressed.

The categories of need are particularly significant; they consist of the following:

- Secondary treatment of wastewater under dry weather conditions;
- More stringent treatment under dry weather conditions;
- Correction of problems causing infiltration and inflow into sewers during storms;
- Sewer system replacement or major rehabilitation;
- New collectors and appurtenances;
- New interceptors and appurtenances; and
- Correction of combined sewer overflows.

Each state is given both the sole authority to determine the priority of the categories of need and the authority to determine the relative weight given to each criterion. Whether a given combined sewer overflow control project falls in the fundable part of the list is thus dependent on state policy as well as the nature of the combined sewer overflow problem. It is easy to envision, for instance, a situation in which secondary treatment is being achieved at most locations in the state even though water quality is still below standards in a populous urban area served by combined sewers. In such a case, a combined sewer overflow control project might rank high on the priority list. In another state, however, where secondary treatment has not been achieved in a number of plants and where extensive unsewered areas with septic tank malfunctions continue to exist, the combined sewer overflow control category would likely be given a lower priority, and such projects would be unfundable.

Although the state sets priorities, the federal EPA has provided specific policy guidance on the supporting justification and cost allocation approaches it will allow when approving a combined sewer overflow project for federal construction grant assistance. The first of two program requirements memoranda, PRM No. 75-34[4] has as its stated purpose the assurance that projects be funded only when careful planning has demonstrated that they are cost effective. The memorandum makes clear that the combined sewer overflow planning must include, for a 20-year period, a thorough analysis of the following aspects of the proposed project:

- Alternative control techniques that might be utilized to attain various levels of pollution control (related to alternative beneficial uses, if appropriate);
- The costs of achieving the various levels of pollution control by each of the techniques appearing to be the most feasible and cost effective after the preliminary analysis;
- The benefits to the receiving waters of a range of levels of pollution control during wet weather conditions; and
- The costs and benefits of treating combined sewer overflows as compared to the costs and benefits of advanced treatment of municipal dry weather flows in the area, i.e., treatment beyond the required secondary treatment.

The alternative finally selected will qualify for funding only if the following criteria have been met:

- Analysis has demonstrated that the level of pollution control provided will be necessary to protect a beneficial use of the receiving water even after technology based standards are achieved by industrial point sources and at least secondary treatment is achieved for dry weather municipal flows in the area;
- Provision has already been made for funding of secondary treatment of dry weather flows in the area;
- The pollution control technique proposed for combined sewer overflows is a more cost effective means of protecting the beneficial use of the receiving waters than other combined sewer pollution control techniques and the addition of treatment higher than secondary treatment for dry-weather municipal flows in the area;
- The marginal costs are not substantial compared to marginal benefits.

PRM 75-34 recommends graphic displays of marginal costs and benefits. Monetary, social, and environmental costs should be compared to pollution reduction, water quality improvements, and improvements in beneficial uses, in quantitative or qualitative terms, as appropriate. The significance of the beneficial uses to be protected also should be explained.

PRM 75-34 also states that multipurpose projects (combining flood control, recreation, and pollution abatement, for example) will be eligible for construction grant assistance only after an equitable allocation of cost savings has been made among the several projects; funding will not be allowed for an amount which exceeds the most cost effective single-purpose project for pollution control. The details of how this eligibility is to be determined, and how any cost savings arising from combining multiple purposes are to be dealt with, are the subjects of the second major EPA combined sewer overflow policy guidance document, PRM 77-4.[5] The cost allocation approach discussed in these memoranda is referred to as the alternative justifiable expenditure method.

> The alternative justifiable expenditure method is fundamentally based on the justified investment for each function. That justified investment is taken to be the cost of the most economical alternative single-purpose project which will achieve substantially the same benefits as does that function in the multiple-purpose project. That investment, sometimes called the alternative justifiable investment, represents the largest amount which could justifiably be expended on the function in the multiple-purpose project, for, in most instances, no more should be spent on a purpose than the cost of producing those benefits from the least expensive alternative source.

Further discussion of this allocation approach can be found in Chapter IV of this publication.

References

[1]Clean Water Act of 1977, 33 U.S.C. 1251 et seq. P.L. 95-217.

[2]Federal Water Pollution Control Act Ammendments of 1972, 33 U.S.C. 1251 et seq. P.L. 92-500.

[3]40 CFR 35, 37 FR 11650, June 9, 1972, effective July 1, 1972.

[4]Rhett, J. T., Water Programs Operations, U.S. Environmental Protection Agency, ''Program Requirements Memorandum, No. PRM 75-34'', received December 3, 1976.

[5]_______, ''Program Requirements Memorandum, No. PRM 77-4'', received December l6, 1976.

Beneficial Uses as Objectives

In any well executed planning process in the public realm, there are two general principles regarding the preparation of objectives. First, the effort to define them should begin early in the project. Definition may not be completed immediately. In fact, it may be impossible to arrive at a complete set of objectives until more information becomes available, but it is essential that all who will participate in the various aspects of the planning process be introduced to the work of identifying objectives. The refinement and final selection of objectives can occur as the work proceeds. Second, though decisions on objectives can be facilitated by the technicians and consultants who can suggest alternatives and indicate the range of choices, the actual choices must be made by elected officials. Moreover, the public must be allowed and encouraged to participate.

A third principle has applicability to many types of projects but is of critical importance to planning for control of pollution from combined sewer overflows. The tasks of developing a combined sewer overflow control program that will qualify for EPA approval and funding and then obtaining the funding as well as local support for the proposal will be immensely easier if the combined sewer overflow control objectives are related to benefits and expressed in such a way that measurement of benefit is made possible.

PRM 75-34[1] requires a measurement of benefits. Abating pollution is not, in itself, sufficient benefit in this context. It is the benefits that are the results of pollution abatement – the improvements expected in receiving water uses – that must be demonstrated. Because this is the case, it makes sense to select as pollution control objectives the maintenance of or improvement in specific beneficial uses. There is good precedent for this; water quality standards are already based on beneficial uses to be protected.

Requirements and Limitations

The first step in this examination is to sort out what uses the community wants, or is required, to provide and what uses are, in fact, possible. Subsequent chapters of this publication will discuss the relationship of these beneficial uses to water quality and pollution, the determination of polluting sources and their contribution to the pollution affecting beneficial uses (Chapter IV), the estimation of the costs of control (Chapter VI), and the assessment of the benefits (Chapter VII).

This whole sequence may appear rather simple and straightforward as it is set down in print, but this is anything but true, even in the early stages. The selection of specific water use objectives can be a highly political and complex activity. For instance, the realization of a particular benefit may conflict with the attainment of other desired objectives. In addition, citizens may agree in principle with the goals of the project but be unwilling to pay the costs that they perceive to outweigh the benefit.

Though some of the inputs into the decision making process regarding objectives, particularly those that relate to cost, cannot come until fairly far into the planning process, much can be contributed early in the process to narrow the number and scope of the alternatives that must eventually be evaluated in detail. Certain rules of thumb can also be used at early stages of the analysis to indicate the general magnitude of probable costs to achieve certain beneficial uses.

Beneficial uses may be uses new to the community, uses that were lost and now are to be restored, or uses that presently exist and are to be maintained. To determine the uses for a given body of water, one could consider the following possibilities:

1. Near shore land uses:
   - Recreational
   - Residential
   - Commercial
   - Industrial
2. Near shore water uses:
   - Swimming
   - Skindiving

- Boating – recreational or commercial
- Shellfishing
- Fish spawning
- Fish rearing
- Fish habitat
- Crustacean habitat
- Wildfowl food chain

3. Receiving water uses:

- Water supply
- Boating – recreational or commercial
- Fish habitat
- Wildfowl food chain

The list could be extended. However, the choices to be made are not unconstrained. A realistic choice among uses for a given body of water, or portion of it, must take into account the following:

- Federal, state, and regional government mandates;
- Compatibility with other objectives, including economic and social goals;
- Mutual compatibility of multiple uses of the receiving water;
- Limitations imposed by natural characteristics;
- Seasonal limitations;
- Public interest in or demand for certain uses;
- Design conditions and the concept of acceptable risk; and
- Technological and financial feasibility.

Each of these considerations are discussed briefly in the following sections.

Mandated Goals

The language of Section 101(a) of the Clean Water Act of 1977,[2] which amended the Federal Water Pollution Control Act of 1972,[3] is familiar:

> The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. In order to achieve this objective it is hereby declared that, consistent with the provisions of this Act —
>
> (1) it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985;
>
> (2) it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983;
>
> (3) it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited;
>
> (4) it is the national policy that federal financial assistance be provided to construct publicly owned waste treatment works;
>
> (5) it is the national policy that areawide waste treatment management planning processes be developed and implemented to assure adequate control of sources of pollutants in each state; and
>
> (6) it is the national policy that a major research and demonstration effort be made to develop technology necessary to elimate the discharge of pollutants into the navigable waters, waters of the contiguous zone, and the oceans.

Because this is national policy, any local water quality goals must be consistent with it.

The Act establishes certain technology-based requirements to be met by point source dischargers; effluent limitations based on secondary treatment for all publicly owned treatment works are an example [Section 301(b)].

It also directs the states to promulgate water quality standards consisting of statements of the uses designated for the waters involved and the water quality criteria which must be met to protect those uses.

> Such standards shall be such as to protect the public health or welfare, enhance the quality of water and serve the purposes of this Act . . ., taking into consideration [the waters'] use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other purposes, and also taking into consideration their use and value for navigation [Section 301(c)(1)].

As a result, there are already designated uses and related water quality criteria for most waters, with some variation from stream to stream and state to state.

Moreover, the Act recognizes that the technology-based effluent limitations required of all point source discharges may be insufficient for the protection of the designated uses of the states or the attainment of the Act's overall objectives in certain waters. It provides that states may establish more stringent effluent limitations in these cases [Section 302(a)]. Therefore the selection of local beneficial uses is further constrained in that not only must the local objectives for water quality be consistent with federal policy but also they cannot be less stringent than state standards.

Compatibility With Social and Economic Objectives

Though Section 302(a) of the Clean Water Act permits the imposition of effluent limitations more stringent than the national requirements for certain waters, it also requires that, where this is proposed, there be

> . . . public hearing to determine the relationship of the economic and social costs of achieving any such limitation . . ., including any economic or social dislocation in the affected community . . ., to the social benefits to be obtained (including the attainment of the objective of this Act) . . . [Section 302(b)(1)].

Congress recognized that there may be circumstances when proceeding beyond nationally required minimum levels of pollution control, even if necessary to attain the act's objectives, may exact costs, both economic and social, that are out of proportion to the expected benefits. If "there is no reasonable relationship between the economic and social costs and the benefits to be obtained," the more stringent limitations will not become effective.

This policy applies to the states as well as to EPA, and it should be embodied in any local planning process when water quality uses or benefits are being determined. The application of this policy, for instance, would prevent the objective of increasing trout fishing opportunities from being implemented if it is seriously incompatible with other goals such as maintaining high employment in a particular area.

Any such incompatibility of goals should be considered carefully by the decision makers involved and should be resolved long before elaborate plans and control alternatives are developed.

Mutual Compatibility of Multiple Uses of the Receiving Water

A related question to be considered in determining desired uses is whether or not any uses of particular segments of the receiving water are mutually incompatible. While swimming and fishing opportunities may not be impaired by recreational boating, for example, commercial ship navigation and bulk cargo handling may greatly restrict those activities. A reach of river that is a busy seaport should not also be designated for swimming and fishing since efforts to protect the latter uses would, in all likelihood, simply waste the tax-payers' money. Similarly, swimming is dangerous near large hydroelectric facilities and is therefore incompatible with such a use. Likewise, the use of the receiving water for irrigating agricultural lands may lead to fluctuating water levels, making boating impossible. A list of beneficial uses should not include two or more which are mutually incompatible.

Limitations Imposed by Natural Characteristics

No matter how clean the water may become, a warm-water stream will not become a self-sustaining trout fishery, any more than a white-water river is suitable for racing sailboats. Naturally acid rivers and lakes have a characteristic flora and fauna that cannot be replaced by plants and animals adapted to neutral or alkaline waters, regardless of public policy. There are other, more subtle natural limitations than these, and they should be taken into account when selecting desired water quality uses. For instance, when a certain use, such as swimming, is precluded by the absence of necessary conditions such as a beach, the cost of pollution control beyond the national minimum may be unwarranted.

Seasonal Limitations

Swimming and, to a great extent, boating, are not possible in many of the nation's waters during the winter months. Fishing, too, has seasonal aspects, especially in fresh water. Substantial savings in pollution control may be realized by including seasonal requirements in the objectives.

Public Interest or Demand

Water uses should not be selected on the basis of assumptions about public desires. Demand for a given beneficial use should be ascertained through public hearings, surveys, opinion polls, statistics on use of facilities, and any other available information sources. This is especially important, of course, when two incompatible uses are being considered or when protection of the use in question would involve large expenditures of public moneys. For example, rivers in the arid Southwest that are intensively managed as sources of irrigation water offer only limited opportunity for recreation. Most planners assume that water-based recreation is universally desired, but that assumption would have to be tested locally. It would take a strong expression of public demand to support changes in stream management that might adversely affect agricultural productivity and thus the economies of farming communities.

A second issue, also implicit in this example, is the question of distribution of costs and benefits. Recreational development is likely to attract users (beneficiaries) from outside the immediate area, but the local share of the costs of the necessary pollution control is borne by area residents. There may be non-financial costs as well. Greater recreational use can lead to traffic congestion on local roads, for example. These points, and others, such as the issue of economic benefits to area shops and restaurants, are certain to emerge in any public discussion of water uses, and they need to be carefully considered.

Design Conditions and the Concept of Acceptable Risk

Selecting the storm conditions (frequency and intensity of storms in a year) around which a control system or facility will be developed is intimately involved in the whole process of determining water use objectives to be achieved through combined sewer overflow controls. The size of control facilities and therefore capital and operating costs can be directly related to the design condition. Financial and technological feasibility, achievable levels of benefits, and public acceptability of the local financial portion of the costs all depend on the design condition selected.

Therefore, early in the benefit selection process, the idea of acceptable risk should be introduced since it will be important when design conditions are set and if any adjustment of the package of desired benefits is made necessary by unacceptably high estimates of cost. Here the aim is to determine the level or range of levels of acceptable beneficial use. Though ideal goals often cannot be reached because of limited funds, it is not always essential that they be achieved anyway.

Consider a situation in which swimming has been selected as a desired use at a given beach but each combined sewer overflow results in a 2-day beach closing because of high fecal coliform counts. If rain normally causes a combined sewer overflow once every 3 days, regardless of season, the beach will be closed an average of 20 days per month. The community is enjoying the use of its swimming beach for only one-third of the season, clearly an unacceptable level of benefits. Let us assume that a decision is made to prevent or treat overflows for not only these frequent, small storms, but for all storms up to ones expected to occur only once in 10 years. This 10-year event becomes the design storm for combined sewer overflow controls. An effective control system would reduce overflows to one every 3,650 days, essentially eliminating all beach closings during swimming season. However, the cost of this much protection, or this amount of benefit, can be quite large. If a community is willing to accept a somewhat higher risk of loss of benefit – beach closings, in this case – one could use a smaller, more frequent design storm and reduce the cost. In fact, if a 1-year storm were selected as the design storm, there would be only one overflow every 365 days on the average. If this large storm were typically in the non-swimming season, the beach would not be closed at all for swimming. Allowing overflows from all storms of a size likely to occur once every 3 months (and therefore, of course including even larger storms) would result in 0.7 days of closed beach each month. The decision maker should obviously seriously consider accepting the risk of a few days of closed beaches each season if it results in significant savings.

A note of caution should be added here. Public outcry over 0.7 days of lost benefits is likely to be much louder than the expressions of appreciation for the 29.3 days of benefits received unless the public is aware of the financial consequences of greater control. Such situations underscore the need for full public participation in the process of determining pollution control objectives, as well as clear graphic presentations of control alternatives and costs.*

Technological and Financial Feasibility

Questions of technological and financial feasibility become most clear when one begins to estimate the costs involved in providing the selected benefits. It is then that one sees the need for feedback in this planning process, from the evaluation of costs back to the selection or refinement of desired benefits. The objectives may have to be modified when the technological or financial resources available fall short of what would be required to meet them. This will be discussed further in Chapter VI. For the moment, it is sufficient to say that some concern for technical and financial feasibility should be included in the process of selecting desired uses of the receiving water. Rules of thumb and general information on control alternatives and approximate costs can be used.

Selection and Ranking

The public (defined as broadly as possible) must participate in the selection of a set of beneficial uses to serve as objectives. The question, after all, is one which only the public can properly answer: "What beneficial uses are important to you?" As already pointed out, protection of some uses is mandated by state or federal regulations, whereas other uses are made either possible or impossible (or impractical) by natural limitations or established conflicting uses. However, a range of choice remains, and each interest group is likely to have its own position. Environmental groups, sportsmen, industry, and commercial interests should contribute to the selection. Government agencies other than those directly concerned with water quality management – park and recreation, fish and wildlife, or transportation, for instance – should also be consulted to identify and resolve any conflicts in goals. Obtaining and utilizing these inputs require great effort, especially because it is sometimes difficult both to draw attention to the project and to provide potential participants with enough information for them to make meaningful contributions. Somewhat easier is the job of analyzing the results for use by the decision makers. Finally, participants must be given feedback to enable them to see how their inputs were used.

In preparing the list, one should be alert for situations in which provisions for protection of one group of uses meets or exceeds requirement for protection of another group. For example, EPA's Continuous Stormwater Pollution Simulation System has shown that when water quality objectives for swimming are met, fish and wildlife objectives, in most cases, will also have been achieved.[4]

When the objective selection process is complete, the list should:

- Be expressed in terms of specific beneficial uses,
- Include mandated uses,
- Be sensitive to natural and seasonal constraints and opportunities,

*An alternative to the single event, or design storm, as the basis for determining pollution control needs is continuous simulation. It is more complex but, in many ways, conceptually more realistic, and it may be appropriate in certain circumstances. See Chapter IV for a discussion of this approach.

- Be geographically specific to protect uses where they can occur, and
- Insofar as possible, be stated in such a way that achievement is measurable.

