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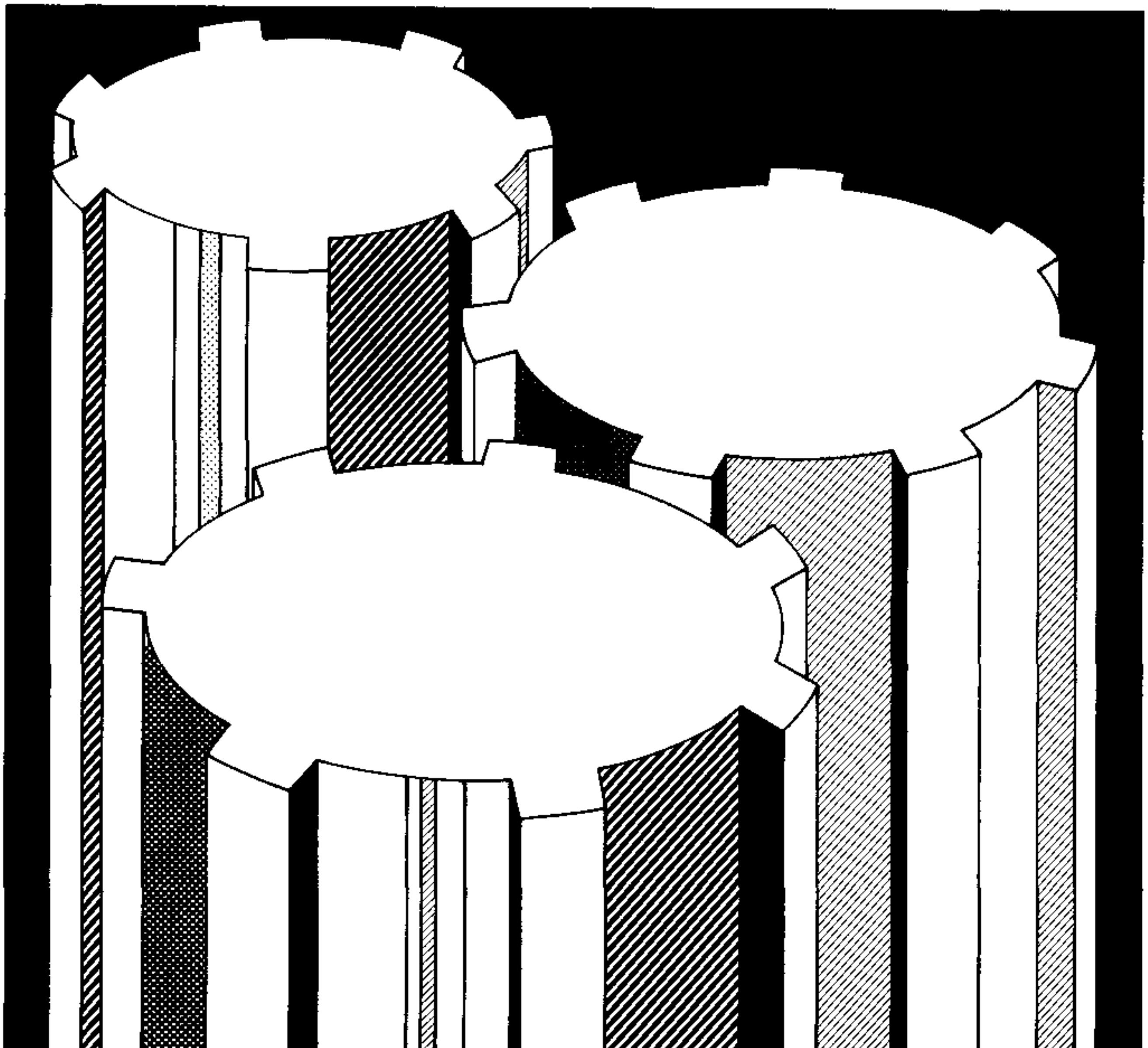
Efficient Investments in Wastewater Treatment Plants



CBO STUDY

EFFICIENT INVESTMENTS IN WASTEWATER TREATMENT PLANTS

The United States Congress
Congressional Budget Office

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PREFACE

Federal grants to localities for construction of wastewater treatment facilities, administered by the Environmental Protection Agency (EPA), constitute the second largest federal infrastructure grants program. From fiscal years 1960 through 1985, these grants will total some $56 billion (in 1983 dollars). The EPA estimates, however, that twice that amount will be needed by the year 2000 to meet Congressionally mandated goals for wastewater treatment. This study, undertaken at the request of the Senate Committee on the Budget, analyzes factors that affect the cost of meeting the nation's wastewater treatment needs as well as policy options to promote an efficient federal program to attain the nation's clean water objectives. In keeping with CBO's mandate to provide objective analysis, the study offers no recommendations.

The report was prepared by Kenneth Rubin of the Congressional Budget Office's Natural Resources and Commerce Division, under the supervision of David L. Bodde and Everett M. Ehrlich. Andrew Stoeckle provided valuable assistance in data collection and analysis. Jenifer Wishart, of CBO's Public Investment Unit, devised the model of state revolving loan funds used in Chapter IV. The author wishes to thank all those members of the water quality management community who took the time to provide CBO with local project information and those who offered valuable comments on the draft paper: Claudia Copeland of the Congressional Research Service, Linda Eichmiller and Robbi Savage of the Association of State and Interstate Water Pollution Control Administrators, and Dr. Paul Portney of Resources for the Future. Patricia H. Johnston edited the manuscript. Angela Z. McCollough typed the many drafts and Kathryn Quattrone, Patricia A. Joy, and Mechita O. Crawford prepared the paper for publication.

Rudolph G. Penner
Director

June 1985

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SUMMARY

Throughout the nineteenth and first half of the twentieth centuries, industrial and municipal wastewaters increasingly polluted U.S. waters. To help reverse this trend, the federal government began to subsidize local construction of wastewater treatment plants in the mid-1950s. In 1972 the Congress established stringent clean water goals and mandated that all publicly owned wastewater treatment facilities would have to meet much more exacting discharge standards. To facilitate compliance by local governments, the Congress set up an expanded federal Construction Grants program, administered by the Environmental Protection Agency (EPA). As a result, the level of federal aid expanded into the billions and the federal share of project costs increased to 75 percent. While water quality has improved in some areas and declined in others, overall national quality has remained about the same as in the 1970s. Without the expanded federal program, of course, pollution would have continued to worsen.

Federal grants are distributed to municipalities by states according to state priority lists. Only those that rank high on the lists have received grants each year, however. Through fiscal year 1984, those communities that did qualify received at least 75 percent of the eligible capital costs of building new facilities. If special federal and state aid was also provided, some localities needed to raise as little as 5 percent through local taxes or locally issued municipal bonds. These substantial subsidies resulted in the construction of larger and more sophisticated wastewater treatment plants than some localities might have built--or needed--had more local funds been at stake.

In 1981 the Congress recognized the investment inefficiencies that had arisen under the Construction Grants program. Confronted with mounting federal budget deficits and growing estimates of future costs to meet minimum treatment standards, the Congress reoriented EPA's water quality program. Federal authorizations for wastewater treatment grants were cut from the $4 billion to $6 billion range of past years to $2.4 billion a year through fiscal year 1985. The federal share of project construction costs was reduced from 75 percent to 55 percent beginning in 1985. Finally, federal grants were restricted to the needs of current populations and could be used only for certain types of facilities.

Authorization for EPA's Construction Grants program will expire at the end of fiscal year 1985. Two current proposals (S. 1128 and H.R. 8) call for continuing EPA's grants through 1990 when they would be replaced with federal contributions to state revolving loan funds through 1994. The Administration, in its 1986 budget proposal, seeks to phase out the Construction Grants program entirely by 1990 with no federal aid thereafter. This paper examines these and several other options for future funding of local wastewater treatment facilities.

ISSUES IN REAUTHORIZATION

As the Congress debates reauthorization of the Construction Grants program, it will consider three major issues:

- The cost of facilities still needed to meet secondary treatment standards;

- The relationship between local cost shares and efficient investment decisions by municipalities; and

- The degree, length, and type of federal subsidy and how these factors affect state and local governments and users of treatment facilities.

Estimates of Remaining Needs

The EPA is responsible for estimating outstanding wastewater treatment needs; this estimate is presented as the amount of spending that is necessary to install a minimum of secondary treatment at all publicly owned treatment facilities. 1/ The agency divides needs into several categories: treatment plants, sewer system repairs, new sewers, and stormwater management facilities. Depending on the condition of existing facilities, a

1. Secondary treatment standards require removal of 85 percent of the solids and organic material in untreated wastewater. This performance standard has been associated with "typical" technologies capable of producing the minimum standard of treatment. Such technologies include screening to remove gross solid material, settling tanks in which finer particles are removed, some type of biological (bacterial) degradation of organic material, and chemical disinfection prior to discharge to rivers, lakes, and streams.

community may need to construct any or all of the above in order to comply with federal standards. In EPA's latest calculation, the agency estimated remaining nationwide needs would cost $109 billion by the year 2000. Of this amount, about $53 billion is eligible for federal grants under the revised program established by the 1981 amendments. More than half of this amount, or about $29 billion, is needed for construction of secondary wastewater treatment plants. The remaining $24 billion can be spent for more advanced treatment and new interceptor sewers.