One final step, also the task of the elected officials, is to rank the beneficial uses. Technical or financial limitations may make it impossible to provide protection for all desired uses immediately or for certain uses at all possible times or locations. Consequently, they should be ordered from the most critical or important to the least critical. This is by no means an easy task, because interest groups again may conflict, and political pressures and technical recommendations may differ. However, this ranking will be extremely useful when budgeting local capital, preparing the justification portion of the construction grant application, and demonstrating that the planning process has been a reasonable one.

References

[1]Rhett, J. T. "Programs Requirements Memorandum, No. 75-34", Water Programs Operations, U.S. Environmental Protection Agency December 3, 1976.

[2]Clean Water Act of 1977, 33 U.S.C. 1251 et seq. P.L. 95-217.

[3]Federal Water Pollution Control Act Amendments of 1972 33 U.S.C. 1251 et seq. P.L. 92-500.

[4]Wycoff, R. and M. Mara, *1978 Needs Survey: Continuous Stormwater Pollution Simulation System User's Manual*, U.S. EPA Report, EPA-430/9-79-004, February, 1979.

Relating Pollutant Sources to Beneficial Uses

The determination of both required and desired uses of local receiving water is only the beginning of the analysis necessary to plan for combined sewer overflow control projects that are to be funded by the federal government. As discussed in Chapter II, PRM 75-34[1] states that one criterion for federal approval of combined sewer overflow projects is that the analysis must have

> . . . demonstrated that the level of pollution control provided will be necessary to protect a beneficial use of the receiving water even after technology-based standards . . . are achieved by industrial point sources and at least secondary treatment is achieved for dry weather municipal flows in the area.

Combined sewer overflow control must also be shown to be more cost effective than "the addition of treatment higher than secondary treatment for dry weather municipal flows in the area."

Taken together, these criteria mean among other things that, in order for a CSO project to qualify for federal funding, the pollutants to be controlled must be identified with a specific beneficial use, and that a primary contributor of that pollutant must be demonstrated to be combined sewer overflows. A comprehensive control program that has as its single objective the upgrading of all water quality parameters of the receiving water will not be supported with grant funds; there must be well documented justification relating the program to specific benefits. A municipality and its consultants cannot assume, furthermore, that beneficial uses will automatically be achieved by a combined sewer overflow control program. The federal government requires a demonstration that combined sewer overflows, and not some other source, are a significant source of the offending pollutants and that control of the overflows, and not some other source, will not only bring about the desired improvement but will do so more cost effectively.

Water Quality Problems Associated with Water Uses

The first step in the effort to achieve the selected beneficial uses is to determine what variables in fact are restricting the specific uses at the sites that are appropriate for them. Table 1 illustrates water quality problems that are generally associated with specific water uses.

In many areas, facility planners will be fortunate to have the problem variables in their particular receiving waters already identified in the water quality inventories prepared as a part of a 208 areawide water quality management planning study. However, additional detail may be necessary to be sure that the inventory contains information related to the specifically designated sites and their selected uses. Existing files of water quality monitoring data may be sufficient to supplement the inventories but, in some cases, sampling to determine the concentrations of those variables affecting the desired uses will be needed.

One note of caution is appropriate here. As water quality problems become better understood, changes in standards and in lists of human pollutants occur. As just one example, several recent publications have questioned the appropriateness of bacteria count limits for contact recreation noting that the same pathogens are also present in reservoirs.[2,3] While the issue is unresolved, it leads to obvious questions about the justification of large expenditures for disinfection of overflows. It is important to keep up to date on such developments.

Water Pollution Sources Identified With Beneficial Uses

Most of the urban areas with combined sewers will already have pollution source inventories. Such an inventory should cover four major categories:

- Continuous point sources
  - Municipal sewage treatment plant discharges
  - Industrial waste discharges
- Intermittent point sources
  - Storm sewer outfalls
  - Combined sewer overflow points

- Nonpoint sources
  - Surface runoff
  - Groundwater discharge
  - Atmospheric pollutants
- Background loadings
  - Natural concentrations
  - Upstream pollutant loadings.

Table 1. Water Quality Problems Associated with Beneficial Uses.

Beneficial water uses	Type of impact	Water quality problems
Water supply (public, private, agricultural)	Health	Bacteria Virus Toxics Metals Total dissolved solids
	Aesthetics	Color, taste, odor Plankton
Swimming	Health	Bacteria Virus
	Aesthetics	Solids and color Floatables Plankton Turbidity
Shell fishing	Health	Bacteria Virus Toxics Metals
	Survival	Dissolved oxygen Total dissolved solids Toxics Metals
Fishing	Health	Toxics Metals Bacteria and virus
	Survival	Dissolved oxygen Plankton Toxics Metals
Aesthetic enjoyment	Eutrophication	Nutrients Plankton Rooted plants
	Other	Floatables Solids Odor and color

Source: Driscoll, E. D. and J. L. Mancini, "Assessment of Benefits Resulting from Control of Combined Sewer Overflows", p. 7, presented at EPA Technology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, 1978.

The inventory should include the location of all sources. It should also state whether effluent standards have been met or programs to bring about compliance have been funded for each municipal and industrial discharger. One important use of this aspect of the inventory will be to document the status of industrial and municipal sources, as required by PRM 75-34.

The inventory should also include information on the constituents and volume of each continuous point source. This information may be obtained also from NPDES permit files but usually will not be available for intermittent point and nonpoint sources or for background loadings. Background quality resulting from upstream conditions and activities can be determined in a relatively straightforward manner by measurement of the stream flow and quality immediately upstream of the area; information on background loadings can also be found in water quality monitoring records. Actual measurement to determine quantities of pollutants from non-point sources is often impractical, but estimates of flows and wasteloads can be produced using literature values. The variety of pollutants which can be expected from various non-point sources is indicated in Table 2.

Because these inventories include the location as well as the volume and constituents of each municipal and industrial pollution source, it may be easy in some cases to determine directly the source producing the pollutants that are restricting beneficial uses.

Other cases may be more complex, but the application of a basic knowledge of the time and space relationships of water quality problems and sources may help focus the analysis and eliminate much unnecessary work and expense. This takes into account the fact that pollutants in one section of a river or in one period of time, for example, may not have adverse affects at another place or at a later time. For instance, Figure 3 shows that, because of a high die-off rate, bacteria that enter the receiving water typically have water quality impacts that do not persist for more than a few days. Similarly, Figure 4 shows that typically only a few miles of stream would be affected by floatables discharged at a given location. On the other hand, a dissolved oxygen sag caused by the discharge of oxygen-demanding material at the same point may exert its maximum impact dozens of miles downstream. Distribution of toxic effects generally can be expected to extend for some distance downstream because of extremely slow rates of decay.

Consider the case in which swimming is restricted at a given site because of high coliform counts for long periods of time during wet and dry weather. Combined sewer overflows would not be the most probable source, because the effects of these intermittent storms should not persist for more than a few days after an overflow (Figure 3). A continuous discharge (which could include a combined sewer with a malfunctioning regulator) should be sought as the cause. If, on the other hand, the bacteria counts exceed health standards in a pattern that does seem related to storm events, attention should be focused on storm sewers and combined sewers between the affected point and a point roughly 10 miles upstream (Figure 4). Nutrients and toxic substances, on the other hand, are long-term, regional problems, and unfavorable conditions for swimming or fishing caused by eutrophication or acute or chronic toxicity are not likely to be alleviated by control of local combined sewer overflows alone.

Such simplified analysis can be very helpful for many communities. However, in some cases, the number of point and, particularly, nonpoint sources and the complex mixing, settling and resuspension of the materials during a storm, for example, may make it difficult to identify combined sewer overflows specifically and with confidence as the significant contributor to the reduction in the desired use of the water. The

Table 2. Pollutants Contributed by Various Non-Point Sources.

Non-point source categories	Pollutants							
	Organic matter	Sediment	Nutrients	Micro-organisms	Trace metals	Toxic organics	Salts	Acid wastes
Urban sources								
a. Runoff	++	++	++	+	++	+	++	0
b. Storm sewers	++	++	++	+	++	+	++	0
c. Combined sewer overflows	++	++	++	++	++	+	++	0
d. Separate sanitary sewer overflows	++	++	++	++	0	0	0	0
Construction	0	++	+	+	+	+	0	0
Residual wastes disposal								
a. Rural sanitation	+	+	++	++	+	0	0	0
b. Landfills	++	+	++	0	++	++	+	0
c. Sludge disposal	++	++	++	0	++	+	0	0
d. Dredge spoils disposal	+	++	+	0	++	++	0	0
Hydrographic modifications								
a. Dredging	++	++	+	0	++	++	0	0
b. Maintenance facilities	++	0	++	+	0	0	0	0
c. Channel modification	0	++	0	0	0	0	0	0
d. Dams	+	+	+	0	0	0	0	0
Ground water								
a. Brine	0	0	0	0	+	0	++	0
b. Deicing salts	0	0	0	0	+	+	++	0
Agriculture								
a. Livestock production	++	++	++	++	0	+	+	0
b. Crop production	+	++	++	0	+	++	0	0
c. Manure disposal	++	++	++	++	0	0	+	0
d. Windborne loadings	0	+	0	+	+	+	0	0
e. Tile drainage	++	+	++	+	0	++	+	0
Silviculture								
a. Forestry management	+	0	++	0	0	+	0	0
b. Forest harvesting	++	++	++	0	0	+	0	0
c. Recreation	+	++	0	+	0	0	0	0
Mining								
a. Surface	0	++	0	0	++	0	0	++
b. Subsurface	0	++	0	0	++	0	++	++
Miscellaneous								
a. Atmospheric	0	+	+	0	+	++	0	+
b. Spills	++	+	+	0	++	++	0	++
c. Benthic loads	++	++	++	+	+	++	0	0

Key: ++ = Severe; + = Moderate; 0 = Slight or None

Source: Delaware Valley Regional Planning Commission, Pennsylvania Department of Environmental Resources and Chester-Betz Engineers, *COWAMP 208 Water Quality Management Plan, Southeastern, PA*, April, 1978.

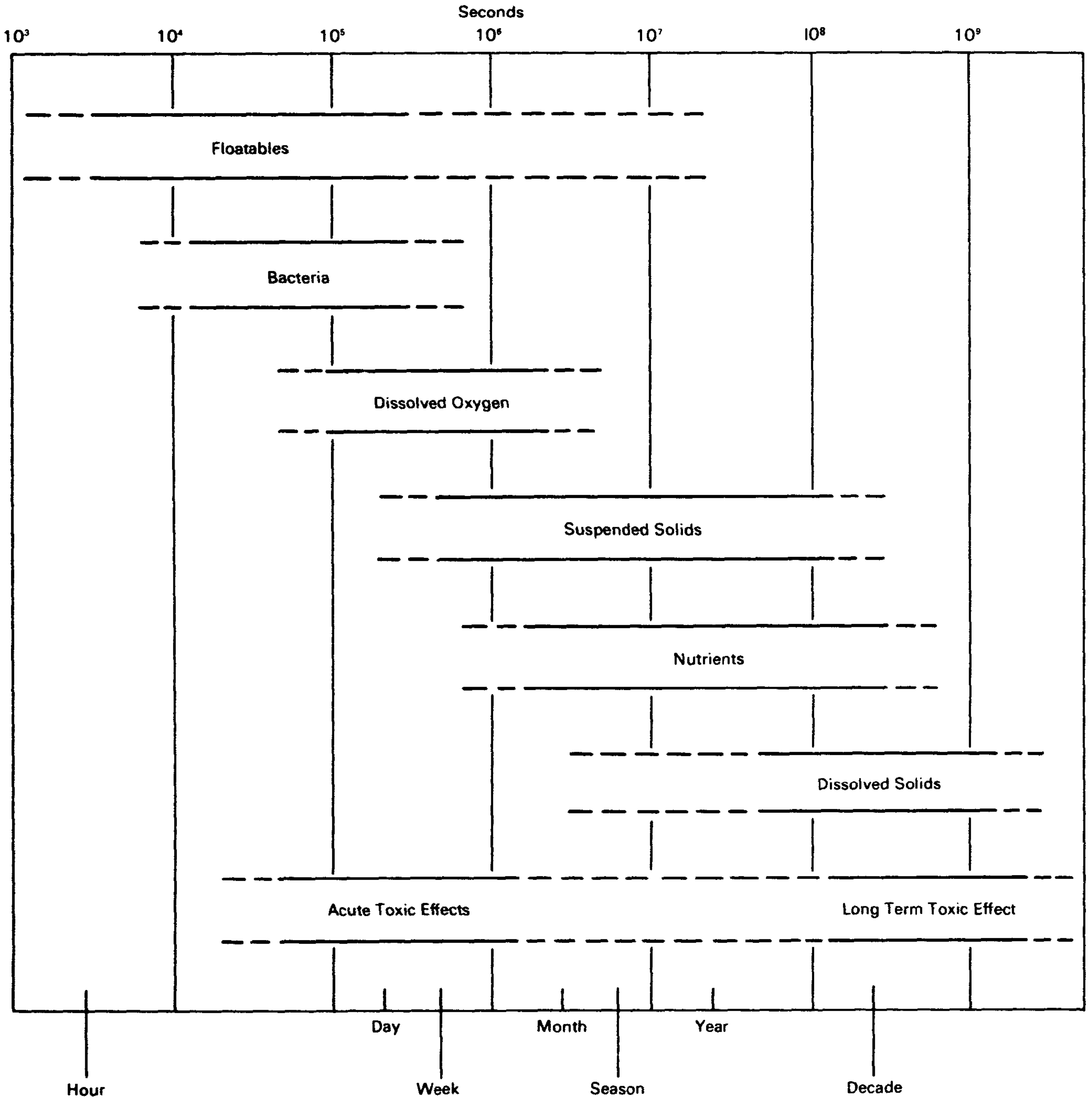

Figure 3. Time Scales for Storm Runoff Water Quality Problems.

Source: Driscoll, E. D. and J. L. Mancini, "Assessment of Benefits Resulting from Control of Combined Sewer Overflows", p. 9, presented at EPA TEchnology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, 1978.

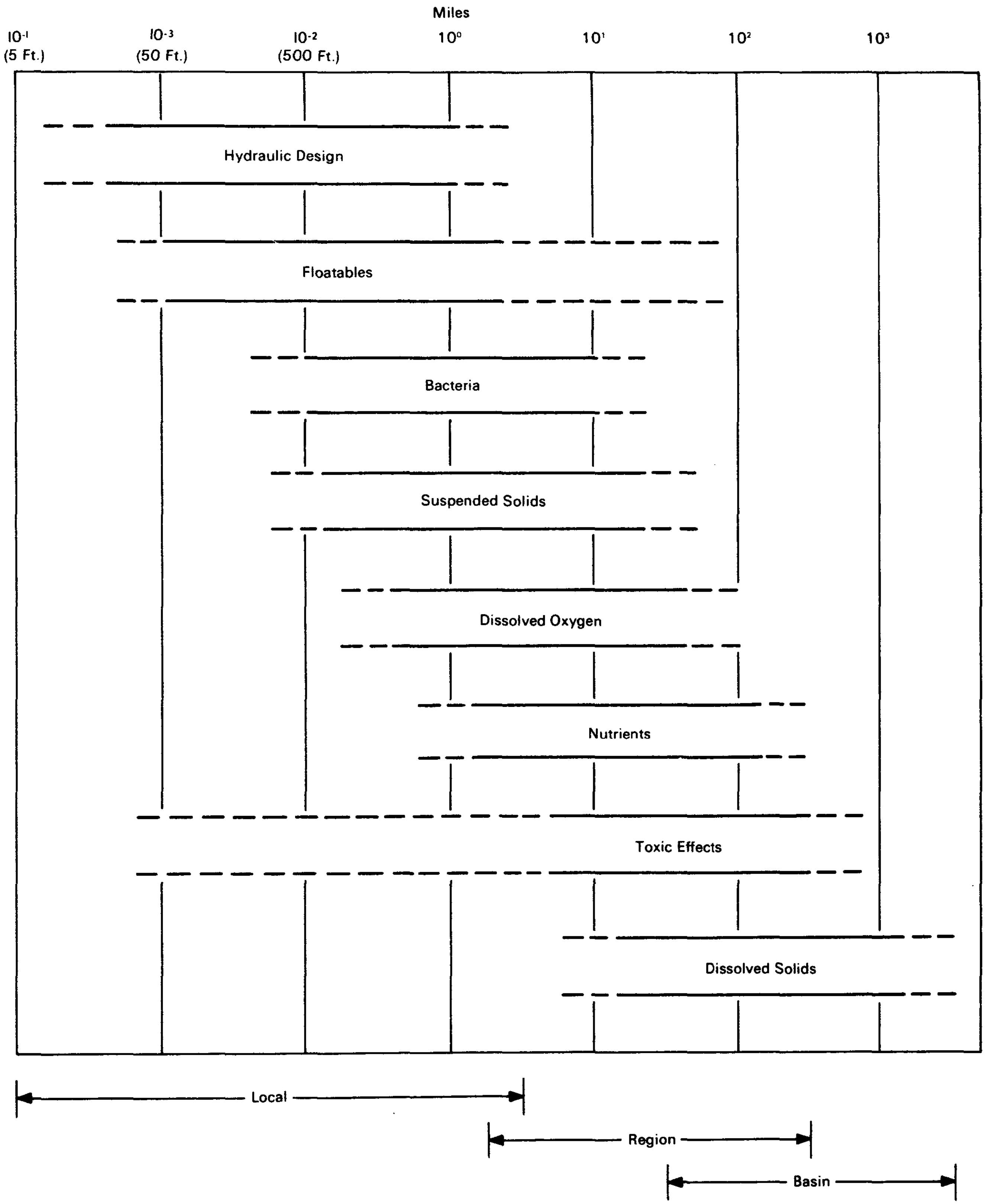

Figure 4. Space Scales for Storm Runoff Water Quality Problems.

Source: Driscoll, E. D. and J. L. Mancini, "Assessment of Benefits Resulting from Control of Combined Sewer Overflows", p. 10, presented at EPA Technology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, 1978.

waste loads which result from storms are difficult to characterize because of the intermittent nature of rainfall, the number and wide spatial distribution of combined sewer overflow points, the variability in size of storm events, and the variety of pollutants and their concentrations found in the runoff.

In addition, the nature of water quality problems associated with the receiving waters and around metropolitan areas is quite varied. Local factors have a predominant influence in determining the specific source or sources that contribute to a problem and to its severity. Factors that affect water quality include, in addition to the amount of rainfall and its frequency and intensity, local geography, population concentration, the character and degree of industrialization in the area, the extent of paved surfaces, and the receiving water system (including its nature, size, hydrology, and upstream and downstream characteristics).

To determine which of several potential sources of particular pollutants is a critical source, and particularly whether or not combined sewer overflows are a significant source, may require extensive monitoring and sampling and perhaps the use of mathematical models. Sophisticated models requiring subtantial data inputs are available; there are also simpler desktop models that are frequently just as useful. (Just as with the planning component of municipal wastewater pollution control projects, the costs for these assessments are eligible for federal 75 percent grants under the construction grants program.)

Models

There are two types of mathematical models useful in combined sewer overflow control planning –stormwater models and receiving water quality models.

The stormwater models are tools to estimate or predict the volume of stormwater discharge and the loadings of its constituent pollutants. They typically consist of two elements – a runoff element that simulates the washoff of pollutants by rain falling on the watershed, and a transport element that simulates the movement of those pollutants in the sewer system and their eventual discharge from it. Such models serve two primary purposes:

- To describe stormwater discharges, including combined sewer overflows, in terms of volume and pollutant concentration and loading, and
- To evaluate the effectiveness of various control alternatives and to identify optimum solutions.

Both applications are complex tasks, except in simple sewer systems. The first use can sometimes be accomplished manually, but the second is much better handled by a computer model of the system.

Receiving stream models, often called water quality models, predict or simulate the effects of pollutant sources on the quality of the body of water into which they are discharged. They are used in the following ways:

- To assess the effects of known sources on water quality,
- To predict the impacts of future discharges,
- To compare the effects of different sources, and
- To determine the reductions in pollutant loadings that will bring about desired water quality improvements.

There are a number of receiving water and stormwater models available for various applications and with differing input data requirements. An excellent discussion on the selection of stormwater models, including a brief description of the common ones, is presented in *Urban Stormwater Management and Technology: Update and User's Guide.*[4] *Stormwater Management Model: Level I – Preliminary Screening Procedures*[5] explains a simplified model that requires a minimum of data collection and is useful in the preliminary assessment of combined sewer overflow problems. More detail on the whole process of stormwater loading estimation, including discussion on data collection and models, may be found in the EPA *Areawide Assessment Procedures Manual*[6] (July 1976). Further details on receiving water quality models are available in *Evaluation of Water Quality Models: A Management Guide for Planners.*[7] It explains modeling approaches, describes existing models, and provides guidance for selection of the proper model.

Most of the models are run for particular design conditions – storm events for the runoff-and-transport models and stream flow for the water quality models. In other words, a decision is reached concerning the conditions to which the results are to apply. That decision may be a policy choice made in the course of defining desired benefits. For example, it may be decided that dissolved oxygen should not fall below a concentration of 4.0 milligrams per liter even during the 7-day, 10-year low flow. The water quality model is then run for that flow, and the results can be used to determine the load reductions needed to achieve that goal. Likewise, a corresponding design condition for the stormwater model might be a particular rainfall duration and intensity, perhaps that of a thunderstorm which typically occurs during that low flow period. (Note that some models are dynamic. The variations in flow that would occur during storms can be simulated. However, antecedent conditions still must be specified and are, in essence, design conditions.)

There are models that do not require a prior selection of design conditions. One of these, the Continuous Stormwater Pollution Simulation System alluded to in Chapter III and newly developed for use in the *1978 Needs Survey*,[8] combines the functions of runoff/transport and receiving stream models in a single package that has three main applicaitons:

- To determine whether a given urban area/receiving water system is experiencing a water quality problem,
- To determine how much of the problem is caused by combined sewer overflows and urban stormwater, and
- To determine the level of pollutant removal required to achieve selected water quality goals.

The model is designed for long-term rather than single event simulation. Instead of a set of design conditions, it accepts historical rainfall and streamflow statistics. It generates a representative array of rainfall depths for a period of 1 year and converts these to runoff arrays, one for separate storm sewers and one for combined, on the basis of watershed characteristics. Pollutant washoff is then computed, using calculated or estimated pollutant accumulation as well as decay rates and washoff coefficients.[9] Overflows are simulated by a sewer infiltration module, and a storage and treatment module permits simulation of the effects of those control techniques on pollutant discharge.

A separate module generates an annual array of dry weather wastewater treatment plant flows and loads. Another uses up to 5 years of flow values to simulate streamflow. These results, plus background water quality data, are used in the receiving water response module, along with the simulated stormwater and combined sewer overflows, to simulate receiving water response. The simulation is long-term and continuous. In other words, the outputs are an array of concentrations of various pollutants that are likely to occur during the course of a typical year under the rainfall, dry weather flow, background, and pollutant washoff conditions originally entered into the system. This is in contrast to the single event model that provides simulated receiving stream response for one design storm.

Before leaving the subject of models, a few observations on their appropriateness and some associated drawbacks may be useful. First, for all but the simplest sewer system, a runoff and transport model is necessary to assist in defining the CSO discharges and permit development and comparison of pollutant reduction alternatives. Fortunately, calibrating such a model for a given system is a rather straightforward process. The system specifications themselves provide most of the needed information.

The selection and calibration of receiving stream or water quality models is a more complicated process. Large amounts of reliable data on waste discharges and in-stream pollutant concentrations may be needed, necessitating expensive and time consuming sampling programs. Without these inputs, the water quality model cannot be expected to produce realistic results. On the other hand, these sophisticated models are not always necessary. If localized public health or gross aesthetic problems are the cause of impaired beneficial use, and if the surface water system is not unduly complicated (as it would be in a major estuary, for example), simple observation and discharge sampling may be adequate to determine the source of the offending pollutants. When a water quality model is needed, the design storm approach will usually be sufficient for public health or dissolved oxygen problems. If eutrophication or other long-term problems are of concern, the continuous, probabilistic model may be the better alternative.

Monitoring and Sampling

When dealing with combined sewer overflows, monitoring and sampling will usually be necessary to meet three goals:

- To determine combined sewer overflow pollutant characteristics,
- To learn the fate of those pollutants, and
- To determine the effects of those pollutants on water quality.

Sampling of the overflow is necessary to meet the first goal. When sufficient data are collected, analysis will permit:

- Determination of pollutant loads discharged,
- Identification of first-flush effect,
- Determination of benefits of best management practices currently in use,
- Development of relationship to tributary land use characteristics, and
- Comparison of antecedent and storm characteristics.

Data to meet the other goals must be obtained from receiving water samples. The actual extent of pollutant effect, in terms of time and distance, is one determination to be made. Other questions concern the nature of the effect. Is benthic life eliminated around the outfall, and if so, how far from it? Do trash and scum accumulate on beaches or boats? Is there a dissolved oxygen sag? How severe is it? How far does it extend? At what time of year is it most evident? Does it coincide with fish migrations? These and other such questions can only be answered definitively by sampling.

When the monitoring and sampling program is designed, careful attention should be paid to the nature of the information being sought. For example, health problems related to combined sewer overflows may be one subject explored. Since, as Figure 3 shows, bacteria that enter the receiving water during a storm event do not have water quality impacts for more than a few days, average bacteria counts or samples taken at regular intervals independent of weather will normally not be useful. Therefore daily or more frequent sampling during and after storms will be necessary. On the other hand, short term daily measurements of instream nutrient concentrations are not usually appropriate in studying eutrophication, since it is a long-term phenomenon with seasonal water quality impacts. Each water quality variable involved in an identified problem must be examined in an appropriate way (see Figure 5).

For a quick appraisal of the effects of combined sewer overflows, data on the total annual or seasonal stormwater quantities and pollutant loadings may be sufficient. This level of analysis is particularly appropriate for an evaluation of pollutants with predominantly long-term effects on lakes and large estuary systems such as nutrients, toxics, settleable solids, and heavy metals. In addition, it gives a rough estimate of storm related waste loads that can be compared to point source waste loads. The data required for this type of analysis can be generated fairly easily, in part by using estimates of loads, runoff, and reaction coefficients extrapolated from other studies or projected from data secured from limited areas over short time periods.

To identify with some accuracy the specific time periods in which storm-related pollutants would affect certain locations, data on the number of storms, their frequency, and the pollutant loadings of each storm would be required. This information would be needed, for instance, if bacterial contamination or dissolved oxygen deficits were the problems being analyzed.

Very detailed information and, therefore, data inputs are usually only necessary when exploring the effectiveness of a specific control strategy. For example, a best management practice may have been proposed to overcome the problems associated with first flush, the concentration of pollutants discharged in the first hour or two of a storm. To evaluate this strategy, data on the variation in the intensity and loading rates within each storm would be necessary.

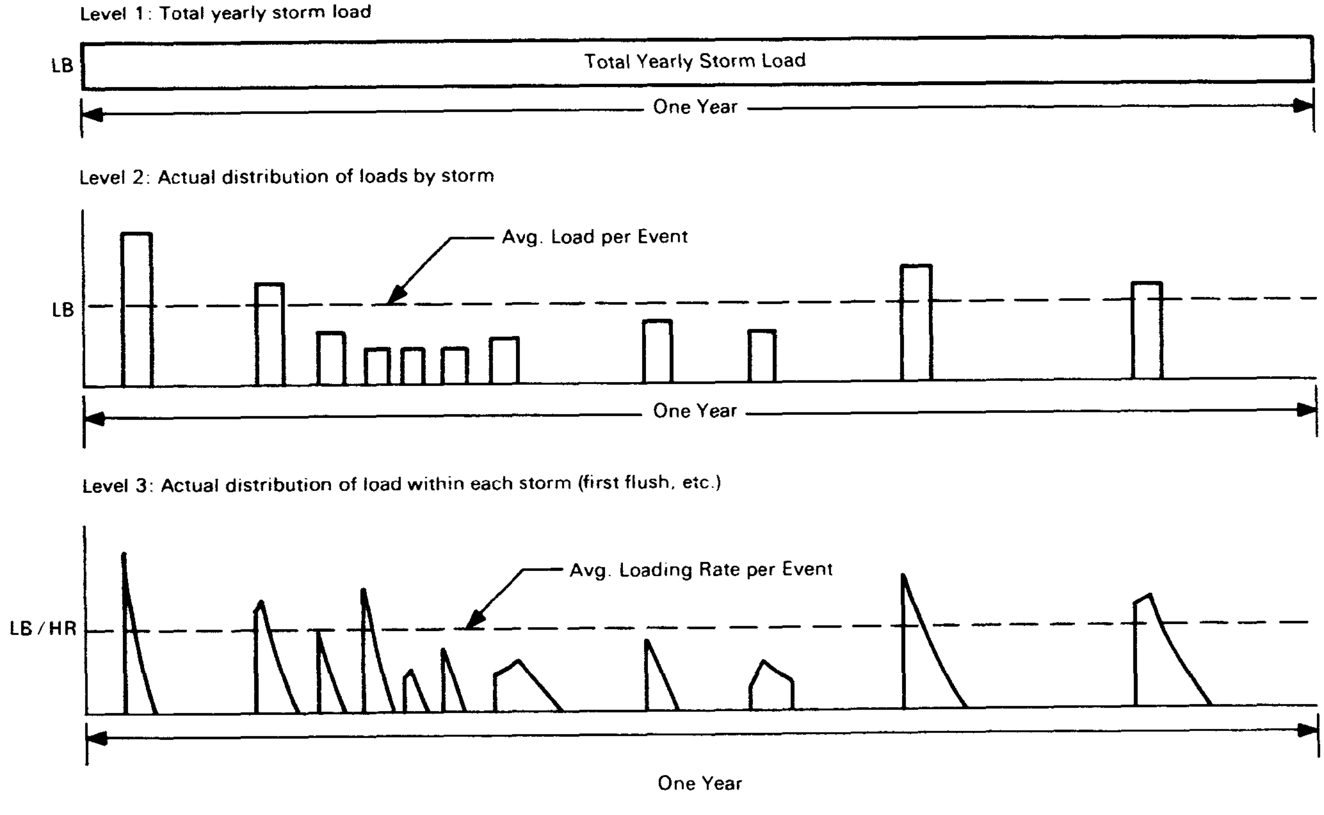

Figure 5. Various Levels of Detail in Stormwater Load Characterization.

Source: Driscoll, E. D. and J. L. Mancini, "Assessment of Benefits Resulting from Control of Combined Sewer Overflows", p. 22, presented at EPA Technology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, 1978.

Summary

By this point in the process of planning for a combined sewer overflow project, a number of significant decisions have been made and data assembled. All of this is essential so that a municipality will be able to determine – and, what is more, provide justification and obtain support for – an overall control strategy for combined sewer overflows, as well as specific control alternatives.

Desired benefits have been identified. The receiving waters have been evaluated, not in terms of all water quality parameters but in terms of the specifically identified beneficial uses and of those pollutants and pollutant sources that are adversely affecting the particular uses. This is necessary because it must be convincingly demonstrated that combined sewer overflows adversely affect the uses to a significant extent. Finally, it will have been shown that the technology-based effluent limitations have been met by industry and municipalities, or it must be evident that meeting them will still not result in the achievement of water quality objectives.

In Seattle,[9] all of these factors were evaluated as Metropolitan Seattle prepared for selecting pollution control alternatives. Seattle determined the following:

- Specific receiving water areas where desired beneficial uses were impaired because of water quality,
- The water quality variables having the adverse impacts,
- The significant sources of pollutants that unfavorably affected the water quality variables,
- The relative contribution of each source to the impairment of use,
- The significant contribution of combined sewer overflow to the impairment of use, and
- The pollution control status of the various sources.

Seattle had also developed an initial list of nine possible beneficial uses for Seattle's waters:

- Residential use
- Swimming
- Shellfishing
- Fish spawning/rearing
- Juvenile fish migration
- Recreational boating
- Shoreline parks
- Commerce
- Industry.

Commercial and industrial uses were determined to be little affected by CSO and were eliminated from consideration. Though fish were assumed to undergo stress as a result of toxics in CSOs, there were not sufficient data to allow a determination of the degree of stress. Control of overflows to protect fish therefore could not be judged eligible for federal funding. Protection of shoreline parks and recreational boating would neither justify nor, in all likelihood, necessitate controls stricter than those necessary for swimming. Ultimately, the package of beneficial uses selected as the objectives of combined sewer overflow control was reduced to human uses with public health implications – swimming, shellfish harvesting, and residential occupancy. The other uses were eliminated either because they were unaffected by combined sewer overflows (or could not be demonstrated to be affected by them) or because more extensive protection necessitated by other uses would protect them as well.

As a result of this process, Seattle was ultimately successful in demonstrating to the federal government the relationship of its combined sewer overflows to the reduction in the beneficial uses of Seattle's numerous receiving waters.

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Alternatives for Controlling Combined Sewer Overflows

Selecting from among the alternatives available for controlling combined sewer overflows does not enter the planning process until many decisions about desired benefits have been made and data gathering is quite far advanced. The water quality parameters associated with the desired beneficial uses provide the link between objectives and control alternatives. The objectives must first be translated into the water quality criteria necessary to protect the uses. Then the reductions in specific pollutant inputs required to meet the criteria can be calculated. With this work completed, two tasks remain: the development of a control strategy and the selection of control alternatives.

Control Strategy Development

Figure 6 illustrates the steps to be taken to determine the control strategy – that is, the combination of pollutant source reductions that yield the required total reduction. The upper half of the chart applies to dry weather conditions. The process it outlines must be completed before or as part of combined sewer overflow control planning, since PRM 75-34[1] requests convincing evidence that achievement of the national minimum levels of point source treatment for municipal and industrial wastewater will be insufficient to protect beneficial uses before funding for combined sewer overflow control can be considered. The lower half of the chart begins with the question, "Will the dry weather controls selected also meet required reductions during storm periods?" If the answer is "no", two strategies must be investigated (a PRM 75-34 requirement): 1) further reductions in continuous point source loadings, and 2) control of intermittent sources including combined sewers. Combinations are, of course, possible. All alternatives produced are checked for technological feasibility, and the one that costs least is selected and rechecked to be sure it provides the necessary reductions. The process is iterative, allowing for the consideration of various levels of control and benefit required by PRM 75-34.

In some cases, the process of developing a control strategy will be quite straightforward. In a stream or lake if fecal coliform standards are met during dry weather but swimming beaches are nevertheless closed because of high bacteria counts after rainfall, a sophisticated model is not needed to show that a stormrelated intermittent discharge is the likely cause. Further treatment of dry weather flows will not increase benefits (swimming opportunities), but a reduction in the amounts of bacteria from the intermittent sources will. The strategy is obvious, and consideration can immediately be given to the various alternative techniques for implementing it.

There are other cases, however, when developing the strategy is more complicated. For example, in a stream in which minimum dissolved oxygen standards are being met during dry weather by compliance with continuous point source effluent limitations, the additional influx of organic material from overflowing combined sewers may drive dissolved oxygen below the minimum for some period of time after a storm. If the concentration is low enough for a long enough period to affect fish, some benefit is possible through organic load reduction. Here, two strategies are possible. Additional treatment of continuous point sources to raise the general dissolved oxygen level may prevent violation of the fish-protecting standard even after a storm though the combined sewer overflow loadings remain the same. Alternatively, if the combined sewer overflow inputs can be reduced to the point at which the oxygen demand they cause is not large enough to carry concentrations below the minimum, the same benefit can be realized. A rather complex receiving water quality model may be necessary to determine the required reductions under each strategy or under a combination of both strategies.