While federal aid may be limited, water quality problems, and, in turn, the mandate for improved local facilities, will persist. The current deadline for complying with federal minimum treatment standards is 1988, with or without federal aid. 2/ Hence, the burden of meeting federally mandated standards of wastewater treatment will fall increasingly on states and localities. For example, by 1990--the date by which the Administration plans to end federal aid--EPA estimates that some $90 billion in needs will remain outstanding. To meet these needs, even by the year 2005, states and local jurisdictions would have to spend about $6.0 billion a year, or about twice current nonfederal outlays.

Local Cost Shares and Investment Efficiency

The results of two different analyses in this study--a statistical analysis of a sample of secondary treatment plants and case studies of construction experiences in four localities--indicate that EPA's estimate of needs may be overstated. According to the statistical results, reducing the federal share of grants from 75 percent to 55 percent in 1985 should result in more efficient investment decisions by local authorities; on average, capital costs for secondary wastewater treatment plants could be reduced by about 30 percent. This would lower the EPA needs estimate by about $10 billion. Large municipalities building plants with little initial treatment capacity beyond that needed for current populations (reserve capacity) could save the most, while smaller communities building plants with high reserve capacity would save the least.

The four case studies examined the issues of causality underlying the statistical relationship between high local shares of costs and high investment efficiency. Two municipalities participated in the EPA grant program

2. This deadline has already been advanced from 1983. It is commonly recognized that the 1988 deadline also will not be met.

and two did not. Cost savings were captured as a result of two factors: local fiscal discipline brought on by high local cost estimates, and special opportunities specific to the community in question.

If local costs were low, fewer cost-saving decisions were made. But as greater financial responsibility was placed on the municipality, expected sewer fees grew and citizens became more concerned, increasing pressure on local officials to reduce costs. This process led to selection of simpler treatment technologies, limited construction of reserve capacity, rigorous local cost oversight, and, ultimately, shorter construction periods. Other attributes associated with low-cost projects appeared to stem from opportunities specific to the locality: economies of scale offered by regional treatment facilities, involvement of technically trained municipal personnel, or innovative reuse of wastewater effluents. These opportunities might never have been explored, however, had local costs or local cost shares remained low. In general, higher-cost projects were more disassociated from the control of municipal officials, took longer to complete, employed more sophisticated technologies, and were often oversized.

Federal and Nonfederal Roles

Despite the potential for more efficient investments promised by full implementation of 55 percent rather than 75 percent federal grants, remaining wastewater treatment facilities needed to help achieve clean waterways could cost as much as $100 billion. The Congress is now considering how long the federal government should continue to subsidize the additional facilities and in what way. However these questions are resolved, it appears that localities will be asked to bear the major portion, or even all, of these costs in the future. While some municipalities will have the financial and technical resources to meet this challenge, others may not. Although states could help meet these costs, some argue that withdrawing federal aid would not only put an inequitable burden on the 50 percent of municipalities yet to receive grants, but could compromise national water quality goals. That burden could fall particularly on sparsely populated rural communities and fiscally troubled cities.

POLICY OPTIONS

The objective of EPA's Construction Grants program is the same as that of the Clean Water Act: to restore and maintain the chemical, physical, and biological integrity of the nation's waters. In considering policy options to reauthorize the grants program, it is important to keep this broad goal in mind as well as the following more specific objectives:

- o Rapid construction of the remaining municipal treatment works;
- o Efficient local investments;
- o Long-term, self-sufficient local financing in place of federal subsidies;
- o Smooth institutional transition during funding changes; and
- o Equitable treatment of disadvantaged communities.

In addition to continuing current policy, three other policy options are analyzed: the Administration's four-year phase-out proposal, replacing project grants with state revolving loan funds, and continuing current policy with regulatory reforms.

Continuing Current Policy

Although continuing current policy might be the simplest policy administratively, it would neither provide a source of long-term, self-sufficient local financing nor ensure timely construction of needed treatment facilities. The federal presence would continue to exert its influence in local investment decisions. To its credit, current policy is likely to promote more efficient wastewater treatment investments once the 1981 amendments to the Clean Water Act take full effect in about 1990. Under this option, the states target funds to disadvantaged communities, a concern now addressed adequately with rural set-asides and state prerogatives to set funding priorities.

The Administration's Four-Year Phase-Out Proposal

Eliminating federal grants for wastewater treatment by 1990 could stimulate more efficient investments, although the analysis in this report suggests that efficiency improvements might be exhausted at the current 45 percent local cost share. Moreover, although financing facilities with completely tax-exempt municipal bonds would lower total federal costs, it would increase tax losses over 20 years without any federal controls on limits to these losses. Rapid curtailment of federal grants also would raise questions of equitable treatment of municipalities that still have to meet the secondary treatment standard without the benefit of federal aid extended to past participants.

While this option would require only normal program close-out procedures at the federal level, states might find that their current institutions are unable to meet the administrative and financial demands of localities. Deadlines for compliance with minimum treatment standards would most certainly have to be extended, especially for disadvantaged communities, thus jeopardizing the timely achievement of clean water goals.

State Revolving Loan Funds

Revolving loan funds operated by the 50 states and capitalized with federal and state contributions would provide reliable, long-term financing mechanisms for construction of a great number of facilities in the short term. Federal support could be eliminated after a 5-to-7-year capitalization period, during which matching block grants to states to set up the funds would be phased in as project grants to localities were phased out. These funds would promote locally self-sufficient financing of projects under terms that could be tailored to needs within each state. Loan repayments would reimburse the federal and state contributions within 25 years, as well as build equity in the funds through continued revolving loan activity that would grow each year the funds operated. This option would require new federal legislation and new state statutes and institutions to manage the program.

Current Policy With Regulatory Reforms

This paper focuses on the efficiency of investments in wastewater treatment facilities entailed by federal requirements. But the Congress could instead view secondary treatment plants as only one of a number of investments to achieve cleaner water. Hence, efficiency would no longer be defined in terms of achieving secondary treatment at the lowest cost, but instead in terms of achieving clean water by any means at the lowest national cost. Four options that offer such efficiencies include promoting ocean discharges of low-quality wastewaters, seasonal or flow-variable permits that take advantage of the natural ability of waterways to degrade wastes, intrabasin permit trading allowing some dischargers to save money, and trading costly point-source controls for less costly nonpoint-source investments such as sedimentation basins.

Although limited in their applications, these options could obviate some types of costly investments and allow more efficient targeting of limited federal grants. Continuing federal grants, however, would keep the federal government involved in the program without creating a system of self-sufficient, long-term local financing. Better targeting of federal funds could imply more rapid attainment of water quality improvements in some areas, although advances would be limited in the long run. Attention to low-income or rural needs could continue through set-asides and state priority list ranking criteria. Institutional, statutory, and administrative adjustments would be necessary at both the federal and state levels, but such changes have already proven successful within several states.

CHAPTER I

INTRODUCTION AND OVERVIEW

Pollution of U.S. waterways (lakes, streams, rivers, estuaries, and bays) is a result both of natural processes and of human activities. One of the latter--the discharge of domestic sewage with little or no prior purification--has significantly contributed to this pollution, threatening public health, reducing recreational opportunities, and killing fish. To improve the quality of water nationwide, the federal government has established minimum standards for the treatment of sewage discharges. Publicly owned treatment works must conform to these standards. To promote compliance with water quality goals, the federal government has subsidized the construction of municipal wastewater treatment plants since the mid-1950s, with a significant increase in the federal grant program in 1972.

Program changes enacted by the Congress in 1981 took effect at the beginning of fiscal year 1985. These changes reduced the level of federal subsidies and are expected to promote more efficient local investments in wastewater treatment plants. Localities must now finance 45 percent of all eligible capital costs, rather than 25 percent, plus all ineligible costs. At the same time, they must comply with the requirement to build adequate treatment facilities by 1988. Estimates of costs to meet this standard are over $100 billion.

Authorization for the federal grant program expires at the end of September 1985. Current legislative proposals to extend the program range from phasing out federal grants by fiscal year 1990 to an expanded level of grants for up to eight years. To facilitate Congressional decisions, this paper analyzes the efficiency of current public investments and presents options for meeting future investment needs.