Inherent in both strategy determination and in the more specific selection of control alternative is the concept of optimization. The goal is to eventually arrive at the optimal, or least costly, combination of control alternatives that will result in the necessary level of pollutant reduction to achieve desired beneficial uses. The economic theory and methodology for optimization are discussed in the *1978 Needs Survey*[2] and by

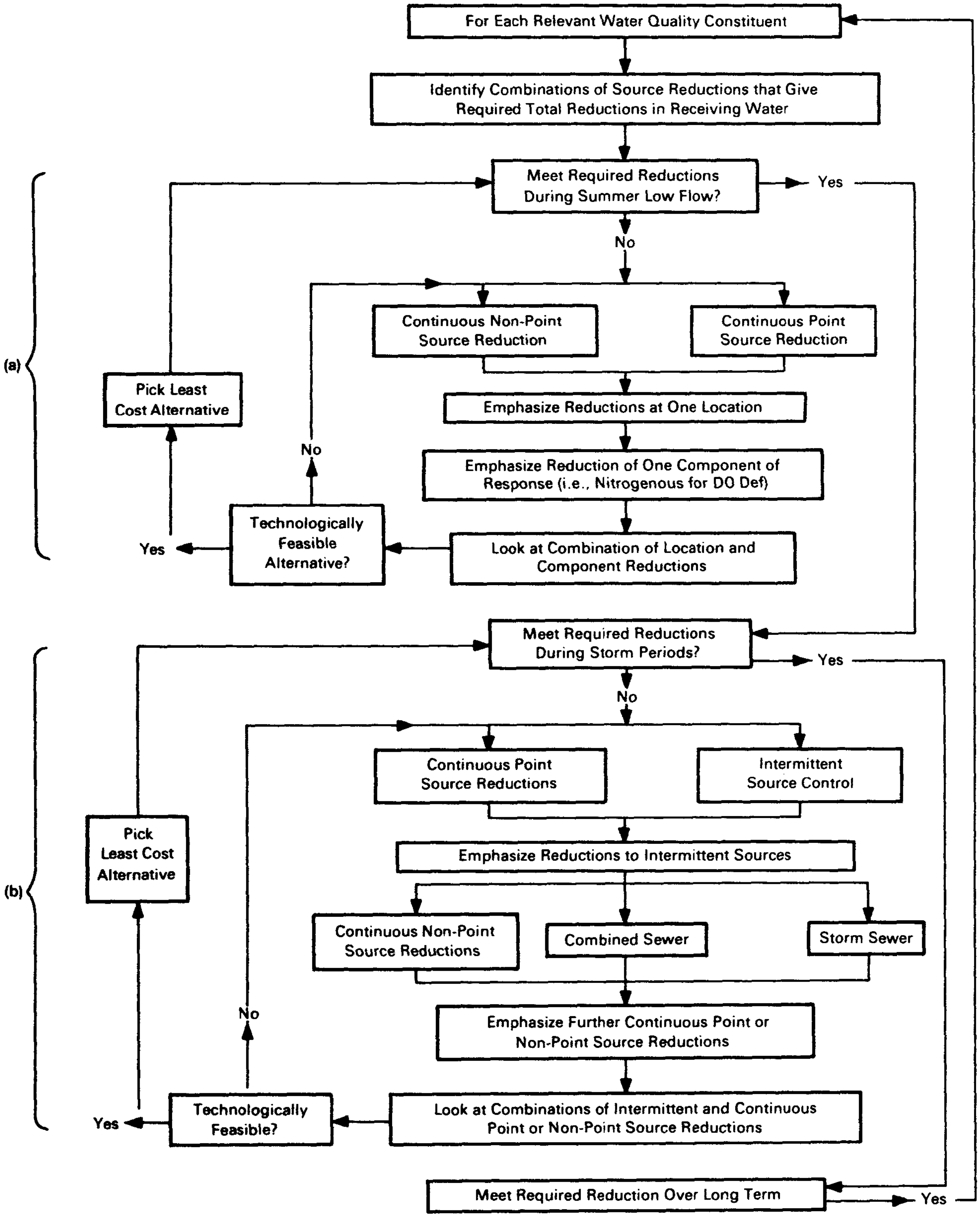

Figure 6. Methodology for Determining Load Reduction Requirements.

Source: Municipal Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, ***Areawide Assessment Procedures Manual Vol. I***, p. 6-10, U.S. EPA Report EPA 600/9-76-014, July 1976.

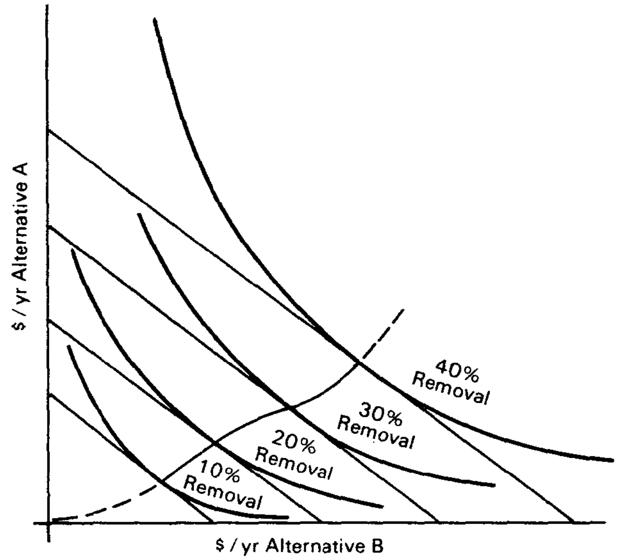

Figure 7. Optimum Combination of Control Alternatives for Various Levels of Pollutant Reduction and Budgetary Limits.

Source: Heaney, J. P., "A Strategy for Integrating Storage Treatment Options with Management Practices", presented at EPA Technology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, 1978.

Heaney and Nix.[3] The essense of the process is the determination, for each possible level of pollutant reduction, of all possible combinations of alternatives that will achieve that level. To do this it is necessary to know, for each alternative, the specific relationship between cost and pollutant removal. From this, a graphical presentation of the sort shown in Figure 7 can be developed. The curved isoquants represent combination expenditures on alternatives A and B to achieve specific removals, while the straight isocost lines show combinations of spending on the two alternatives that are possible within a fixed budget. The points of tangency between the two show optimum combinations.

Control Alternatives

Technologies to control pollution from combined sewer overflow, many of which are also applicable to urban stormwater runoff, can be grouped in three main categories: source controls to reduce the amounts of pollutants entering the sewer system, collection system control to improve the system's effectiveness in storing and handling the flows, and off-line storage and treatment to remove pollutants from combined sewer flows. The control alternative selected for any given situation may include techniques from one or more of these groups.

Source Controls

Most source controls are non-structural in nature, and are often referred to as best management practices or BMP in 208 planning projects. The principle common to all of them is reduction of pollutant accumulation on impervious surfaces in the drainage basin or in portions of the collection system itself, so that pollutant loadings in combined sewer flows during storm events are lowered.

Street cleaning. Originally intended to prevent dust and dirt accumulation in urban streets, street cleaning can be accomplished by manual labor, mechanical broom sweepers, vacuum sweepers, or street flushing. The first three result in removal of some pollutants from streets, typically to landfills, while the last method merely causes pollutants to be transported into sewers during dry weather. The practices are most applicable to highly developed urban and suburban areas. Street sweeping, as opposed to flushing, effectively removes some pollutants from the streets. The degree of effectiveness depends on efficiency of the equipment, frequency of sweeping, method of operation, and coordination with parking regulations and litter control programs. Whether or not any of the various sweeping techniques will preserve or increase desired beneficial uses of waters affected by combined sewer overflows, however, depends not only on effectiveness but also on the pollutants that are impairing those uses. If toxicity from lead is an identified problem, for instance, street sweeping may be helpful, because lead from vehicle exhaust accumulates on street surfaces. On the other hand, if the combined sewer overflow problems are nutrients, BOD, or bacteria, street sweeping may not result in sufficient improvement.[4] The next technique may be more helpful.

Combined Sewer Flushing. A major source of pollutants in combined sewer overflows is the accumulation of sanitary sewage solids that have settled in the sewers. The purpose of combined sewer flushing is to resuspend this material and transport it to the sewage treatment plant before a storm event carries it to the receiving water in an overflow. Flushing can be accomplished using tank trucks or water detained in the sewer system and probably should be carried out by flushing small sections of the system in sequence in a downstream direction. Effectiveness depends on sewer system characteristics, flush volume and discharge rate, frequency of flushing, and efficiency of the treatment plant. Implementation of a sewer flushing program requires detailed knowledge of the functioning of the sewer system.[5]

Catch Basin Cleaning. Catch basin cleaning to remove accumulated solids at the inlets is intended to reduce the first flush pollutant load. It can be accomplished manually or by eductor, bucket, or vacuum. However, the *1978 Needs Survey* cites evidence that it is probably not effective as a pollution control measure. The normal range of combined sewer overflow BOD_5 removal that can be accomplished by street sweeping is 2 to 11 percent. Sewer flushing may result in 18 to 32 percent removals. Catch basin cleaning yields neglible results.[6]

Collection System Controls

Techniques of collection system controls are intended to ensure that the sewer system operates as efficiently as possible and that maximum advantage is taken of any opportunities it offers for combined sewer overflow pollution reduction. All of these measures require detailed knowledge of the sewer system. Some are structural and some are non-structural.

Existing System Management. Correcting malfunctions, unblocking clogged lines, optimizing regulator functions, and locating unused in-line storage capacity are all part of existing system management, comprising continuing repair and maintenance. It begins with a complete sewer system inventory and performance survey, both of which should be the initial phase of any combined sewer overflow control project.[7] The goals of these measures are maximum sewer system efficiency and minimum overflows.

Flow Reduction Techniques. The demands on existing conveyance and treatment capacities are reduced by flow reduction techniques that reduce the volume of water entering the system. In a sanitary sewer system, infiltration and inflow reduction are familiar concepts. A combined sewer is designed by definition to experience inflow. However, when new development occurs in combined sewer service areas, there may be opportunities to employ roof-top or parking-lot storage, detention basins, or infiltration to groundwater to minimize increases in the rates of runoff to the sewer. The frequency and magnitude of overflow would thus not be unnecessarily increased.

Sewer Separation. Sewer separation is the conversion of a combined sewer system into separate sanitary and storm sewer systems. Either a new storm sewer or a new sanitary sewer may be constructed, using the old combined sewer for the other purpose. Some type of pollution control may be necessary for the stormwater after separation, since pollutant loads from that source may continue to impair beneficial uses. Sewer separation can be enormously expensive but may be the cost effective approach in relatively small watersheds (100 acres or less).[8] BOD_5 reductions of 54 to 65 percent are typical.[9]

In-Line Storage. When the collection system is large and has the potential for regulation of flow, in-line storage may be an effective combined sewer overflow control alternative. Static or dynamic regulators (the latter may be manual or computer-operated) are employed to distribute storm flows within the system, essentially storing stormwater to minimize the peak flows at any given points that will cause overflows. The *1978 Needs Survey* points out that this approach may not entirely eliminate overflows. If the predicted results are not sufficient to provide the desired beneficial uses, other measures will have to be combined with in-line storage.[10]

Storage and Treatment

Off-Line Storage. Off-line storage in earthen basins, caverns, or covered or uncovered concrete basins detains storm flows for controlled discharge to treatment facilities. Overflows may be reduced or eliminated and, because flows are more uniform, treatment facilities can be smaller and can operate more efficiently. Storage can be located at overflow points or near dry weather or wet weather treatment facilities. Land availability may constrain the applicability of this alternative.

Treatment. Treatment options are very numerous. The list includes the following, some of which are still in the research or demonstration stage with respect to combined sewer overflow control:

- Sedimentation, with or without air flotation;
- Screens for removal of coarse materials;
- Microscreens for suspended solids and BOD removal;

- High-rate granular filtration which is more efficient than screening;
- Swirl and helical concentrators for solids removal, a treatment that can be used to regulate the volume and quality of overflow;
- Chemical additives to enhance pollutant removal in sedimentation, dissolved air flotation, and high-rate filtration processes through coagulation, flocculation, etc.;
- Disinfection to control micro-organisms using chlorine oxidants – chlorine, calcium or sodium hypochlorite, chlorine dioxide, or ozone;
- Biological treatment to remove nutrients and organic matter;
- High-gradient magnetic separation, a treatment that can provide removal of metals and nutrient as well as solids; and
- Carbon adsorption to remove soluble organics.

Removal efficiencies (BOD_5) of from 10 to 95 percent are possible with storage/treatment options, depending on drainage basin size and level of control desired.[11]

Selection of Control Alternatives

More details and bibliography are available in the *1978 Needs Survey*. Analysis of a wide range of control alternatives can be found in the *Areawide Assessment Procedures Manual*[12] and *Urban Stormwater Management and Technology: Update and User's Guide*,[13] cited in Chapter IV.

Many of the structural alternatives are quite selective in terms of the pollutants removed (Table 3). It is, therefore, very important that alternatives selected be appropriate to the identified beneficial use being protected or enhanced.

A second consideration to keep in mind when structural alternatives are concerned is the concept of staging. Facilities that can be constructed in stages provide future flexibility to deal with water quality problems and allow some control to be achieved even when funds ard limited.

When the list of control alternatives has been narrowed down to those that look most promising, each should be tested again for effectiveness in providing the desired benefit – that is, in meeting the criteria to protect that benefit. Furthermore, a range of control levels to provide a range of levels of benefits must be examined for each alternative (PRM 75-34) and related to costs. Once the cost-beneficial relationship has been determined, the optimal solution can be selected.

References

[1]Rhett, J. T., "Program Requirements Memorandum, No. PRM 75-34", Water Programs Operations, U.S. Environmental Protection Agency, December 3, 1976.

[2]Wycoff, R., J. Scholl, and S. Kissoon, *1978 Needs Survey: Cost Methodology for Control of Combined Sewer Overflow and Stormwater Discharge*, U.S. EPA Report, EPA 430/9-79-003, February 1979.

[3]Heaney, J. P. and S. J. Nix, *Stormwater Management Model: Level I — Comparative Evaluation of Storage Treatment and Best Management Practices*, U.S. EPA Report, EPA 600/2-77-083, April 1977.

[4]Wycoff, R., J. Scholl, and S. Kissoon, p. 3-2.

[5]Wycoff, R., J. Scholl, and S. Kissoon, p. 3-3.

[6]Heaney, J. P. and S. J. Nix.

[7]Wycoff, R., J. Scholl, and S.Kissoon, pp. 3-3 and 4.

Table 3. Pollutants Removed by Structural Alternatives.

Control method	Pollutant removed
Disinfection	Coliforms
Swirl concentration	Floatables, greases, oils, and heavier solids
Screens	Floatables and solids larger than mesh size
Increased sewer transfer/holding	All pollutants
Local treatment-sedimentation	Settleable pollutants
Physical/chemical	Settleable and suspended pollutants

Source: Letter from Jack Warburton, Brown and Caldwell Consulting Engineers, Seattle, WA, received December 29, 1978.

[8]Wycoff, R., J. Scholl, and S. Kissoon, p. 3-4.

[9]Heaney, J. P. and S. J. Nix, p. 7-11.

[10]Wycoff, R., J. Scholl, and S. Kissoon, pp. 3-4 and 5.

[11]Heaney, J. P. and S. J. Nix, pp. 7-11 and 12.

[12]Municipal Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, *Areawide Assessment Procedures Manual*, Vol. I, II, and III, U.S. EPA Report, EPA 600/9-76-014, July 1976.

[13]Lager, J. A., W. A. Smith, W. A. Lynard, R. M. Finn, and E. J. Fennemore, *Urban Stormwater Management and Technology: Update and User's Guide*, U.S. EPA Report, EPA 600/8-77-014, September 1977.

Chapter VI

Costs of Combined Sewer Overflow Control Alternatives

The significance of different aspects of combined sewer overflow control costs varies depending on the needs of the persons reviewing them. Total cost (the discounted present value of capital plus operation and maintenance costs) should be related to benefits or water quality objectives when deciding on the level of control and should be used when selecting the most cost effective alternative and justifying the project to funding agencies. However, since only capital costs are eligible for 75 percent EPA construction grant assistance, they must be used to arrive at the costs to be borne by the local and federal (and, in some cases, state) governments. Once the local share of capital costs is determined, it and the operating and maintenance costs comprise the expense to the municipality (except that some operating and maintenance assistance is available in some states). This is most meaningful when expressed as an annual expenditure (the sum of debt service and operating and maintenance expenses for each year) since it enables municipal officials and taxpayers to see a project's budget and tax implications.

The capital costs of a combined sewer overflow control project consist of costs for construction, planning and engineering, legal services, land acquisition and administration, and interest during construction. Operation and maintenance costs include expenses for labor, power, chemicals, other supplies, laboratory and sampling, and administration. Capital costs, with the exception of land acquisition, can be predicted with reasonable accuracy based on the type and size of the facilities being considered. Land acquisition – both finding a suitable site and paying for it – is of course quite site specific. In an urban area with scarce available land it may be virtually impossible to find a large storage site without expensive tunneling; the cost effectiveness of a storage alternative may thus be more influenced by this variable than any other in many cases. Operation and maintenance expenses are variable but can be estimated in general. EPA *Cost Estimating Manual – Combined Sewer Overflow Storage and Treatment*[1] contains tables of capital costs for a variety of storage and treatment facilities and guidelines for estimating operating and maintenance costs. Though it contains 1976 figures, it should be a useful document in the planning and alternative selection stages of a CSO project, primarily as a source of relative cost information (Table 4 and Figure 8). Table 5 summarizes costs for various source and collection control alternatives, and Figure 9 shows the cost ranges experienced with several treatment processes.

This iterative examination of the cost/benefit relationship is a feature that distinguishes combined sewer overflow control planning from municipal sewage treatment planning. In the latter, once calculations and estimates of present and projected waste flows and loads have been developed and effluent limits assigned, the task is to select the most cost effective system of a size sufficient to treat the projected flows. For combined sewer overflows, the size and, therefore, the cost component is intimately linked to the levels of beneficial uses determined to be necessary. The initial list of desired beneficial uses entails a required facility storage or treatment capacity, for which costs can be estimated. The costs may cause the locality to revise the levels of beneficial uses, and the process can continue until a final alternative is selected. To facilitate this ongoing process and as a requirement of PRM 75-34,[2] the costs associated with various levels of control must be developed and presented graphically in this part of the analysis.