LEGISLATIVE AND FINANCING BACKGROUND

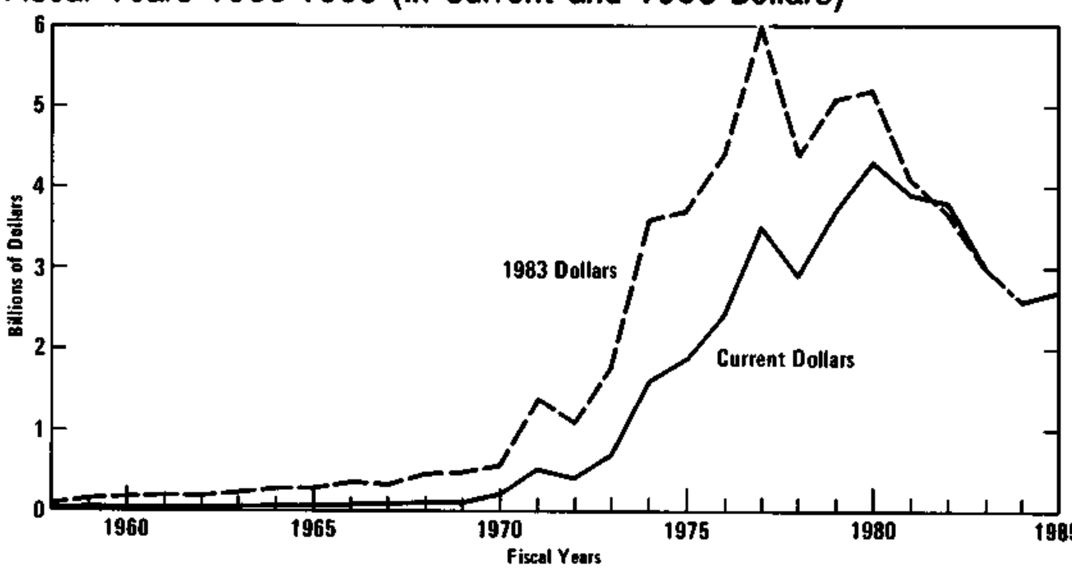
During the 30 years of federal participation in constructing local wastewater treatment plants, the program has undergone several significant changes. The Congress not only has altered the federal share of financing local facilities but also has set more stringent standards and goals to improve the quality of the nation's water.

Legislative History

The federal government first subsidized municipalities for the construction of sewage treatment plants under the Water Pollution Control Act of 1956 (see Figure 1). (This act and its subsequent amendments are known collectively as the "Clean Water Act.") The act authorized $50 million a year in federal grants to pay 30 percent of the total cost of building treatment works; local governments provided the remaining 70 percent. The 1961 amendments raised this funding to $95 million a year for fiscal years 1962 through 1967. Additional amendments in 1966 increased the federal share to 50 percent of construction costs and raised grant funding gradually from $450 million in 1968 to $1.25 billion in 1971 (all in current dollars). By current standards, only a handful of adequate publicly owned treatment facilities were constructed in the 1960s. In addition, the federal government set few standards for state water quality management programs. Also over this period, the nation's rivers and streams became more polluted.

Figure 1.

Annual Federal Outlays for Wastewater Construction Grants, Fiscal Years 1958-1985[a] (In Current and 1983 Dollars)



SOURCE: Congressional Budget Office

[a] Included are federal grants under the 1956 Water Pollution Control Act and its amendments.

The 1972 amendments to the Water Pollution Control Act (Public Law 92-500) dramatically changed government responsibilities at all levels, creating the basis for the EPA's current water quality program and greatly expanding the federal construction grants. These amendments set forth the goal of rendering all navigable waters "fishable and swimmable" by 1983, and mandated that all publicly owned treatment works install a minimum of secondary wastewater treatment by 1983 (later adjusted to 1988). 1/ More advanced treatment facilities could be required if local water quality remained poor despite secondary treatment. The Congress supported these policy goals by offering an unprecedented level of grants to subsidize construction of municipal wastewater treatment facilities--$18 billion (in current dollars) through fiscal year 1976. The federal share of treatment plant construction was increased from 50 percent to 75 percent of total eligible costs.

Since 1972 the program has undergone two basic changes, the first in 1977 and the second in 1981. The 1977 amendments provided for delegation of water quality program management to the states, subject to EPA approval. The act also attempted to remedy any technological biases in the secondary standard by encouraging innovative or alternative technologies. This was done by offering an extra 10 percent, or an 85 percent federal grant, for such technologies.

Reflecting mounting budgetary pressures, recognition of certain inefficiencies, and growing estimates of the costs of secondary treatment, the 1981 amendments reoriented the Construction Grants program. The authorization ceiling for wastewater facility grants was reduced from the $4 billion to $6 billion range of past years to $2.4 billion a year for fiscal years 1982 through 1985 (in current dollars). To encourage local officials to invest more efficiently, the Congress reduced the federal share of new construction projects from 75 percent to 55 percent for conventional technologies and from 85 percent to 75 percent for innovative methods, beginning in fiscal year 1985. Projects begun before 1985 continued to receive the 75 percent federal share. Also starting in 1985, federal grants were limited to certain types of projects and restricted to the needs of current populations in an effort to curtail spending for the purpose of promoting growth.

1. Secondary treatment is defined in EPA regulations (40 CFR 133.102) as such processes that produce an effluent with no more than 30 milligrams per liter (mg/l) of suspended solids and no more than 30 mg/l of oxygen-demanding organic and chemical substances. Secondary treatment is commonly construed to mean removal of 85 percent of solids and organic matter plus disinfection prior to discharge.

Financing History

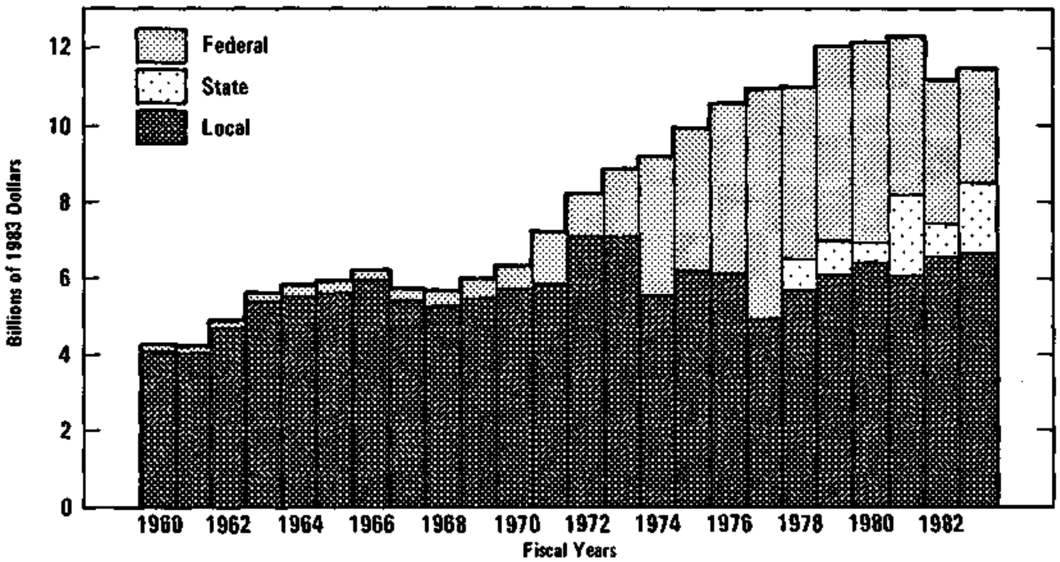
Throughout the 1960s, building and operating wastewater treatment systems remained a local responsibility. Total local spending (capital plus operating expenses) fluctuated between $4.0 billion and $5.5 billion a year, compared with federal spending limited to $100 million to $400 million annually (see Figure 2). As a result of the newly expanded federal grants program in the 1970s and attendant increase in operating and maintenance (O&M) costs for new facilities, total combined government spending for wastewater treatment doubled from about $6.3 billion in fiscal year 1970 to $12.1 billion in fiscal year 1980. In the 1980s, total spending appears to be levelling off at about $11 billion to $12 billion a year. (All dollar amounts here and throughout the rest of the report are in 1983 dollars unless otherwise noted.)

Before 1972 local governments financed most of the construction costs of new municipal treatment plants (see Figure 3). Over the decade of the 1960s, for example, local governments spent $3.0 billion to $4.5 billion a year to build these facilities and accounted for 90 to 95 percent of total government capital spending. The $18 billion federal grant program passed in 1972 established the federal government as the chief financier of local wastewater treatment facilities. Between 1970 and 1977, federal grant outlays rose from about $0.5 billion to $6.0 billion annually while local capital spending fell from about $4.0 billion to about $1.5 billion. Thus, as federal grants partially substituted for local capital spending, total government capital spending also increased--from the $4.0 billion to $5.0 billion range characteristic of the 1960s to the $6.0 billion to $8.0 billion range of the 1970s. Total government capital spending for wastewater treatment now appears to be falling because of reduced federal grants as well as reduced local capital spending. 2/ In 1983, for example, all governments combined spent some $5.8 billion compared with $7.5 billion in 1980.

Although local capital spending has declined, total local wastewater expenditures continue to rise, principally because of steadily increasing operating expenditures (see Figure 4). In 1973, for example, local operating expenses totaled about $2.5 billion, or 48 percent of overall local wastewater spending. A decade later, local operating expenditures had risen by 82 percent (adjusted for inflation) to $5.6 billion annually, or 85 percent of total local wastewater expenditures. Growth in aggregate operating expenses has stemmed from growth in the number of treatment facilities, miles of sewers in service, and number of households served by these facilities.