Availability of funds must play a role here too. The construction grant moneys allocated to each region and state have never been sufficient to cover every proposed project, nor are they likely to be. Thus, since few sewage facilities projects can be constructed without federal assistance, any proposed combined sewer overflow control project will be competing for limited funds and will be taking its place on a state priority list. Realistic proposals (in terms of design storm) and persuasive presentations are essential, especially true when justifiying anticipated costs. A presentation such as Figure 10 would be helpful because it shows clearly the increased levels of control of stormwater that are possible with increased levels of investment beyond a base level.

Table 4. Estimated Construction Costs.

Earthen Storage Reservoirs

Cost component	Volume (million gallons)							
	0.57	1.95	4.90	9.20	14.80	50.85	108.50	187.80
Earthwork	2,540	6,670	14,900	24,700	36,940	93,330	156,320	229,530
Liner	7,730	14,350	32,780	53,720	79,650	233,400	467,150	780,900
Paving	2,180	3,140	4,340	5,540	6,740	11,540	16,340	21,140
Seeding	870	1,750	3,150	4,960	6,540	13,800	20,600	28,000
Fencing	5,650	7,940	10,720	13,500	16,100	26,300	26,300	45,900
Miscellaneous items	2,850	5,100	9,900	15,360	21,900	56,700	103,000	165,820
Contingency	3,270	5,790	11,350	17,650	25,210	65,150	118,290	190,430
Total Estimated Cost	25,090	44,740	87,140	135,430	193,080	500,220	908,000	1,461,720

Concrete Storage Reservoirs—Concrete Reservoirs Without Covers

Cost component	Volume (million gallons)								
	1.0	2.0	4.0	7.5	15.0	30.0	60.0	120.0	240.0
Concrete and forms	80,370	109,030	166,360	230,390	358,450	513,270	822,940	1,239,770	2,073,370
Steel	110,400	149,600	277,200	313,600	486,400	692,000	1,104,000	1,648,800	2,739,200
Labor	99,140	135,850	208,610	294,060	465,840	686,800	1,129,260	1,771,140	3,055,330
Miscellaneous items	43,490	59,170	97,830	125,710	196,600	283,810	458,430	698,960	1,180,190
Contingency	50,010	68,050	112,500	144,560	226,090	326,380	527,190	803,800	1,357,210
Total Estimated Cost	383,410	521,700	862,500	1,108,320	1,733,380	2,502,260	4,041,820	6,162,470	10,405,300

Concrete Storage Reservoirs—Additional Costs for Concrete Reservoirs With Covers

Cost component	Volume (million gallons)								
	1.0	2.0	4.0	7.5	15.0	30.0	60.0	120.0	240.0
Concrete and forms	5,150	15,450	30,900	72,100	144,200	309,000	618,000	1,277,200	2,544,400
Steel	2,650	7,950	15,900	37,100	74,200	159,000	318,000	657,200	1,314,000
Labor	10,150	23,450	46,900	100,100	200,200	413,000	826,000	1,677,200	3,354,400
Precast concrete	20,000	40,000	160,000	320,000	640,000	1,280,000	2,560,000	5,120,000	10,240,000
Roofing material	2,000	4,000	16,000	32,000	64,000	128,000	256,000	512,000	1,024,000
Miscellaneous items	6,000	13,600	40,500	84,200	168,390	343,350	686,700	1,386,540	2,773,080
Contingency	6,890	15,660	46,460	96,690	193,390	394,310	788,630	1,592,350	3,184,680
Cost for Cover	52,840	120,110	356,660	742,190	1,484,380	3,026,660	6,053,330	12,222,490	24,434,960
Total Estimated Cost with Cover	436,250	641,810	1,219,160	1,850,510	3,217,760	5,528,920	10,095,150	18,384,960	34,840,260

Source: Benjes, Jr. H. H., *Cost Estimating Manual — Combined Sewer Overflow Storage and Treatment,* U.S. EPA Report, EPA 600/2-76-286. p. 28, 29.

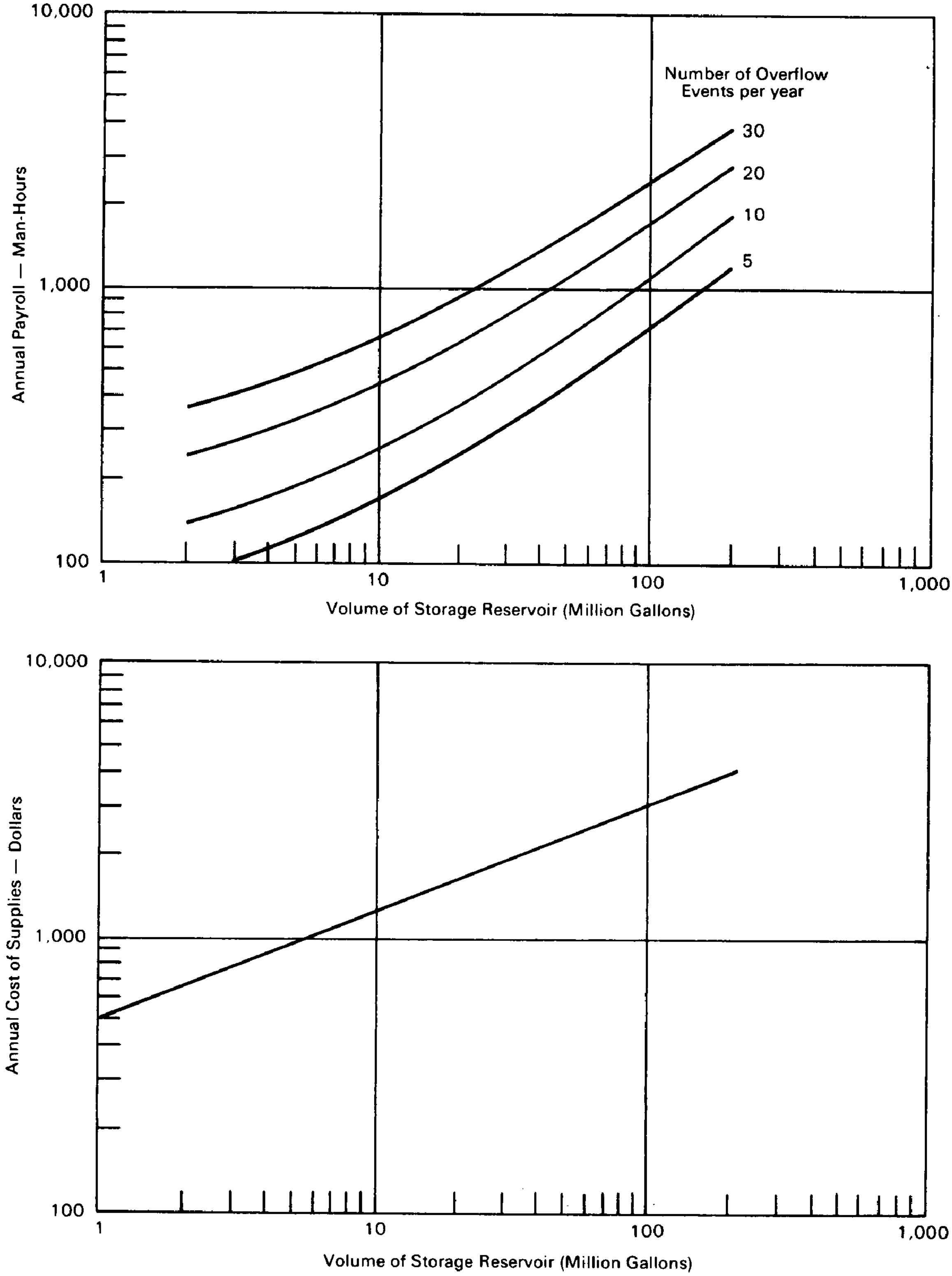

Figure 8. Storage Reservoir Labor and Cost of Supplies.

Source: Benjes, Jr. H. H., *Cost Estimating Manual — Combined Sewer Overflows Storage and Treatment*, U.S. EPA Report, EPA 600/2-76-286, p. 102, December 1976.

Table 5. Cost Ranges for Selected Source and Collection Control Alternatives.

Control	Range of costs ($/lb BODs)
Source controls:	
Street sweeping	3.00—7.50
Catch basin cleaning	>50.00
Sewer flushing	0.94—4.00
Collection system controls:	
Sewer separation	24.00
Swirl concentor	2.30—4.00
Remote control in-line storage	1.25—4.00
Roof drain disconnection	>50.00

Source: U.S. Environmental Protection Agency ,"Report to Congress on Control of Combined Sewer Overflows in the United States (MCD-50)" p. 7-12, 1978.

An additional complication in the cost analysis results from the fact that combined sewer overflow control options include some structural approaches that are capital intensive and some non-structural management techniques that utilize labor and materials more heavily. For instance, peak flow storage and subsequent treatment at an existing plant with adequate capacity requires significant capital investment and, by comparison, little maintenance and operating labor or materials. Increasing the frequency of street sweeping or sewer flushing, on the other hand, has proportionally higher manpower requirements. In a situation where either approach would provide the needed water quality improvement, the eventual budgetary burden on the community might be lower in the more capital intensive alternative because of the federal grant assistance. However, one of the more labor intensive approaches may be somewhat less expensive overall. The community might wish to select the totally structural alternative in that case. However federal regulations require (PRM 75-34) that the project that has least cost overall be chosen.

Cost Allocation in Multi-Purpose Projects

Because combined sewers are multiple-purpose systems, it is not uncommon that combined sewer overflow control projects have multiple benefits. An undersized combined system may back up as well as overflow during storms, causing street flooding with its related traffic and aesthetic problems. Parking lots as well as other public and private lands and, in extreme cases, basements may flood because storm drainage is inadequate. At the other end of the system, smaller streams may be flooded as well as polluted by discharges from combined sewers. Bank erosion and sediment deposition may increase the expense of channel maintenance. Consequently, a project that improves the efficiency of the sewer system's operation — separating the combined system, for example, or utilizing in-line storage — may provide benefits by reducing street flooding while improving water quality. Any storage alternative may reduce stream flooding and bank erosion as well as pollutant discharge. These are considered multiple purpose projects.

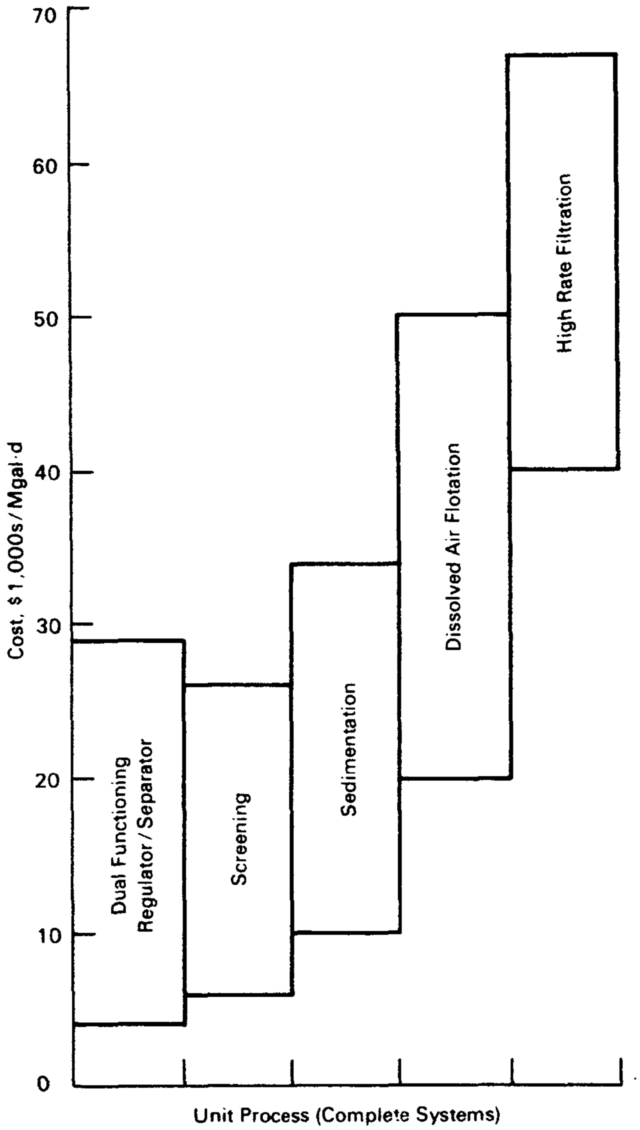

Figure 9. Capital Cost Ranges for Selected Treatment Processes.

Source: Lager, J. A., "CSO Treatment Potential and Information Source for Small to Medium Sized Communities, p. 18, presented at EPA Technology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, 1978.

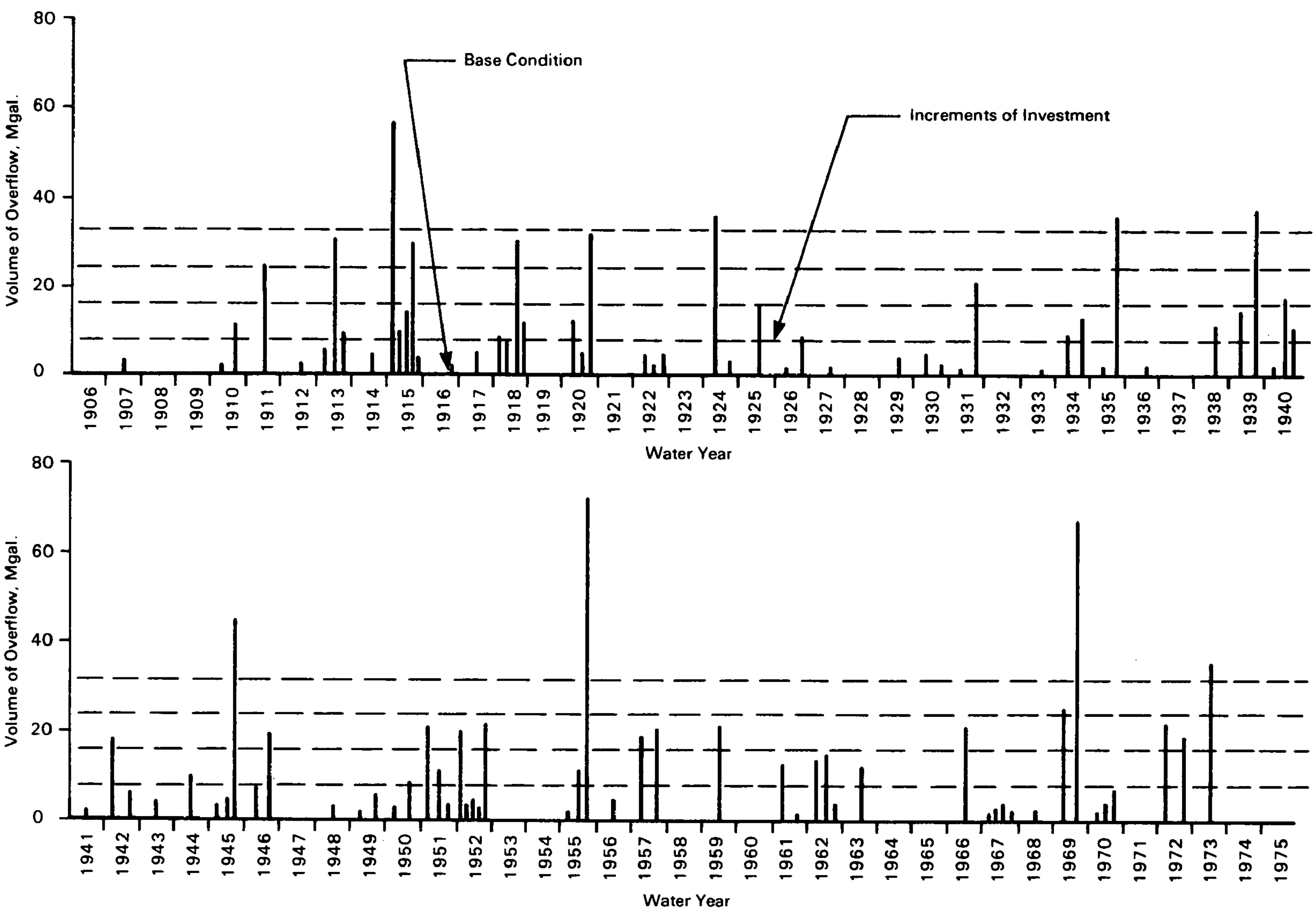

Figure 10. Overflow Volumes and Incremental Levels of Control.

Source: John A. Lager, "CSO Facilities Planning Using a Macroscopic Model" (A Case Study), presented at EPA Technology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, 1978.

EPA policy on pollution control facilities construction grants for multiple-purpose projects is that they "may be eligible for an amount not to exceed the cost of the most cost effective single-purpose pollution abatement system" (PRM 75-34), since the agency is not permitted to fund construction of storm drainage facilities. Therefore, when application is made for an EPA construction grant, it is necessary first to differentiate project costs in such a way that EPA does not fund any non-pollution control elements (PRM 75-34). Second, the costs must be allocated so that any savings resulting from multiple-purpose construction are shared equitably among the various purposes.

Alternative Justifiable Expenditure Method

In PRM 77-43,[3] EPA expands on how costs should be allocated. It requires the use of the alternative justifiable expenditure method (AJE) to make the necessary cost allocation, except under unusual circumstances, with the provision that construction grant-eligible costs shall "in no case, exceed the cost of the least cost single-purpose pollution control alternative". To apply it, one needs to know the following:

- Total cost of the multipurpose project,
- Costs that can be specifically attributed to each purpose in the project, and
- Costs of the most cost effective single-purpose project to achieve the same objectives as the multipurpose project.

The unknown quantities are the fractions of joint costs – those which cannot be attributed solely to one purpose or the other – to be added to the specific costs for each purpose. One way of determining these is use of the AJE method.

The method is based on the assumption that it is possible to develop cost estimates for a set of most cost effective, single-purpose projects that would accomplish the same objectives as the multipurpose project. (When this cannot be done, the "unusual circumstances" mentioned above can be assumed to exist.) In the case of an off-line storage project as in Figure 11, for instance, the two single-purpose projects might be construction of a storm sewer to relieve street flooding and enlargement of a municipal sewage treatment plant to avoid the necessity for overflows. Construction of off-line storage facilities, in this example, solves the flooding problem by eliminating local system overloads and reduces the rate of wet weather flow to the treatment plant to the point that overflows no longer occur.