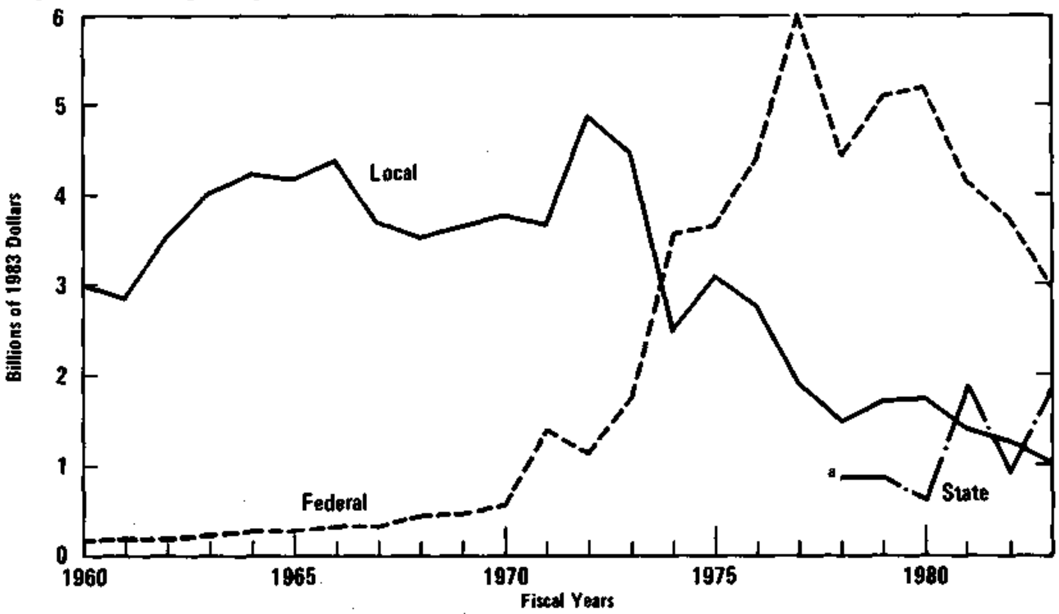
2. Although data are not yet available, many experts believe that local capital spending will increase in 1984 and thereafter in response to reduced federal capital outlays.

Figure 2.
Total Wastewater Spending by All Governments, Fiscal Years 1960-1983



SOURCE: Congressional Budget Office.

Figure 3.
Capital Outlays by All Governments, Fiscal Years 1960-1983



SOURCE: Congressional Budget Office.
[a]State spending before 1978 is not available.

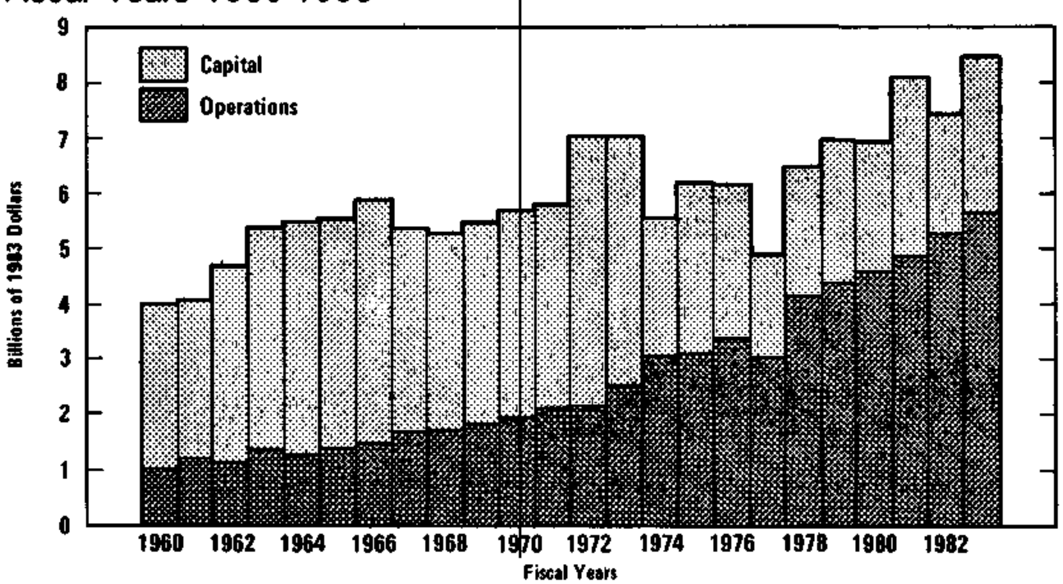
Moreover, while construction costs have risen much more slowly than inflation since 1982, operation and maintenance costs have risen about 1 percent to 2 percent a year above inflation. For example, a $10 million project built in 1982 would cost the same if built today, but $1 million a year in O&M costs in 1982 would total about $1.1 million today.

State aid for municipal wastewater treatment plants has increased recently in partial compensation for the decline in federal funding. In 1978, for example, federal funding authorizations fell by 25 percent as a result of the 1977 amendments. In that year, the states spent about $0.8 billion, mostly to help localities meet the 25 percent match required to receive federal grants. In the 1980s, aggregate state capital expenditures for wastewater treatment plants increased to between $1 billion and $2 billion annually. Today, about 40 states offer grant or loan programs to help municipalities construct the required facilities under the federal program as well as to build major sewer lines that are not eligible for federal grants.

Program Accomplishments

Though much progress has been made, the Congress clearly underestimated the size of the job needed to bring municipal treatment plants into compliance with the secondary-or-better standard and to achieve cleaner

Figure 4.
Composition of State and Local Wastewater Spending, Fiscal Years 1960-1983



SOURCE: Congressional Budget Office.

water. To date, about 6,700 wastewater treatment plants have been built--about half of all facilities required by the federal standards. Some 2,000 plants are now under construction and the EPA has identified another 6,600 that would qualify for federal assistance under the current program. From fiscal years 1960 through 1985 (the year the program expires under current law), EPA construction grants totalled about $56 billion. The EPA estimates that $109 billion in combined government funding will be needed by the year 2000 to complete construction of the remaining facilities. The EPA's needs estimate is discussed in a subsequent section.

In general, the quality of the nation's waterways has improved only slightly since 1972. Over the 1972-1982 decade, 49 states monitored the water quality of some 350,000 miles of streams (about 20 percent of the nation's total). Water quality was found to have improved in about 13 percent of the miles monitored, while water quality deteriorated in only 3 percent. The remaining 296,000 miles of streams (84 percent) were reported to be unchanged. Similarly, of the 16 million acres of publicly owned lakes monitored by the states (roughly half of the nation's lake area), about 10 million acres (63 percent) maintained the same quality; 390,000 acres (2 percent) improved in quality; and 1.7 million acres (10 percent) deteriorated. 3/ There is little question, however, that without the federal program, water quality would have continued to worsen as it had during the 1950s and 1960s before federal intervention.

BUILDING WASTEWATER TREATMENT FACILITIES

Almost all publicly owned wastewater treatment facilities built since the early 1970s were planned and constructed under the program established by the 1972 amendments to the federal Water Pollution Control Act and more recent amendments. Under this program, each level of government--federal, state, and local--has well established responsibilities. Increasingly, however, localities are experiencing pressure to seek alternative sources of financing in order to solve local water quality problems, provide for additional growth, and meet the 1988 compliance deadline for secondary treatment.

3. See Association of State and Interstate Water Pollution Control Administrators, *America's Clean Water: The State's Evaluation of Progress, 1972-1982* (April 1984).

The EPA Construction Grants Program

In 1972 the Congress set forth a simple statement of policy: all publicly owned treatment facilities must comply with the secondary-or-better standard in order to achieve fishable and swimmable waters by 1983 (later extended to 1988). To help localities pay for treatment, the Congress set up a program of matching capital grants to be administered by the EPA and the states. Annual appropriations, which traditionally have equalled authorized levels, are divided among the states (for redistribution as grants to localities) by formula on the basis of state population and state share of remaining treatment "needs" as determined by the EPA.

The EPA and the states now share the administrative responsibilities for grants management and program oversight under EPA regulations. In addition, based on data submitted by the states, the EPA is responsible for estimating the remaining cost to construct or upgrade to secondary levels all publicly owned treatment plants. This estimate--EPA's "needs survey"--is published every two years, the most recent in 1984.

Most states manage their own water quality programs consistent with federal guidelines. The state programs set and monitor water quality standards, issue discharge permits to municipal and industrial facilities, and enforce permits. Each year the states must submit to the EPA a priority list of pending municipal treatment plant projects. 4/ Only those projects high on each state's priority list are eligible to receive grants from that state's annual allotment. About 40 states also provide some assistance to localities to help them meet the nonfederal share of projects. Historically, when the federal share was 75 percent, the state contribution ranged from 5 percent to 20 percent in either grants or loans. It is not clear whether states will increase their contributions as the federal share drops to 55 percent in 1985.