Within this hypothetical multipurpose project, there are certain costs, referred to as specific costs, attributable to one purpose or the other. Constructing new stormwater inlets, for example, is solely an urban drainage cost, but rehabilitating or replacing interceptors may be considered pollution control costs. When all such specific costs have been identified and subtracted, the remaining amount is the joint cost.

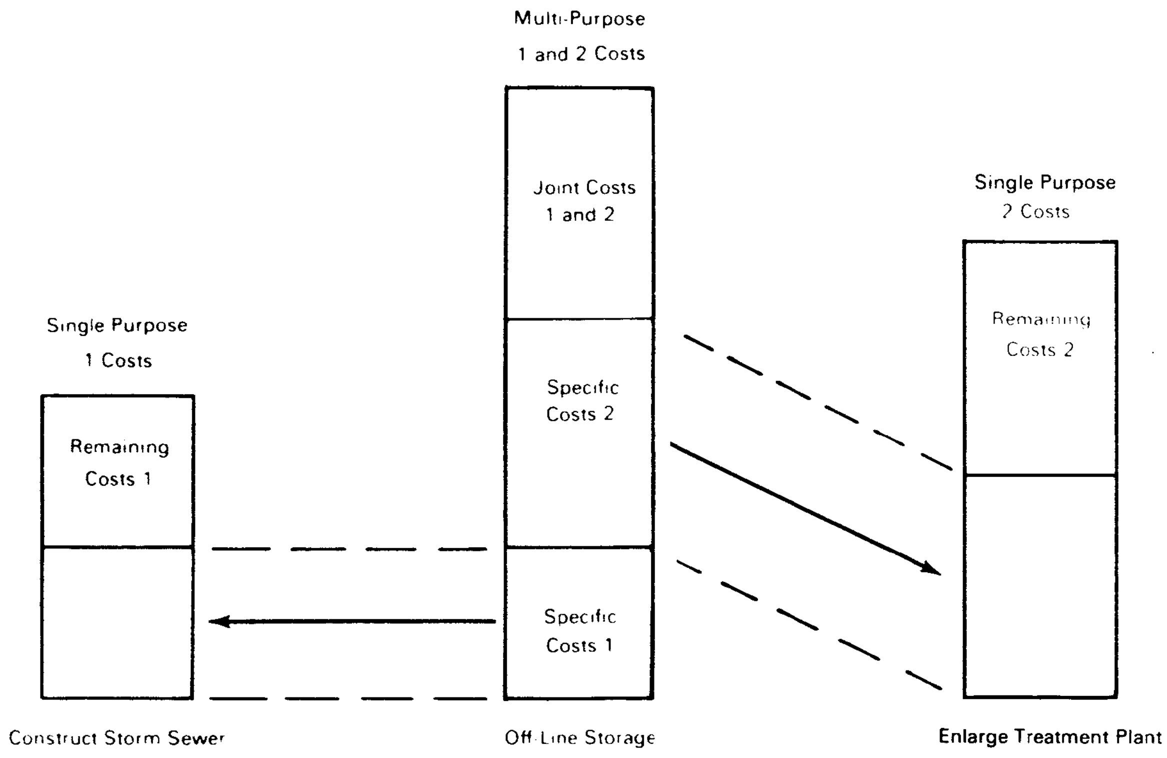

Figure 11. Identifying Specific-Purpose Costs Within the Costs of a Multi-Purpose Project.

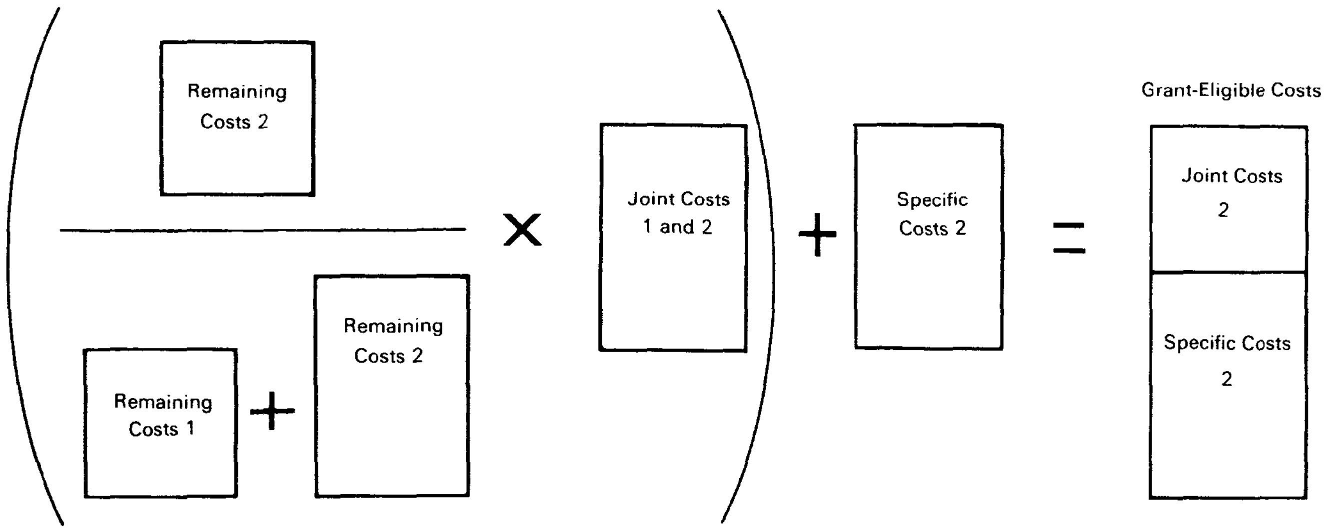

Figure 12. Allocating Joint Costs in a Multi-Purpose Project.

Much of the storage basin construction would be joint cost in this case. Clearly the capital costs specific to pollution control are eligible for construction grant assistance, and those specific to urban storm drainage improvement are not. To determine what fraction of the joint costs can also be included in the grant application to EPA, first, the specific costs for each purpose in the multipurpose project are subtracted from the corresponding single-purpose costs. The remainders (two in this case), or the remaining costs, provide the basis for allocating the joint costs. Dividing the remaining cost for pollution control by the sum of the remaining costs yields a fraction by which the joint cost is multiplied, as in Figure 12. The result is the pollution control share of joint cost; this amount is added to the specific costs for pollution control, and the sum is eligible for EPA construction grant assistance. The specific costs for storm drainage and the remainder of the joint cost are not grant eligible.

This procedure can be expressed in simple equation form, where:

- TC = total multipurpose project cost
- JC = joint costs within multipurpose project
- SC_i = specific costs for purpose i within multipurpose project
- SPC_i = cost of single purpose project that would accomplish purpose i
- RC_i = remaining cost of purpose i
- AC_i = portion of multipurpose project cost allocated to purpose i

Joint costs are then determined by:

$$JC = TC - (SC_1 + SC_2 + \cdots + SC_n)$$

In order to allocate joint costs, remaining costs must be calculated for each purpose:

$$RC_1 = SPC_1 - SC_1$$
$$RC_2 = SPC_2 - SC_2$$
$$\vdots$$
$$RC_n = SPC_n - SC_n$$

Assuming the pollution control purpose is purpose 1, the share of total project costs eligible for construction grant assistance becomes:

$$AC_1 = SC_1 + JC\left(\frac{RC_1}{RC_1 + RC_2 + \cdots + RC_n}\right)$$

Costs can be allocated to other purposes in the same way, but these are not EPA grant-eligible.

$$AC_i = SC_i + JC\left(\frac{RC_i}{RC_1 + RC_2 + \cdots + RC_n}\right)$$

It should be noted that in no case will the costs allocated to a given purpose exceed the cost of the most cost effective single-purpose equivalent or be less than the specific costs for that purpose.

$$SC_i \leq AC_i \leq SPC_i$$

One unusual situation which may arise occurs when no specific costs can be identified for the pollution control component of the multipurpose project (purpose 1 in this example). However, this can be handled in the same manner as above; nothing is subtracted from the single-purpose pollution control cost, and the pollution control share of joint cost is proportional to the unreduced single purpose cost.

$$SC_1 = 0$$
$$JC = TC - (0 + SC_2 + \cdots + SC_n)$$
$$RC_1 = SPC_1 - 0$$

Therefore:

$$AC_1 = JC\left(\frac{SPC_1}{SPC_1 + RC_2 + \cdots + RC_n}\right)$$

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[1]Benjes, Jr. H. M., *Cost Estimating Manual — Combined Sewer Overflow Storage and Treatment*, U.S. EPA Report, EPA-600/2-76-286, December, 1976.

[2]Rhett, J. T., "Program Requirements Memorandum, No. PRM 75-34", Water Programs Operations, U.S. EPA, December 3, 1976.

[3]_______, "Program Requirements Memorandum, No. PRM 77-4", Water Programs Operations, U.S. EPA, December 16, 1976.

Back to Benefits

The analysis and planning for combined sewer overflow correction has rested solidly on a determination of desired or required beneficial uses of a receiving water body and the most cost effective controls that will result in these beneficial uses. The culmination of this process in a decision to proceed depends on the presentation of the answers to three basic questions:

- What are the benefits?
- How costly is the project?
- Do the benefits expected justify the commitment of public funds and other resources?

The key to a successful outcome of this stage is that the questions be answered in a clear, logical, and realistic manner. No elected officials – and they are the ones who make the decisions that will begin the implementation process – can proceed further without being satisfied on these points. The dollar amounts involved in combined sewer overflow control projects are invariably large enough to attract more than casual interest. If it is not possible to demonstrate to the taxpayers a favorable relationship of benefits to costs, it is not likely that they will lend their support to the undertaking. Furthermore, EPA requires evidence that the proposed project is necessary to "protect a beneficial use" before it will provide a construction grant.

Estimating Benefits

There are four general methods for estimating benefits of water quality management projects:

- Apply available technology with no explicit estimating analysis,
- Control water quality standards,
- Estimate increased water use potential, or
- Use classical cost benefit analysis.

The first is the simplest. It assumes that benefits will automatically be realized from the proposed activity and that they are so large that they justify the allocation of required resources. It completely avoids the benefit measurement problem. An example of this method is the federal requirement for secondary treatment at all publicly owned treatment works. This approach is appropriate under certain circumstances – when water quality is very poor and public demands for it is high, for instance.

In the second method, it is assumed that certain water quality standards are associated with the protection of water uses. This is generally felt to be the case, although the connection may not always be scientifically defensible. Once standards to protect desired beneficial uses have been established, the comparison of projected water quality with the standards provides an estimate of benefit. When the level of pollutant reduction required to meet water quality standards can be determined, then pollutant reduction can also serve as a surrogate measure of benefit. This is particularly convenient, since pollutant reduction can also be related rather directly to control cost.

Estimates of increased water use potential are developed by translating improvements in water quality into numerical increases in usable length of beaches, swimming days, fishing days, or water-front property values, to name a few possibilities. This is, in effect, a refinement of the water quality standards approach, allowing benefits to be estimated directly.

The best known method is classical cost benefit analysis. In this method each anticipated water usage has a dollar value assigned as a measure of unit worth or willingness to pay. The actual project usages are multiplied by the corresponding unit values, and the sum is compared directly to total project costs.

The first approach is unacceptable for combined sewer overflow control planning, because a demonstration of anticipated benefit is necessary. The public, local officials, and EPA must be shown that there will be an improvement in water quality producing benefits which are consistent with the costs. The third and fourth methods suffer from great subjectivity that can only be overcome at considerable expense by detailed studies of demand, use, and willingness to pay. The water quality standards approach seems most appropriate for combined sewer overflow control planning at this time. Of course, when information on increased water use potential is available and can be related to the standards, it will strengthen the analysis, and it should, therefore, be employed.

Comparing Costs and Benefits

How the relationship between costs and benefits for various levels of combined sewer overflow control is developed and presented is as critical as the initial determination of desired beneficial uses. PRM 75-34[1] specifically recommends graphical displays of this information, relating quantified pollutant reduction and water quality improvements to dollar costs. supporting descriptive material should compare monetary, social, and environmental costs to benefits. The decision makers will focus most of their attention on this part of the report.

The presentation must meet the needs of three groups: local elected officials, citizens, and funding and regulatory agencies. The most important users of the analysis results, the public and its elected officials, are for the most part not specialists in water quality management. Moreover, they have other demands on their time. They will appreciate material that they can understand without technical consultants and that they can read and digest in a reasonable amount of time.

All of the report should therefore follow these recommendations:

- Be presented in non-technical language,
- Be concisely written, with well-conceived graphics,
- Set for its arguments completely and logically,
- Be expressed in terms relevant to beneficial use and cost interests of the reader, and
- Be responsive to EPA requirements.

The way the results are displayed is critical. Tables should be uncomplicated and informative. Graphics should be designed to highlight key findings. Details should be placed in an appendix or in supporting documents. The explantory text should help the reader follow the analyst's reasoning, briefly describing methodology and stating any assumptions.

Table 6 contains information on design storm alternatives when controlling bacterial contamination from combined sewer overflow to increase the usability of bathing beaches in a hypothetical urban area in the northeastern United States. Figure 13 is a graphic presentation of the cost benefit relationship of Table 6, showing expected increases in swimming availability as a function of dollars invested in the construction of covered concrete retention basins. Note the characteristic knee of the curve, the point at which the amount of additional benefit obtained for each additional dollar spent declines sharply. Expressed in the language of PRM 75-34, marginal costs become substantial compared to marginal benefits in this range. That is, the cost for each additional unit of pollution control becomes large enough, and/or the amount of benefit anticipated from that unit of control small enough, to

Table 6. Relation Between Design Basis and Benefits.

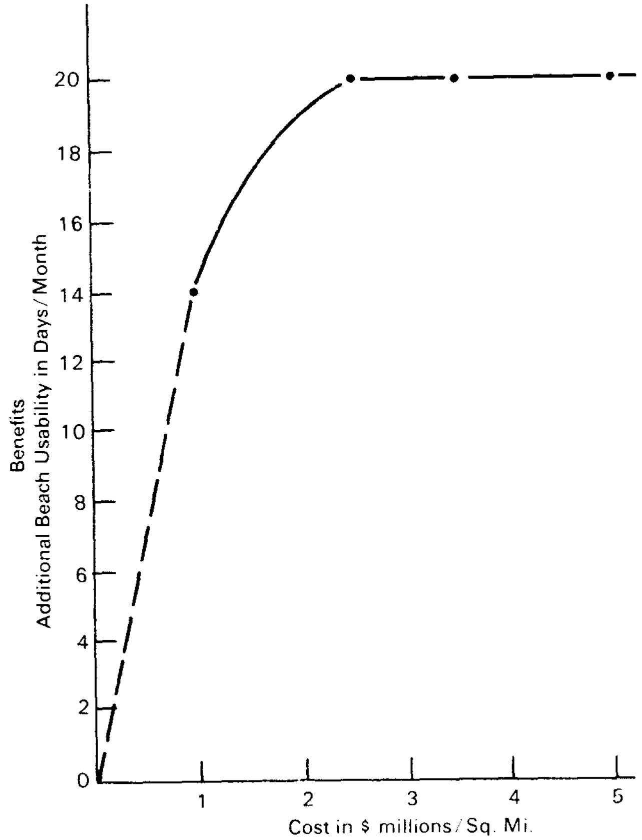
Design Storm Return Frequency	Days Between Overflow Events	Average Days/Month Beach Closed	Retention Tank Required to Achieve Control: mg/sq mi	Retention Tank Required to Achieve Control: 1975 $/sq mi	% Storms Smaller Than Design Storm
—	3	20	0	0	—
0.33 Month	10	6	3.5	1,000,000	70.5
3 Month	90	0.7	16	2,500,000	96.7
1 Year	365	0.2	28	3,500,000	99.18
10 Year	3650	0.02	45	5,000,000	99.92

Assumptions:

- Each overflow event closes beach for 2 days.
- Storm characteristics typical of N. Eastern U.S.: 122 storms/year; mean unit rain volume = 0.4 inches; coefficient of variation of storm volume = 1.5; runoff/rainfall ratio for area = 0.5.
- Retention tank is concrete basin with cover.
- Aereal coverage provided by 1 basin/sq. mi. drainage area.

Source: Driscoll, E.D. and J.L. Mancini "Assessment of Benefits Resulting from Control of Combined Sewer Overflows", presented at EPA Technology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, p. 21, 1978

Figure 13. Relation Between Costs and Benefits. (Data from Example in Table 6)



call the advisability of purchasing that additional unit into question. These are familiar tools in economic analysis, when the theoretical optimum level of production (i.e., pollution control) is the point at which marginal cost equals marginal revenue (i.e., benefit).

Selection of Design Storm

During the early phases of the planning process, rough costs were used to assist in selecting desired levels of benefit. Now, with more detailed information available, the design storm can be selected more precisely and, moreover, the selection can be explained and justified. It may be that the initial choice has proven to require expenditures beyond the knee of the curve, and a more modest objective should be considered. On the other hand, if the first selection proves to be considerably below the knee, the objective should be reexamined to determine if a higher level of control would produce additional usable benefit.

Reference

[1]Rhett, J. T., "Program Requirement Memorandum, No. PRM 75-34", Water Programs Operations, U.S. EPA, December 3, 1976.

Case Studies

Seattle

Metropolitan Seattle (Metro) has 110 sewer overflow locations. Overflow averages 40 occurrences per year, with approximately 6 during the summer recreation season. Planning for control of pollution from overflows, conducted under Section 201 of the Clean Water Act, involved two major technical phases – evaluation and optimization of control alternatives and quantification of benefit or effects of proposed facilities. Optimizing control alternatives was a straightforward process of comparing appropriate alternatives and establishing the overall least cost facility configuration. Quantification of benefits was complicated by the existence of multiple receiving waters with a wide range of beneficial uses and sensitivities to pollution.

The seven distinct steps in the study were:

- Development of a collection system model with flexibility to allow optimization at successive levels of control.
- Application of a collection system model to establish optimum controls as a function of a storm recurrence interval.
- Application of a collection system model to establish effectiveness of controls as a function of recurrence.
- Determination of combined sewer overflow quality parameters.
- Measurement of impacts on receiving waters.
- Identification of beneficial uses for all receiving waters and determination of sensitivity to pollution by CSOs.
- Relating CSO impacts to beneficial uses.