Local jurisdictions are responsible for planning the type, size, and timing of municipal wastewater treatment works; raising the local share of capital costs; and establishing user fee systems to pay all operating and maintenance costs. Many localities receive planning or engineering assistance from state agencies or private consultants. Larger municipalities generally have full-time professionals on staff who handle many of these

4. Each state may (and generally does) add its own ranking criteria, but all must consider, at a minimum, the severity of the pollution problem, the existing population affected, and the need for preservation of higher quality waters. Other factors that sometimes affect project rankings include readiness for construction or a locality's influence at the state level.

responsibilities. Once localities are placed near the top of state priority lists, they can expect to receive what amounts to open-ended federal grants for 55 percent of the cost of the construction project (or 75 percent for those projects begun before 1985). 5/

Alternatives to EPA's Program

Not all localities--especially those low on state priority lists--can afford to wait for EPA grants. Confronted with a federal statutory mandate to comply with secondary-or-better treatment by July 1988, some municipalities may have to seek alternative financial arrangements. Others may have local incentives to build improved treatment works without EPA assistance. Local water quality problems, such as failing individual septic tanks or polluted recreation areas, are frequently serious enough to force local officials to seek immediate improvements rather than wait for an EPA grant. In addition, where treatment or collection systems are operating at capacity, only larger, improved facilities will allow new hook-ups. In some instances, capacity problems have led to moratoriums on sewer construction, effectively halting municipal and industrial growth. Finally, a community may proceed without EPA financing (or, indeed, build a larger system than EPA will pay for) in order to attract industrial development, which brings increased tax revenue and jobs to the community.

Without EPA grants, communities must assume more financial responsibilities, often relying on state grants or loans, if available; other sources of federal aid--Farmers Home Administration grants, for example; or, most often, traditional or innovative local financing. State funds are limited and non-EPA federal funds amount to only about 10 percent of all federal money available for wastewater treatment, about $300 million in outlays under the Administration's 1986 budget proposal (see Table 1). Thus, localities must resort to traditional sources of local financing, such as the tax-exempt municipal bond market, or to more innovative sources. Emerging innovative alternatives include privatization (private ownership and operation on a fee-for-service basis), nondebt financing (special tax assessments or extra connection charges to fund system expansions), and concessions from private developers. The latter option is generally restricted to small developments that add a small service area to a larger system.

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5. Grants appear open-ended to localities insofar as annual state allocations cover the federal portion of their project's costs. There are, however, cost-effectiveness guidelines and value engineering tests that help control the cost of locally planned projects. Of course, too elaborate a proposal could cause unacceptably high local sewer fees--another check on local costs.

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POLICY ISSUES

The nation is clearly committed to the pursuit of clean water, but estimates of the cost to achieve it are high, raising questions of who should pay, how much, and how fast? Basic to these issues is an understanding of EPA's estimate of investment "needs" considered necessary to clean up all municipal wastewaters.

TABLE 1. FEDERAL SPENDING FOR WASTEWATER TREATMENT, FISCAL YEARS 1984-1986 (In millions of current dollars)

			1986 (Projected)			
			Current Policy		Administration Proposal	
Program	1984 OT	1985 (Estimated) OT	BA	OT	BA	OT
EPA Construction Grants	2,623	2,742	2,479	2,582	2,400	2,581
HUD Community Development Block Grants a/	200	204	182	204	164	184
FmHA Rural Waste						
Disposal Grants	36	80	48	74	12	86
Loans b/	108	106	84	171	25	25
Economic Development Administration Grants	40	14	14	14	0	12
Total	3,007	3,146	2,807	3,045	2,601	2,888

SOURCE: Congressional Budget Office.

NOTE: OT = outlays; BA = budget authority.

a. HUD = U.S. Department of Housing and Urban Development.

b. FmHA = Farmers Home Administration. Loan outlays under this program are equivalent to the federal subsidy to loan recipients. Thus, outlays understate actual loan disbursements.

The EPA Estimate of Wastewater Treatment Needs

The most recent EPA needs survey, conducted in 1984 on the basis of state data, estimated the remaining cost to provide every municipality with wastewater conveyance and treatment works capable of meeting the federal standard for the quality of wastewater discharges. 6/ Needs that qualify for federal grants are termed "eligible needs." These include secondary treatment plants; more advanced, tertiary plants; infiltration and inflow corrections; and new interceptor sewers. Those that are required to achieve clean water but that do not qualify for federal grants are called "ineligible needs." The EPA estimated that eligible needs would total some $53.1 billion and ineligible needs would add another $56 billion. To meet all eligible needs under current policy, the EPA estimated that the federal government would have to spend about $36 billion, or about $2.1 billion a year between 1984 and the year 2000. To match these expenditures, states and local governments would have to spend about $17 billion or about $1.0 billion a year over the same period. These implied spending levels are roughly comparable to current outlays (see Table 1, line 1).

Because the 1981 amendments made some facilities ineligible by limiting the types of projects that EPA would fund and by restricitng funding to the needs of current populations, states and local governments now bear a larger burden in meeting ineligible needs. These ineligible needs include building collectors (or large sewers), remedying combined sewer overflow problems (from combined storm and sanitary sewer systems), repairing existing sewer lines, and expanding to serve future populations. Thus, while the statutory requirement still exists to achieve clean water by building treatment facilities, the 1981 amendments shifted much of the financial burden of complying with this mandate from the federal government to the states and local jurisdictions. To meet their share of eligible needs and EPA's estimate of ineligible needs, combined state and local outlays, currently estimated at about $2.8 billion a year, would have to increase by 54 percent to $4.3 billion a year beginning in 1985 and continuing through the year 2000.

Purposes and Problems of Federal Subsidies

The Congress decided to subsidize local construction of wastewater treatment plants for two reasons. Federal participation in funding local facilities was deemed necessary in order to achieve the mandated national goal of

6. Environmental Protection Agency, *Needs Survey Report to Congress* (prepared by Roy F. Weston, Inc. and the EPA's Office of Municipal Pollution Control, February 1985).

clean water. To ensure local compliance with this expensive mandate, the Congress offered the incentive of large federal grants.

Construction of treatment plants not only would solve local water quality problems, but also would result in benefits--cleaner water--that would flow downstream to other communities which had not helped pay for the upstream facilities. Earlier attempts to control water quality problems demonstrated that few if any communities were willing to pay for secondary or more advanced treatment facilities that solved more than local problems. A second purpose of capital subsidies, therefore, was to compensate local taxpayers--the primary users of treatment plants--for these external benefits that they could not capture under ordinary circumstances.

But federal subsidies have drawbacks as well. The principal disadvantage of a generous federal capital subsidy is that it provides little incentive to local decisionmakers to seek the most cost-effective solutions. A community that expects to pay only 5 cents to 25 cents on the dollar will have far fewer incentives to control plant costs than if it had to pay for the entire investment.[7] In fact, localities could use the subsidies to build excess capacity in the hope of promoting growth or attracting industrial development. The extravagent structures that capital subsidies can promote not only inflate federal expenses, but also can increase operating costs or cause treatment plants to perform poorly.[8] In the last instance, a federal subsidy aimed at achieving clean water could easily end up impeding this goal. At the very least, a low local cost share, which risks only limited local resources, reduces the incentive for rigorous local project oversight and generally reduces local concern for project costs.

Although the statutory requirement for secondary treatment or better does not specify the technologies that can be used to produce the required removal of pollutants, the federal standard was chosen initially on the basis of the efficiency of the best available technologies. Then engineers learned through experience that wastewater facility grant applications were more likely to be approved if relatively standard technologies were proposed. Thus the standard of secondary treatment or better--originally a performance standard--became closely linked to acceptable technologies, and blunted incentives to examine alternative technologies. Because engineers

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7. About 40 states pay a portion of the nonfederal share, often lowering the local share to less than 25 percent.

8. See General Accounting Office, *Costly Wastewater Treatment Plants Fail to Perform As Expected* (November 1980).

know that an activated sludge system, for example, will qualify for a federal grant, they might try to force this technology to fit local conditions. This could increase costs and reduce efficiency. Reduced demand for new and less costly technologies could also reduce private incentives to pursue research and development of innovative methods.

Finally, as recent estimates of needs have demonstrated, the federal wastewater grant program has created a system in which localities line up and wait for federal assistance. Because annual appropriations are limited and needs appear great, localities with low-priority projects could wait 10 years or more. While communities wait for federal subsidies, their wastewater discharges remain in violation of Clean Water Act mandates and the quality of local rivers and streams shows little or no improvement.

Decisions Facing the Congress in 1985

Funding authorizations for EPA's Construction Grant program expire in 1985. Thus, the Congress must once again address the issues of whether to extend the grant program, and if so, under what terms and at what funding level. The Administration's fiscal year 1986 budget proposal calls for $2.4 billion in grants in 1986, followed by a three-year phaseout of the program, with authorizations reduced to $1.8 billion in 1987, $1.2 billion in 1988, and $0.6 billion in 1989. Over this period, federal funds would be limited to completion of projects currently under way. In 1990 and thereafter, localities would be expected to pay the entire costs of building new facilities and expanding old ones to meet the needs of growing populations. The Administration suggests increased state financing and additional local borrowing in the bond market to meet the EPA estimate of some $92 billion in outstanding capital needs as of 1990 (down from $109 billion estimated in 1984 because of six years of expenditures).

Alternatives to the Administration's plan include the following:

- Current Policy. Continue the federal contribution of 55 percent for plant construction, subject to annual appropriations and distributed according to state priority lists.

- State Revolving Funds. Provide federal grants over a five-year period to help capitalize state revolving funds to finance future projects, which would replace the current project grant program.

- Innovative Permits and Relaxed Water Quality Standards. Continue current policy, but promote innovative permits that cut costs to municipalities. Also require fewer communities to meet strict national standards by allowing more ocean discharge waivers and relaxed water quality requirements in some streams.

In evaluating these options, the following concerns should be considered: the extent of the future federal financing role, the long-term ability of localities to finance wastewater investments on their own, the ability of any new program to achieve clean water goals rapidly, the efficiency of investments, and the program's flexibility to meet the needs of all sizes of communities in both urban and rural areas.

CHAPTER II

THE RELATIONSHIP BETWEEN LOCAL COST SHARE AND INVESTMENT EFFICIENCY--A STATISTICAL ANALYSIS

This chapter employs empirical evidence to demonstrate the relationship between levels of federal subsidization and local investment efficiency for wastewater treatement plants. All regression models used to draw inferences are presented and fully discussed in the appendix. The appendix also provides a reestimate of future capital demands for wastewater treatment plants under the shift from a 75 percent federal share of new construction projects to a 55 percent share, which takes effect this fiscal year.

ANALYSIS OF INVESTMENT EFFICIENCY

Perhaps the greatest problem embodied in the construction grants program has been its tendency to promote larger or more sophisticated treatment facilities than may have been necessary, with attendant higher costs. This, in turn, has inflated estimates of future needs and provided a basis to argue that continued and even expanded federal subsidies are appropriate. The Congress believed that these problems would be solved with the 1981 amendments to the Clean Water Act. The following analysis largely supports this assertion.

Although relatively few wastewater treatment plants have been built with local governments paying high shares of the costs, enough exist to examine the relationship between investment cost effectiveness--or investment efficiency--and the local share of capital or lifetime costs. Certainly other factors influence cost effectiveness, and they are included in the following statistical analysis to the degree that they are quantifiable. Other nonquantifiable, but no less important, factors affecting investment efficiency are examined in the case studies presented in the next chapter.

Measuring Investment Efficiency

Investment efficiency can be described as the level of output achieved per dollar invested in a given project. In the case of secondary treatment plants, investment efficiency is simply the total flow of wastewater treated to standard secondary levels divided by the present value of all costs necessary to build and operate a plant. 1/ Unit cost (dollars per 1,000 gallons treated), the inverse of investment efficiency, is frequently used by design engineers to illustrate the cost of a project to its potential users. Unit cost measures also are used as the measurements of investment efficiency throughout this study.

There are three types of unit cost measurements: capital, operating, and lifetime. Capital unit costs are the initial construction costs of the facility divided by the total volume of wastewater treated over the system's projected life. Operating unit costs are the costs of operating the facility over the systems projected life, discounted to present value, divided by the total flow through the facility. Lifetime unit costs are formed by adding unit capital and unit operating costs.

Discounting is a way to calculate, in today's dollars, the value of a future expenditure or future stream of annual expenditures--in this case, operating unit costs. The result is called present value. A future expenditure is discounted to its present value using the following formula:

$$\text{Present Value} = \text{Future Value} / (1+i)^n,$$

where n=the number of years between the present year and the year in which the expenditure is made, and i=the discount rate. The discount rate used in this report is 10 percent. Although there are many ways to interpret the discount rate, used in this analysis, it is simply the rate at which society is willing to exchange present consumption for consumption in the future. Thus, a discount rate of 10 percent means that society would be equally willing to purchase a good today for $1.00 or the same good one year from today for $1.10. 2/

1. A different definition, termed program efficiency, would measure the unit achievement of clean water per dollar invested. This definition would substitute, in the numerator, some measurement of total benefits derived from the construction and operation of the project. These would include at least such quantifiable benefits as the increased fisheries, recreation, and adjacent land values stemming from cleaner water. Unfortunately, these data are rarely available. Investment efficiency uses available data and in so doing, simplifies the calculation of program efficiency by assuming that all secondary treatment plants have the same pollutant removal efficiency and that all secondary discharges result in equivalent clean water benefits.

2. For a more complete discussion of establishing a social discount rate for public works, see Robert C. Lind, " A Primer on the Major Issues Relating to the Discount Rate for Evaluating National Energy Options," in *Discounting for Time and Risk in Energy Policy* (Washington, D.C.: Resources for the Future, 1982).

Presumably, local decisionmakers attempt to minimize the local costs of wastewater treatment investments; but it is not clear that lifetime unit cost is the primary decision variable they consider. A low local share of construction costs, for example, could provide an incentive for a community to spend more on treatment facilities than it otherwise would, perhaps in the hope of reducing future operating and maintenance costs. By examining lifetime, capital, and operating unit costs separately, it is possible to discern whether these measures of investment efficiency react differently to changes in the local cost share and other factors.

Factors Affecting Efficiency

Several factors influence investment efficiency: economies of scale, initial excess capacity, choice of technology, and local project management. The local cost share can influence both the choice of technology and the rigor with which local officials oversee their construction project.

Economies of scale allow larger facilities to reduce unit costs by using common components to treat a greater amount of wastewater. For example, one treatment tank handling 10 million gallons per day (mgd) is less expensive to build and operate than are 10 tanks handling one mgd each. Although reducing unit costs through economies of scale is well documented, many communities do not have an opportunity to join a larger, regional facility. Political or natural geographic boundaries can restrict the feasibility of a regional solution regardless of the potential savings. Other communities may purposely choose a small local plant over a larger regional one, fearing the rapid growth typically induced by such facilities.

The construction of initially ***unused, reserve capacity*** is sometimes necessary to accommodate anticipated growth in demand, based on reasonable population projections. But design capacity in excess of current needs also may be built to attract development, especially when the local share of capital costs is small. Thus, reserve capacity may or may not be the most efficient way to build treatment plants for growing populations.

Excess capacity, for whatever reason, adds to both capital and operating costs, which initial users of the system must pay. Higher unit costs for treatment will persist until actual flows approach the plant's design capacity. Although individual situations differ, one alternative to building reserve capacity that will not be used for 10 or 20 years is to plan for staged expansion. In this way, unit costs can be reduced by building only basic facilities at the outset, with allowances for incremental additions as growth demands. This design method assesses initial users more fairly and imposes growth-related costs on new population as the community expands.

The type of ***treatment technology*** chosen has a profound effect on both capital and operating costs. Technologies vary from low-cost alternatives such as facultative ponds and oxidation ditches, for simple secondary treatment to relatively costly and technology-intensive biological and chemical secondary treatment. But flow variations, pollutant removal requirements, project size, local geology, or weather can limit the choices of technologies available to a locality. For example, if the stream flow is low in a plant's receiving water, a higher quality effluent and more advanced treatment may be needed. Although some of these factors are beyond local control, flexibility in the choice of technology allows a locality to take advantage of significant savings in unit costs.

There is no substitute for ***rigorous local project oversight.*** The experience and involvement of local officials as well as their interest in cost control can be the most significant source of cost savings. Local concern for cost control results directly from the share of total project costs paid from local sources. Decisions left to a disinterested third party may not be made with cost savings in mind. For example, an engineer under contract to a municipality is not responsible for paying off the local bond issued to fund the plant construction. His objective is to design and build a facility in compliance with regulations that nets him a reasonable profit margin. Thus, unless instructed to do so by local officials, he would have no direct incentive to explore process modifications or alternatives to conventional technologies that would reduce costs.

Statistical Analysis

This analysis was designed to explore the relationship between the local cost share of wastewater treatment facilities and the efficiency of wastewater treatment investments. Multiple regression was carried out on data gathered from 68 facilities to test the effect of several independent variables, including local cost share, on unit costs of secondary treatment. Thus, only facilities employing secondary or advanced secondary processes were selected for analysis. In addition, the analysis focused on treatment plant costs; conveyance costs were not included because the cost of piping and pumping stations is more a function of local geography and land use than of local decisionmaking. Plants were selected in order to bracket a wide range in the variables of interest, including plant size, local cost share, and excess capacity. Treatment plant sizes ranged from 0.2 mgd to 50 mgd. Of the 68 localities surveyed, 51 communities participated in the EPA construction grant program and 17 did not. Treatment plant design and cost data were provided by local administrators or town engineers.

Lifetime local cost share was calculated as the percentage of total discounted lifetime costs (capital plus the present value of operating costs) paid by the locality. Local costs included the local share of capital costs eligible for federal grants, all ineligible capital costs, and operating costs. The typical EPA project with a 25 percent local capital share corresponds roughly to a 59 percent lifetime local cost share because of the effect of locally paid operating costs. Lifetime local cost shares in the sample ranged from 18 percent to 100 percent.