Collection System Analysis

Several hundred storm sewer network simulation models are available in the current literature; however, none could handle the complexities inherent in the Seattle system without extensive modifications. Those models that did have the basic sophistication to handle the flood routing aspects were too detailed and thus too time consuming for the planning effort. Consequently, at the start of the planning it was decided to custom-build a model that would not only address the needs of the study but would also, with minimum refinement, be suitable for subsequent detailed design and be a useful tool for future Metro planning.

The adopted two-part model consists of a runoff model based on the unit hydrograph technique that provided the input to the transport model that simulates the flow of the runoff through the system.

Once the model was built and calibrated, the tool was available to evaluate and optimize control alternatives and to determine CSO volume reductions for specific control levels.

CSO control alternatives evaluated included the following:

- Full separation in partially separated areas,
- Full and partial separation in combined areas,
- Roof-top storage,
- In-line storage of existing system (CATAD, or Computer Augmented Treatment and Disposal),
- In-line storage with new pipe/tunnels,
- Off-line storage,
- Localized storage/transfer and centralized storage,
- Local off-shore discharge,
- Local treatment, and
- Transfer and centralized treatment.

Controls were optimized for 114 sub-basins, considering overall cost based on a range of permitted overflow frequencies from the present 40 per year to 10 per year, 1 per year, and 1 in ten years.

In basins tributary to the fresh inland waters of Lake Washington and the ship canal downstream to the outlet of Lake Union, control alternatives were limited to storage, transport, and source control. In other drainage basins, additional alternatives of localized treatment or upgraded outfalls were evaluated. Once the range of alternatives was established, the analysis was conducted for each drainage basin by detailing the size of physical facilities required and establishing their cost.

Systemwide cost optimization was accomplished by matching flows at drainage boundaries and apportioning the cost for downstream facilities based on their proportion of total facility required. Selected facilities were based on flexibility for areal emphasis and stageable controls within specific areas.

The facility arrangements that yielded most economical control at the three selected storm frequency control levels were identified. In general, localized and/or centralized holding was found to be the most cost effective in the areas remote from the treatment plants. A combination of holding, transport, and increased treatment capacity was found to be the most economical for controlling overflows closer to the plants.

At the conclusion of this phase, the tools were available to find the least cost for controlling any combination of overflows, and incremental control level and corresponding reduction in overflows could be determined.

Table 7. Average CSO Pollutant Levels — Seattle.*

Pollutant	Minimum	Maximum	Average
BOD	15	82	60
COD	100	330	236
SS	141	296	217
NH_4-N	0.5	1.5	0.9
P	1.2	1.7	1.4
Cu	0.1	0.3	0.2
Pb	0.5	0.9	0.6
Hg	0.01	0.01	0.01
Cr	0.02	0.20	0.10
Cd	0.01	0.02	0.01
Zn	0.2	0.5	0.4
Total coliforms	8×10^3	7000×10^3	–
Fecal coliforms	3.6×10^3	780×10^3	–

*All values in mg/l except for coliform units, which are in *colonies/100 ml.*

Source: Warburton, J., "Seattle's Approach to Evaluating Costs and Benefits of Combined Sewer Overflow Control per PGM-61", p. 8, presented at U.S. EPA Technology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, 1978.

CSO Characteristics

Of the 110 overflow points, 5 were selected from representative runoff areas and subjected to detailed analysis. Investigation included analysis of the overflows, dye studies, coliform die-off studies, and benthic studies. Grab and composite site sampling was conducted at each point through a representative range of storms. A large range of values was obtained from the analyses (Table 7), but some general conclusions could be made: Tributary land use did not significantly affect conventional pollutant concentrations; the phenomenon of the first flush was not evident; season was not significant; and the size of the storm was not significant. Average pollutant concentrations could therefore be used for determination of pollutant loadings throughout the area and for various sizes of storms.

Dye studies indicated that the impact of overflows was typically localized within one-half mile for specific wind and localized current conditions. Coliform levels exceeded local public health water contact quality standards for up to 3 days. Benthic analysis at the overflow indicated significant dead areas overlain by sludge deposits.

Identification of Beneficial Uses and Sensitivity of Receiving Waters

Recognizing that the impact of overflows differs depending on the sensitivity of the receiving water and their attendant uses, Seattle's consultants prepared a geographical inventory of water use areas, aquatic life habitats, and ranking of relative risk to pollutant loadings based on physical characteristics (e.g., water circulation, dilution factors, and flushing) to assist in ranking overall sensitivity of the various water bodies to degradation from pollution loads.

Individual environmental risk maps, depicting recreational use (Figure 14), biotic life zones (Figure 15), and water quality sensitivity (Figure 16) were combined utilizing the overlay technique developed by Ian McHarg, and three levels of risk were identified for locations with combined sewer overflow (Figure 17). This prioritization does not constitute a cost effective analysis for abatement techniques but simply groups the overflows relative to their degree of environmental risk. It is the first step in grouping overflows with specific beneficial uses. The more localized the analysis, the easier it is to identify the relationships between beneficial use and CSO impact.

The next step was an evaluation of the commonality of collection subsystem, CSO impact overlaps, water body physical characteristics and dominant beneficial uses. This evaluation resulted in defining nine separate overflow areas that were then prioritized utilizing the initial risk analysis concept.

Cost Control Relationship

For each of the overflow areas, a plot of cost versus control level was made utilizing data developed in the control level optimization (Figure 18). In all cases, a pronounced "knee" (indicating a dramatic increase in control costs) was indicated in the one-per-year to one-per-ten-year overflow limit range. This knee of the curve is significant because it represents a point where marginal costs begin to increase quite rapidly. In other

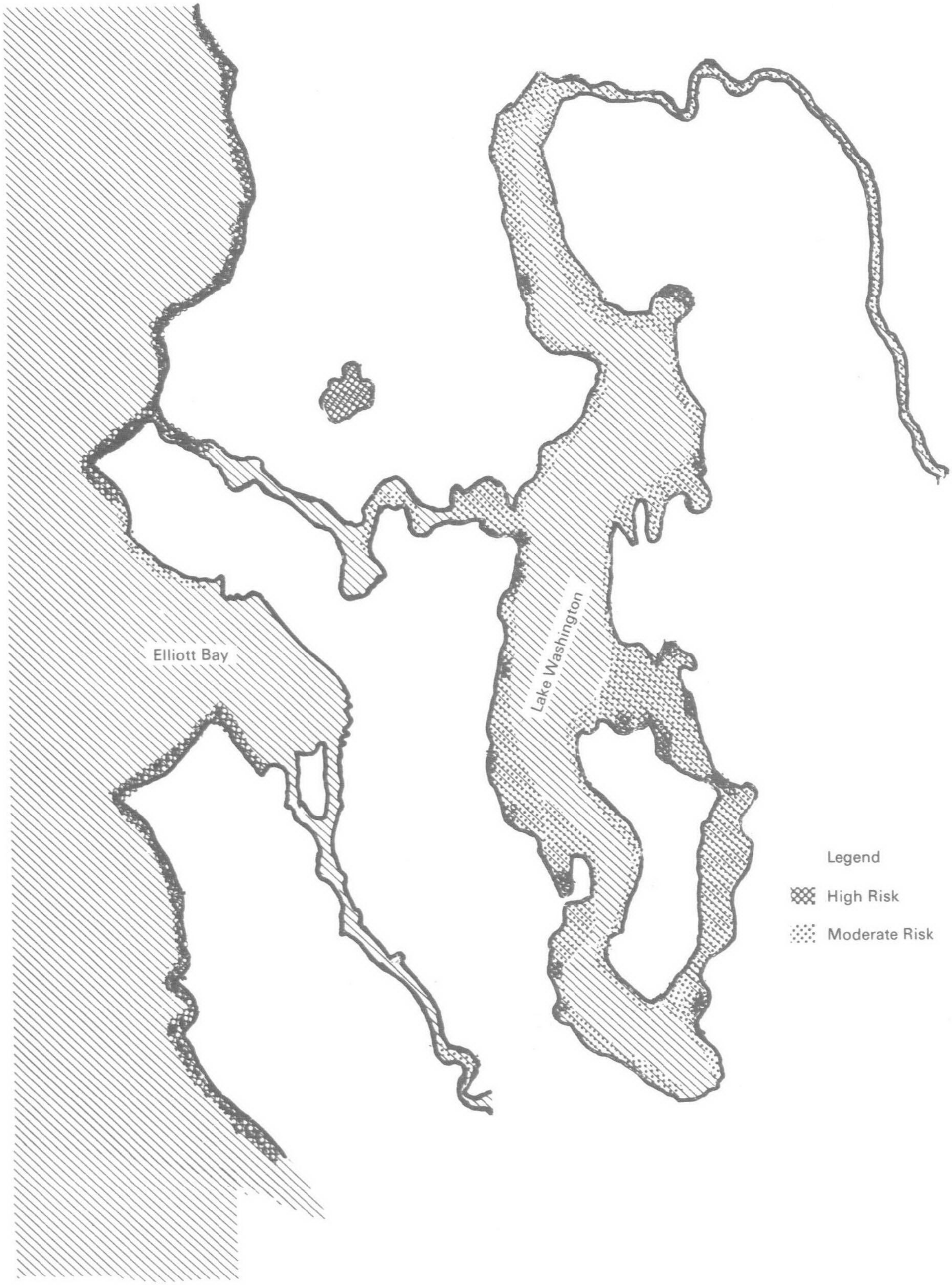


Figure 14. Water Contact Recreation: Risk of Degradation from Combined Sewer Overflows.

Source: Brown and Caldwell, Consulting Engineers for Municipality of Metropolitan Seattle, *Combined Sewer Overflow Control Program*, p. 6-23, January 1979.

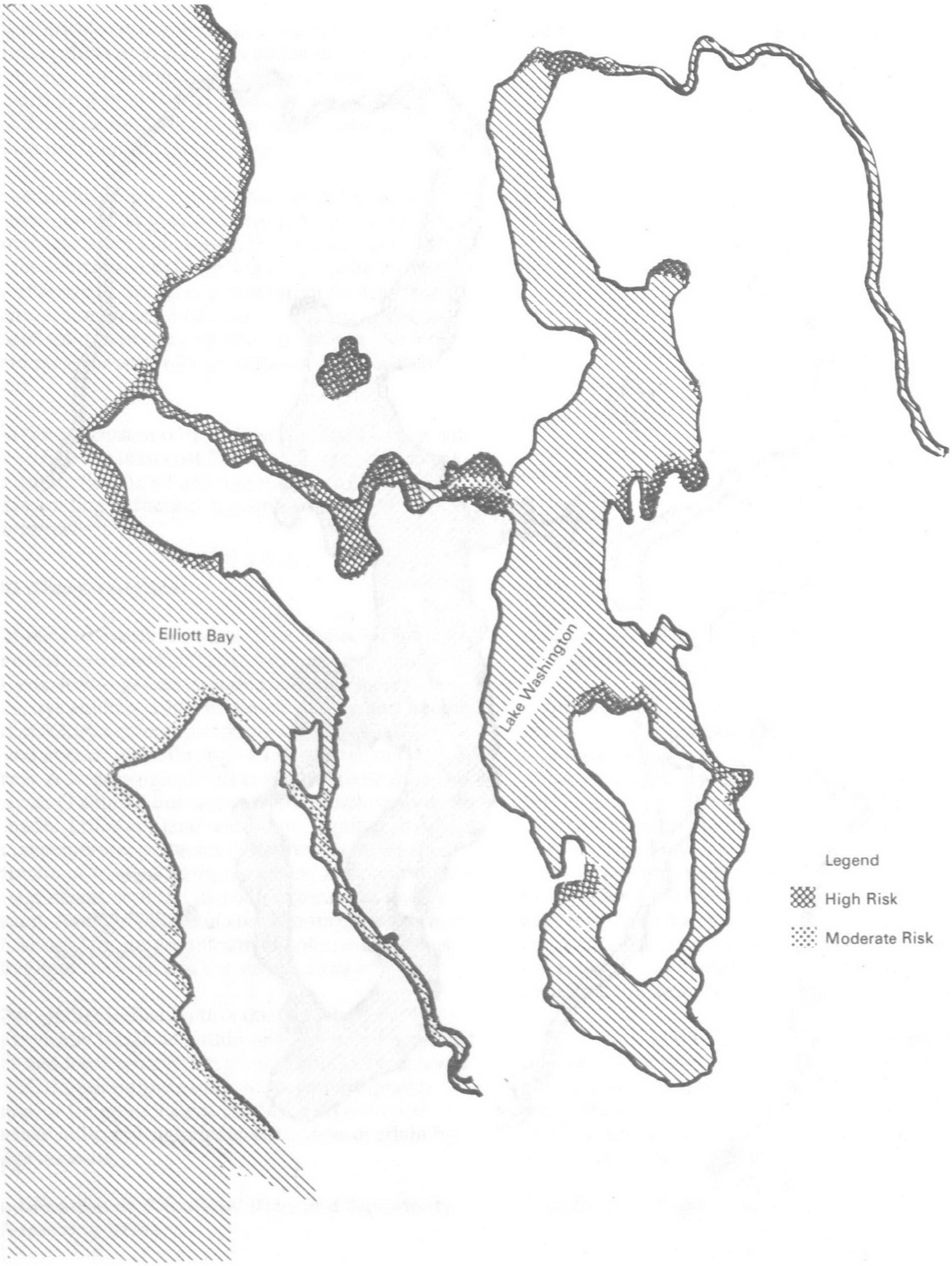


Figure 15. Biotic Life Zones and Critical Habitats: Risk of Degradation from Combined Sewer Overflows.

Source: Brown and Caldwell, Consulting Engineers for Municipality of Metropolitan Seattle, *Combined Sewer Overflow Control Program*, p. 6-24, January 1979.

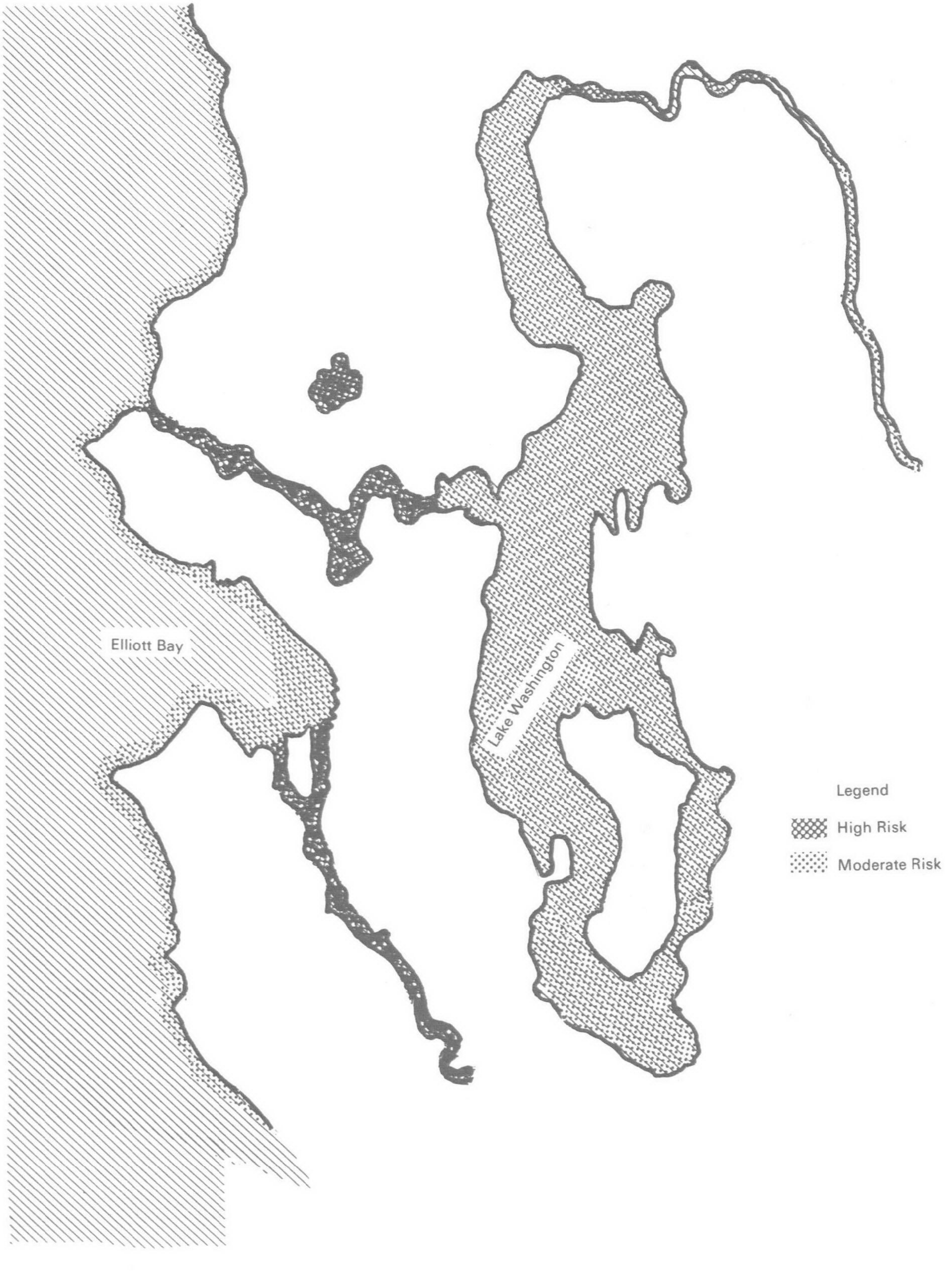


Figure 16. Water Quality: Relative Sensitivity to Pollutant Loading.

Source: Brown and Caldwell, Consulting Engineers for Municipality of Metropolitan Seattle, *Combined Sewer Overflow Control Program*, p. 6-25, January 1979.

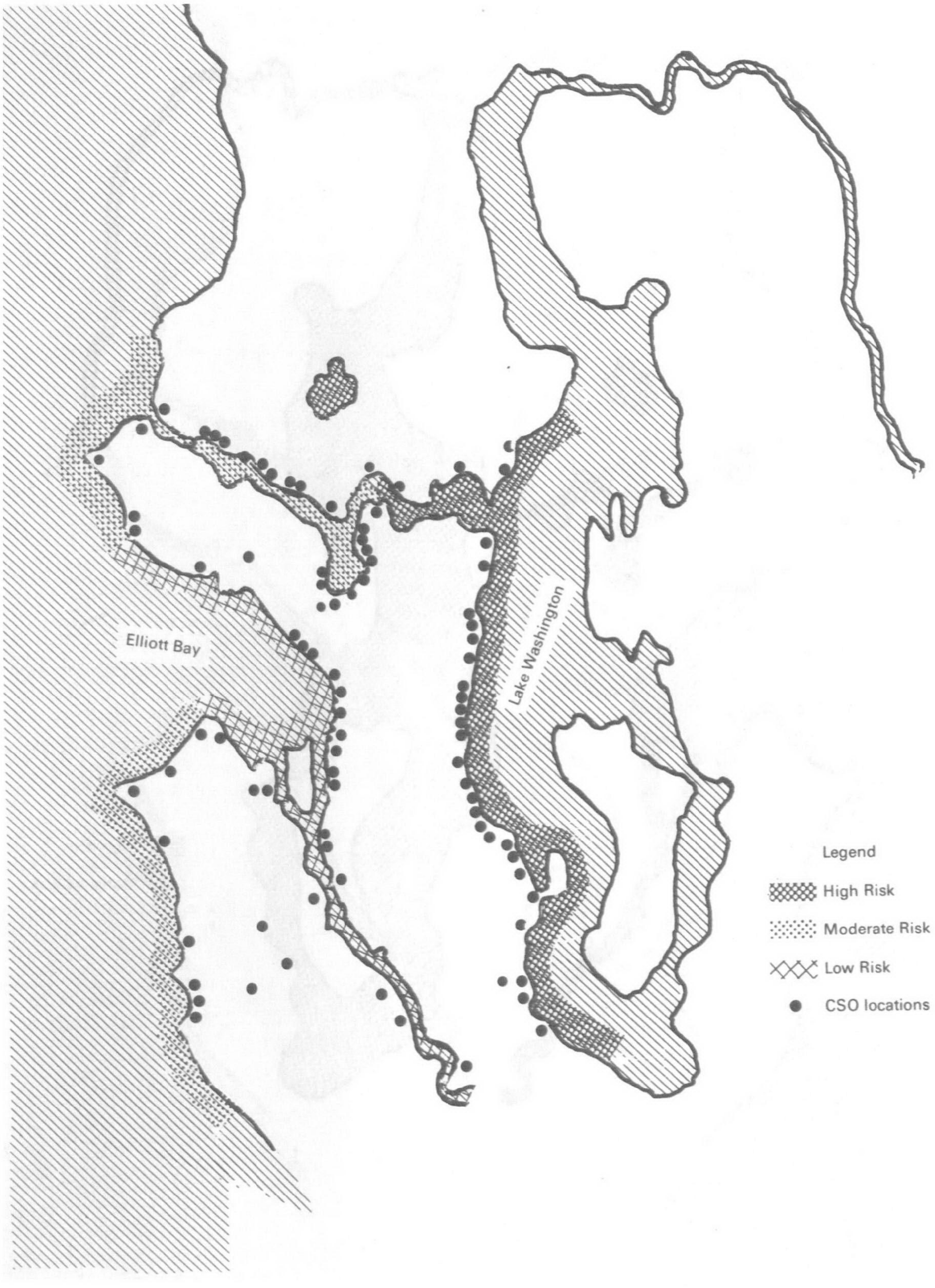


Figure 17. Relative Priority in Terms of Pollution Risk from Combined Sewer Overflows.

Source: Brown and Caldwell, Consulting Engineers for Municipality of Metropolitan Seattle, *Combined Sewer Overflow Control Program*, p. 6-26, January 1979.

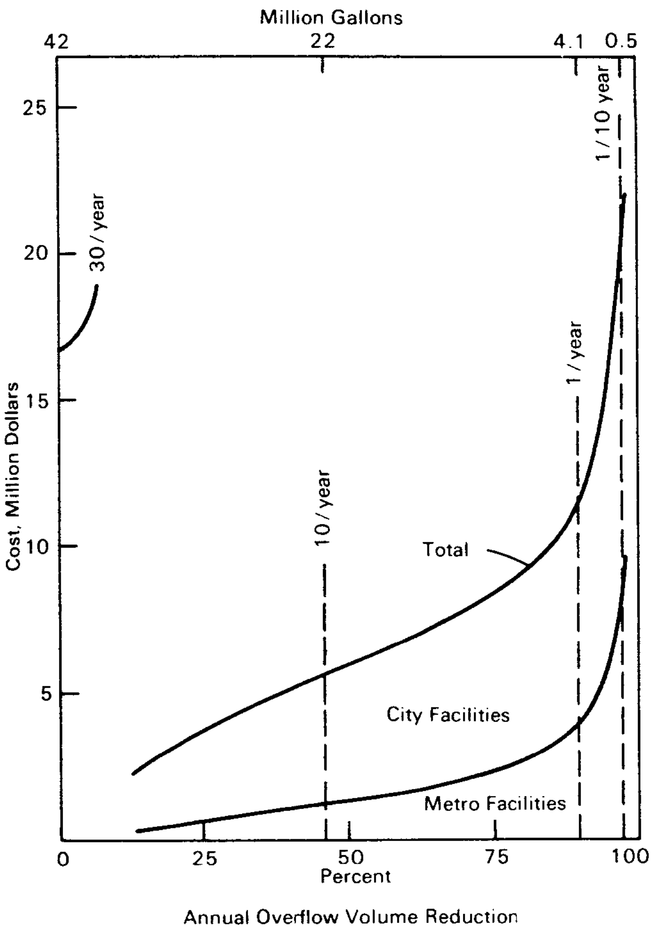


Figure 18. Cost-Overflow Control Curve — Priority 5 Overflow Area: Lake Union (South and East Shores) and Portage Bay.

Source: Warburton, J. "Seattle's Approach to Evaluating Costs and Benefits of Combined Sewer Overflow Control per PGM 61", p. 11, presented at U.S. EPA Technology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, 1978.

words, the cost for each additional unit of pollution control above the knee is much greater than the cost for a comparable increment below it. EPA examines this relationship critically in deciding whether marginal costs are substantial in comparison to marginal benefits.

The next step was to relate the reduction in pollutant to increase in benefit.

Water Body Beneficial Use

A list of all existing beneficial uses and potential beneficial uses lost because of the existing CSOs was prepared for each of the overflow areas. Use information was based on field observations, state environmental and wildlife departments, local universities and colleges, the county health department, the city parks department, local community groups, and comments made during the public hearing. The beneficial uses were then listed in order of importance, based on a combination of factors including public risk, biota sensitivity, and city zoning/planning policies for the area. A list of identified beneficial uses is shown in Table 8.

CSO Control Levels and Beneficial Uses

For each of the nine overflow areas and for each beneficial use within each area, the relationship of CSO control to beneficial use was evaluated, assessing existing conditions and projecting the benefits that would accrue by increased reductions in overflow events.

For illustrative purposes, priority 2 area, Lake Washington South is shown. The prioritized beneficial uses were:

- Swimming,
- Fish rearing,
- Fish spawning,
- Recreational boating, and
- Shoreline parks.

Swimming. Up to 20 overflows per year were discharging near the shore, resulting in up to 3 days of health standard coliform count violations for each occurrence. Up to 5 overflows occurred during the summer recreation season. CSOs did not preclude swimming activity, because beach closing procedures were not in effect, but participants were subjected to risk when swimming during the effects of CSOs. Thus, on a strict use definition basis, elimination of CSOs would not increase swimming activity, only reduce a potential health risk. However, the reduction in risk was a sufficient argument to meet EPA guidelines. Le-

Table 8. Beneficial Uses and CSO Pollutants — Seattle.

Use	CSO Pollutants
Residential	Coliforms/floatables
Swimming	Coliforms/floatables
Shell fishing	Coliforms/virus
Fish spawning/rearing	Toxicity/suspended solids
Juvenile fish migration	Toxicity
Recreational boating	Floatables
Shoreline parks	Floatables
Commerce	Minimal
Industry	Negligible

Source: Warburton, J., "Seattle's Approach to Evaluating Costs and Benefits of Combined Sewer Overflow Control per PGM-61", p. 8, presented at U.S. EPA Technology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, 1978.

gal substantiation for this approach has recently been provided in a court case involving the State of Illinois versus the City of Milwaukee, Wisconsin. The judge stated that "exposure to a hazard is itself actionable, whether or not that exposure results in the actual contraction of a disease."

Other factors taken into consideration were prior community commitment to CSO control, local political policy to reduce overflows to 1 per year, the large percentage of the shoreline accessible by public park, and the number of swimming areas operated by the city within the CSOs areas of influence. For swimming use, funding of facilities to control overflows to 1 event per year was agreed upon; this is equivalent to 1 summer overflow every 2 years.

Fish Rearing / Spawning. Combined sewer overflows are potentially toxic to fish, particularly during spawning and early development. It was the opinion of fishery experts as well as the regulatory agencies that overflows do affect these processes adversely, but available information on the degree of CSO stress was lacking. Until a closer definition of stress can be determined, the funding agencies would not participate in CSO controls to protect fish rearing/spawning.

Recreational Boating / Shoreline Parks. Control levels beyond those developed for swimming would not be necessary to protect recreational boating or shoreline park use.

Similar analyses were conducted for each water body, and in each case it was only the human health-related beneficial uses that could meet the EPA benefit requirements – namely, residential areas subjected to CSOs, swimming, and shellfish harvesting. The case for CSO control to protect fishery related uses could not be made sufficiently strong to meet the rigors of PRM 75-34.[1]

Conclusions of Seattle Case

Success of technical aspects of planning, facilities optimization and control effectiveness estimation is highly dependent on the collection system model used. In this case, the model used was highly flexible and readily adaptable to various control alternatives.

Available data on actual effects of CSO discharge to local receiving waters were sufficient only to justify control of overflows to receiving water segments where human contact recreation is the controlling beneficial use. Receiving water effects considered did not include those from the comprehensive list of EPA priority pollutants. Further studies to identify specific effects of overflows on the biological community are currently being developed by Metro.

The results of the planning process demonstrate that EPA will consider favorably funding CSO controls when benefits are demonstrated and when reduction of CSO is one element in an overall comprehensive 201/208 solution approach to addressing a water quality problem.

New York City

The combined sewer overflow control planning accomplished as part of the New York City 208 project illustrates the intimate connections among water quality problems, desired benefical uses, objectives, and control alternatives.

Even before the 208 grant application was submitted, the city of New York set, as one water quality objective, the opening swimming beaches along the Hudson River and in the South Bronx and the opening of additional beaches on Staten Island. This would be of direct benefit to lower income people concentrated in the South Bronx and Manhattan, for whom access to the usable beaches in Brooklyn, Rockway, and Staten Island was difficult. A desired beneficial use had thus been specified and the locations at which it was to be provided pinpointed.

Analyzing the relationship of overflows to water quality at the beaches involved the development of a rainfall simulator that could provide estimated pollutant loads from overflow events. This information for 80 distinct drainage lines, together with continuous point source loads, could be fed into a complex time-variable hydrodynamic model of the Hudson River estuary. These analytical tools were used to first screen and then evaluate the many alternatives that could conceivably be pursued to open the beaches.

The first conclusion drawn from the modeling analysis was that once secondary treatment of dry weather flows had been achieved, control of combined sewer overflows did not have to be accomplished throughout the city to attain the stated objective. The water quality problem preventing the use of the beaches in question, high fecal coliform concentrations, could be traced to overflows in the vicinity of the beaches themselves. Some of these overflows occurred in dry weather, indicating that repair and maintenance of regulators should be a part of any control alternative. The areas in which this was necessary were delineated. Further analysis showed that after elimination of these dry weather overflows, disinfection would be necessary at 240 major overflow points and at about 12 separate storm sewer outfalls, all clustered near the beaches (Figure 19).

Up to this point, the analysis had concentrated on health problems. A new dimension was added to the problem when health department officials pointed out that floatable solids and other visible signs of pollution would make beaches aesthetically unattractive even if they were safe from the fecal coliform standpoint. After simple observations from a small boat, it was decided that skimmers at 10 overflows would solve this problem.

Significantly, it was by precise definition and location of desired beneficial uses, by use of analytical tools suited to the problem, and by careful matching of control alternatives to both problem and beneficial use, that the solution ultimately recommended was a substantially more practical and less costly approach than might otherwise have been developed. The estimated capital cost to provide the desired beneficial uses was $280 million. Of this, $40 million was for rehabilitation of interceptors. Expenditure of $120 million would cover the 10 skimming basins and $120 million would provide disinfection at 240 points. There are more than 850 overflow points in the metropolitan area; if the recommendation been to provide skimming and disinfection at all of them, the cost would have approached $10 billion.

Although this CSO project is obviously larger than most others in the country, savings of similarly large proportions are often within the reach of municipalities through similar well-conceived planning as the municipalities seek to provide enhanced use of local water bodies through the control of combined sewer overflows.

Reference

[1]Rhett, J. T. "Program Requirements Memorandum, No. PRM 75-34", Water Programs Operations, U.S. EPA, December 3, 1976.

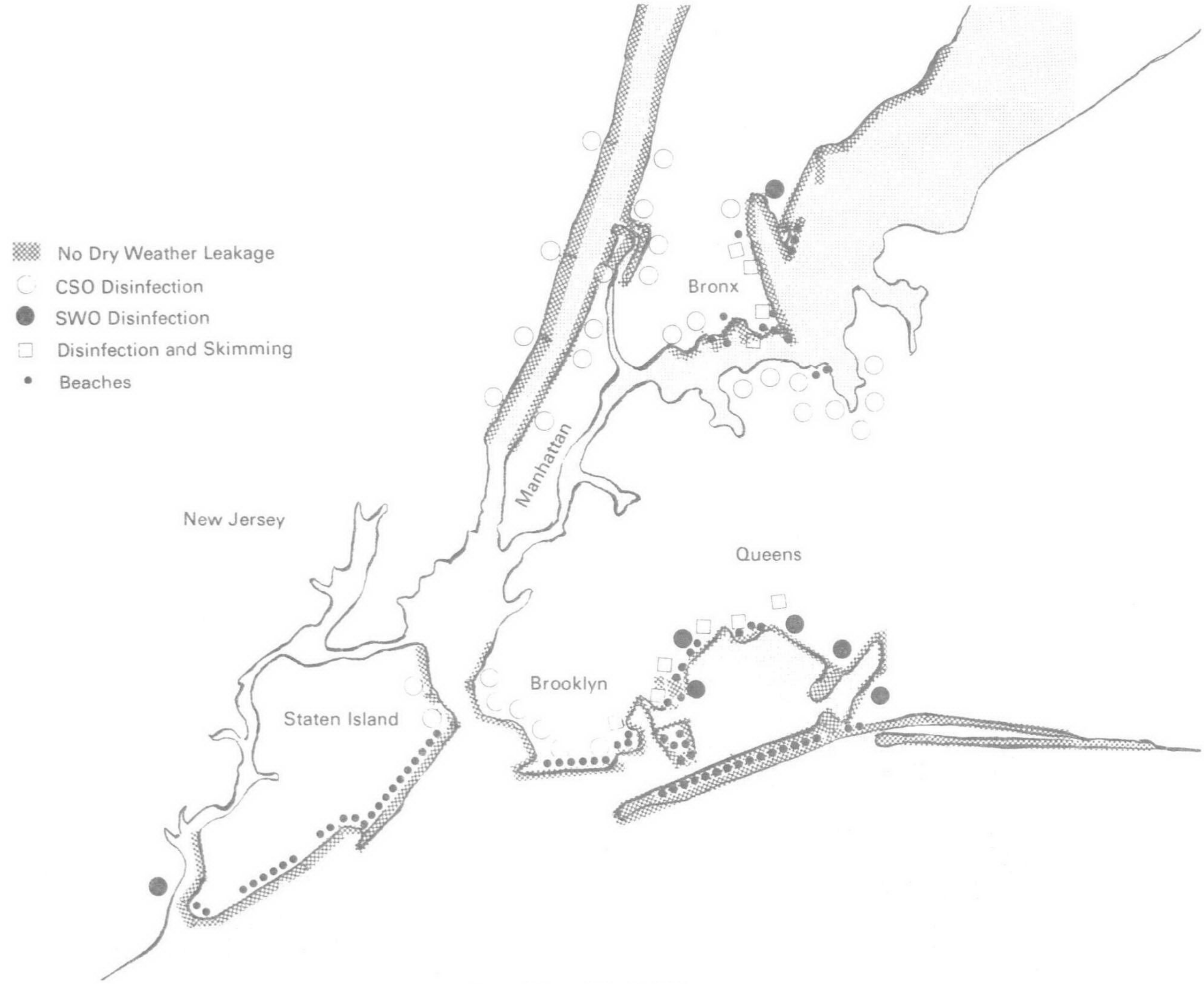


Figure 19. Facilities for Areawide Swimming: New York City.

Source: Mancini, J., "Assessment of Benefits Resulting from Control of Combined Sewer Overflows", presented at U.S. EPA Technology Transfer Seminars on Combined Sewer Overflow Assessment and Control Procedures, 1978.

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11. Lager, J. A., W. G. Smith, W. G. Lynard, R. M. Finn and E. J. Finnemore, *Urban Stormwater Management and Technology: Update and User's Guide,* U.S. EPA Report, EPA 600/8-77-014, September 1977 (NTIS: PB-275-654).

12. Municipal Environmental Research Laboratory, Office of Research and Development, U.S. EPA, *Areawide Assessment Procedures Manual,* Vol. I, II, and III, U.S. EPA Report, EPA 600/9-76-014, July 1976.

13. Rhett, J. T., "Program Requirements Memorandum, No. PRM 75-34", Water Programs Operations, U.S. Environmental Protection Agency, December 3, 1976.

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