Lifetime unit costs--the primary measure of investment efficiency--were calculated by dividing total lifetime costs by total lifetime flow through the facility, expressed as 1983 dollars per 1,000 gallons treated. Lifetime unit costs in the sample range from $0.23 per thousand gallons to $3.86 per thousand gallons. The sample average lifetime cost is $1.01 per thousand gallons. Capital and operating unit costs, alternative ways to measure investment efficiency, were also calculated for each plant.

Reserve capacity was calculated as follows:

$$\text{percent reserve capacity} = \left\{\frac{\text{design flow - initial flow}}{\text{initial flow}}\right\} \times 100$$

Reserve capacity ranges from zero to 750 percent in the sample.

Construction costs for all facilities were converted to first quarter 1983 Kansas City/St. Joseph, Missouri dollars, using EPA cost indexes for small and large treatment facility construction.[3] Operating costs were inflated using historical real increases in operating unit costs (2 percent per year) plus an annual increase resulting from growth in sewage flow from startup to design capacity at year 20, the assumed project life. (The capacity flow at 20 years is called "design flow.")

The statistical analysis was undertaken in three stages. (See the appendix for a more complete discussion of the variables and regression results.) First, for the entire data set, changes in the dependent variables--each of the three measures of unit costs--were related to changes in the independent variables--lifetime local cost share, design flow, reserve capacity, treatment technology (conventional secondary treatment, or more expensive advanced secondary treatment), and a variable to identify EPA

3. Environmental Protection Agency, Office of Water Program Operations, Facility Requirements Division, *Construction Cost Indexes (First Quarter-Construction Year 1983)*.

versus non-EPA projects. This analysis showed general relationships evident in the data set as well as the relative effect of variations in each independent variable on variations in the dependent variables.

The data were then grouped into four flow categories--0.3 mgd to 0.5 mgd, 2.5 mgd to 3.1 mgd, 7.1 mgd to 8.3 mgd, and 20 mgd to 28 mgd--to avoid the masking influence of economies of scale which are generally not subject to local control and which also hide the influence of overdesign.[4]/For each category, indepedent variables included local cost share, reserve capacity, treatment code, and EPA code (design flow was dropped). All three measures of efficiency (unit costs), served as dependent variables. Statistical relationships between dependent and independent variables were then established.

Finally, the data were segmented by lifetime local cost-share quartile. This allowed an analysis of the effect of local cost share on unit costs within more narrow ranges of the cost-share variable. Such an analysis provides some guidance on the extent to which local cost share might reasonably be increased and still achieve the desired lowering of unit costs.

OVERVIEW OF RESULTS

Regressing the independent variables against each of the efficiency measures for the entire data set revealed a statistically significant relationship between all independent variables and investment efficiency. Investment efficiency was found to increase (that is, lifetime unit costs decreased) with increases in local cost-share, increases in design flow, and decreases in reserve capacity. For the entire data set (n = 68), the independent variable, reserve capacity, was associated with or explained the greatest amount of variation in lifetime unit costs, followed by local cost-share and design flow. Local cost-share explained the greatest amount of variation in unit capital costs, followed by reserve capacity, design flow, and treatment code. Reserve capacity explained the greatest amount of variation in unit operating costs, followed by EPA code and local cost-share. Similar relationships were found for each of the sets of data grouped by size of project, although because of the small number of data points, the significance of some of the coefficients is in question.

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4. The range forming each group was determined by searching over increasingly larger groups of data points and selecting those groups within which variation in flows had no statistically significant influence on unit costs.

Nonetheless, there is strong statistical evidence that higher local cost shares are associated with increased investment efficiency (lower lifetime and capital unit costs). For a 10 mgd secondary treatment plant constructed under the EPA program with 100 percent reserve capacity, for example, a 10 percent increase in local cost share leads to a 6.8 percent decrease in lifetime unit costs, a 14 percent decrease in unit capital costs, and a 25 percent increase in unit operating costs. These findings support the observation that localities make capital investment decisions at the margin (the greater the local share of resources committed to the investment, the more efficienct the investment is likely to be). This largely stems from the dominant relationship between local cost share and capital costs, however. In fact, results indicate that increases in local cost share are associated with increases in operating unit costs. That operating unit costs appear to increase with higher local investment share could indicate that localities may be willing to substitute lower initial capital outlays for small future increases in operating expenses.

Whether or not a project received EPA funding had little effect on the measures of investment efficiency. The reason for this may be the relatively strong effect of local cost share on efficiency. EPA projects generally had much lower local cost shares than did non-EPA projects, and this effect was captured by the local cost share variable rather than the EPA code variable. 5/

Several other statistical relationships were also evident. First, reserve capacity and more advanced secondary treatment were associated with increased capital costs, thus higher unit costs. These results, though intuitive, imply that localities may be able to reduce unit costs by reconsidering initial overconstruction to meet growth projections and substituting staged expansion or examining less capital-intensive secondary treatment technologies. Second, larger facilities were able to achieve lower unit costs through the economies of scale often found in construction. While this result was also expected, it underscores the possibility of reducing unit costs by planning for regional treatment facilities. 6/

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5. The problem arising from having two variables measure, in part, the same factor is discussed in the appendix.

6. Regional treatment facilities are not always feasible. Experience has shown that there are institutional, economic, and geographical barriers to regional solutions. For details, see Richard D. Tabors, Michael H. Shapiro, and Peter P. Rogers, *Land Use and the Pipe: Planning for Sewerage*, (Lexington, Massachusetts: Lexington Books, 1976).

Rerunning the same regressions for the data disaggregated by lifetime local cost-share quartile reveals that the strength of the inverse relationship between lifetime local cost share and unit costs is not equal across the quartiles. For the first and second quartiles (lifetime local cost shares in the ranges of 0 percent to 47 percent and 48 percent to 56 percent, respectively), the evidence unambiguously supports the inverse relationship. All regressions and coefficients are significant, leading to the conclusion that up to about a 50 to 60 percent lifetime local share (or about 25-45 percent local capital cost share), increases in that variable are associated with more efficient investments (decreases in lifetime unit costs).

For lifetime local cost shares above 60 percent, however, the evidence supporting the inverse relationship is weak. In the third quartile (lifetime local cost share in the 57 percent to 69 percent range), the inverse relationship remains, but there is no statistical significance in the results. In the fourth quartile (greater than 70 percent lifetime local cost share), the inverse relationship is significant, but more than half the data points are grouped at the 100 percent local cost share level and the estimated relationship may be spurious. Other nonquantifiable variables, therefore, may play an even greater role in determining unit costs at very high levels of local cost shares.

STATISTICAL INFLUENCE VERSUS CAUSALITY

Design flow, local cost share, treatment technology, and reserve capacity have all been shown to influence investment efficiency in the expected ways. Generally, as local cost share or design flow increases, so does investment efficiency. As the percent of reserve capacity increases, investment efficiency decreases. But these statistical results do not imply causality. Specifically, while the basic engineering concept of economies of scale explains the influence of design flow on costs and the obvious costs of underutilized structures explain the influence of building reserve capacity, the mechanisms underlying the influence of local cost share on investment efficiency are less apparent.

One interpretation of the influence of local cost share is that, as the expected local cost share of the project grows, municipal or sewage agency officials make adjustments to reduce those costs, specifically the local contribution. If local costs are low, fewer cost-saving decisions are made. If a greater financial responsibility is placed on the municipality, expected sewer fees increase and citizens become more concerned, thus increasing the pressure on officials to reduce costs. Ultimately, more cost-saving decisions are made. Further, statistical evidence indicates that the greatest savings are captured by reducing the initial costs of a project, that is, capital, planning, and design costs. Future operating costs appear less important to local decisionmakers.

It is also possible that state priority lists (which determine the localities that will receive EPA grants) favor the more difficult and costly projects--those that are somehow constrained in their choice of project design, technology, or management. Those localities with the opportunity to pursue lower cost alternatives may have been excluded from the construction grants program because they are low on the priority list. This raises the second possible interpretation of the observed relationship between local cost share and lifetime unit costs: the prospect that those projects with high local cost shares and low unit costs are "self-selecting." Specifically, a high local cost share may be strongly correlated with low unit costs in the sample because municipalities may be willing to forego EPA's grant funds only if lower-cost local alternatives are available even without federal grants. If this were the case, then it would not be surprising that projects with high local cost shares had lower unit costs. According to this explanation, therefore, high local cost shares are correlated with low unit costs because of opportunity rather than the discipline imposed by high local cost shares themselves.

The difference between these two causal explanations is important. If cost shares and unit costs are correlated because of the discipline imposed by higher local costs, then the results of this analysis may be readily generalized to all wastewater treatment projects. But if projects with high local cost shares and low unit costs are self-selecting, that is a product of opportunity rather than discipline, then the reductions in costs associated with higher local cost shares may not occur if higher local cost shares are imposed on all communities.

Probably both explanations are valid. As the four case studies examined in the next chapter reveal, cost reductions result from both engineering opportunities that are peculiar to a specific site and from local vigilance and project oversight. But for whatever reason low-cost alternatives are used, they do exist and the willingness of localities to pursue them seems to be a function, at least in part, of the local share of project costs.

CHAPTER III

FOUR CASE STUDIES OF LOCAL EXPERIENCE IN CONSTRUCTING WASTEWATER TREATMENT FACILITIES

Unlike statistical analysis, case studies can reveal specific causal mechanisms. Four wastewater treatment projects were studied to determine the underlying causes which led to lower unit costs. Of the four projects, two participated in the EPA Construction Grants program and two did not. The four case studies are described briefly below:

- **Aroostook-Prestile Treatment District, Maine.** This regional treatment district abandoned the EPA Construction Grants program when a simpler treatment solution was found at one-third the estimated cost of the original project. Nonlocal funding for the municipal facility came from an Economic Development Administration grant for regional development and the state's own construction grants program.

- **Tolleson, Arizona.** This treatment facility was designed and built entirely with local funds to serve four high-growth communities and one high-strength industrial source--a meat packing plant that had a waste stream with highly concentrated pollutants. Project success required effective cost controls and timely construction.

- **Valley Forge Sewer Authority, Pennsylvania.** This facility was planned originally in the late 1950s with the expectation of a 30 percent and, later, a 50 percent federal grant. Program requirements then were generally less restrictive than they are under current policy. But this relatively complex project designed to serve eight neighboring communities was eventually resubmitted to the EPA and built under the 1972 act. Thus delays in approval and construction resulted in cost increases.

- **Wareham, Massachusetts.** This EPA project was constructed for a small community dependent on the technical and planning expertise of design and engineering consultants. Of particular importance in this project were the innovative solutions to a unique sludge disposal problem and the relatively rapid construction

> period made possible by concerned federal, state, and local officials. But the Wareham plant cost 50 percent more than comparable non-EPA projects.

As discussed in Chapter II, efficient investments or low unit costs can result from a number of factors. In the four projects studied here, the local share of construction costs unambiguously influenced two factors--the choice of treatment technology and the degree of engineering sophistication and overdesign. In two instances, high projected local costs resulted in project redesign using more efficient technologies and/or staged expansion rather than initial construction of unused excess capacity. Situational opportunity, on the other hand, allowed some communities, but not others, to adopt a regional wastewater treatment plan offering lower unit costs because of economies of scale. Special situations also resulted in reduced unit costs through site-specific opportunities, such as prepurchasing of construction materials or resale of treated wastewater for irrigation or industrial cooling. It is not at all clear, however, that the other two factors--local project oversight and project delays--could be attributed solely to either fiscal discipine or to opportunity. While all the case studies here showed that rigorous local project management and concern for cost control were essential, it appeared that cost savings were attributable to both fiscal discipline and situational opportunity.

OVERVIEW OF FINDINGS

The findings of all four case studies supported the theory that the extent of capital subsidies influences the choice of treatment technology, as noted in the statistical analysis. Capital subsidies also were found to affect both the degree of engineering sophistication and the initial reserve capacity of each plant. A low local cost share promoted greater facility sophistication than may have been necessary in two instances. High initial reserve capacity also inflated unit costs both because high fixed costs were spread over a small initial flow and because flows lower than the design capacity decreased operating efficiency.

Regional planning of projects and regional collection and treatment of wastes served to reduce capital unit costs. Combined planning for several smaller systems permitted the use of professional expertise that would not have been available permanently for individual localities. Larger regional plants allowed economies of scale and lower unit costs in these treatment facilities. But in only two of the case studies were the localities able to join larger regional facilities.

In both of the low-cost, non-EPA projects, local technical professionals were involved, to varying degrees, in project management and oversight. For the two projects partly funded by the EPA program, planning and project management were contracted out. Although these contracts were handled by experienced professionals, local officials felt that the contractors had less incentive to control costs than they would have as part of the municipal government. On the other hand, experienced contractors might have been necessary, in the view of local officials who handled the EPA projects, to ensure compliance with complicated federal grant regulations. Running a non-EPA project could be less complicated, affording local officials more opportunity for involvement and control.

Short project duration, averaging less than two years from planning to completion, was characteristic of the two lower-cost projects. In both cases, the treatment districts chose not to participate in EPA's program, partly because of anticipated delays in planning and construction. This would support the "self-selection" explanation. Project delays prolong the time without service; increase interim financing costs; and for revenue systems based on user fees, increase the period of expenditures and accrual of interest without compensating revenues.

Other factors contributing to lower unit costs were specific to individual projects and do not apply generally to all EPA or non-EPA projects. In one case, incorporation of cost-reduction incentives and facility performance requirements into the design and construction contracts shifted some of the burden of cost control from the municipality to the engineering and construction firms. In another, personnel of the local sewerage agency prepurchased most of the construction materials, thereby dramatically lowering materials cost. A third project accommodated future expansion by including integral structures (pump stands, internal piping, foundations, and so forth) in the original plan. This inclusion added minimally to the initial cost and is expected to obviate costly retrofitting in the future. In the same project, local operating costs were partially offset with revenues collected from the sale of treated effluent as a coolant or as irrigation water.

A summary of the pertinent engineering and financial data for the four case study facilities is presented in Table 2. These facilities also are compared with other similarly sized facilities in the 68-plant data base used in Chapter II. In the 1 million gallon per day to 3 million gallon per day flow range, the lifetime unit cost for the Aroostook-Prestile plant--recipient of nonlocal grants equal to 67 percent of capital costs--is $0.42 per 1,000 gallons, compared with $0.66 per 1,000 gallons for similar non-EPA projects and $0.98 per 1,000 gallons for comparable EPA projects. In the latter

TABLE 2. SUMMARY OF ENGINEERING AND FINANCIAL DATA FOR CASE STUDY PROJECTS

Project	EPA Funded	Local Cost Share (In percents)		Design Flow (In millions of gallons per day)	Completion Time (In months)	
		Capital	Lifetime		Of Project	Average of Similar EPA Projects
Aroostook-Prestile, Maine	No	33	53	1.71	14	36
Tolleson, Arizona	No	100	100	8.30	18	48
Valley Forge, Pennsylvania	Yes	25	59	8.00	72	48
Wareham, Massachusetts	Yes	10	55	2.87	23	36

(Continued)

category, for example, the 87 mgd Wareham plant--an EPA project with a 90 percent capital subsidy--has a lifetime unit cost of $1.00 per 1,000 gallons. In the 7 mgd to 10 mgd range, the non-EPA Tolleson project-- with a 100 percent local share--has a lifetime unit cost of $0.39 per 1,000 gallons, compared with an average lifetime unit cost of $0.30 per 1,000 gallons for non-EPA projects and $0.99 per 1,000 gallons for EPA projects. The 8 mgd Valley Forge project--recipient of 75 percent nonlocal construction grants--shows a lifetime unit cost of $1.01 per 1,000 gallons. Initial reserve capacities and construction periods of the non-EPA plants were substantially lower than those of the EPA projects.

AROOSTOOK-PRESTILE TREATMENT DISTRICT, CARIBOU, MAINE

Under the auspices of the Caribou Utilities District, the Aroostook-Prestile Treatment District (APTD) planned and oversaw construction of a new 1.71 mgd facility along the Aroostook River in rural northern Maine. The service area includes the city of Caribou and its industries, located in a small farm-

TABLE 2. (Continued)

Project	Percent Reserve Capacity: Of Project	Percent Reserve Capacity: Average of Similar EPA Projects	Percent Reserve Capacity: Average of Similar Non-EPA Projects	Lifetime Unit Cost (In 1983 dollars per 1,000 gallons): Of Project	Lifetime Unit Cost: Average of Similar EPA Projects	Lifetime Unit Cost: Average of Similar Non-EPA Projects
Aroostook-Prestile, Maine	22	105	81	0.42	0.98	0.66
Tolleson, Arizona	16	127	86	0.39	0.99	0.30
Valley Forge, Pennsylvania	220	127	86	1.01	0.99	0.30
Wareham, Massachusetss	220	127	86	1.01	0.99	0.30

SOURCE: Congressional Budget Office.

land valley. About 6,000 of the area's 9,950 residents are served by the conveyance and treatment works. Two potato processing plants in Caribou contribute half of the influent wastewater, as measured by strength, not volume. Between 1970 and 1980, the population of Caribou declined by nearly five percent and shifted to an older constituency. The median household income in 1980 was $13,000 per year, well below the annual national median of $17,700. Ten percent of the residents' incomes fell below the poverty level.[1/] The economic base of the area is largely potato farming and processing.

Project Details

Under the EPA Construction Grants program, a preliminary estimate of $6 million to build a rotating biological contactor treatment plant increased to $13.5 million by 1981 when detailed designs were completed. After the

1. U.S. Bureau of the Census, *County and City Data Book, 1983*.

project's ranking fell on Maine's priority list of proposed projects, local planners concluded that APTD would probably never receive federal assistance. Alternative financing mechanisms and project designs had to be considered if APTD was to meet the national mandate of secondary treatment without an EPA grant. A rough cost estimate of a simplified treatment process--facultative lagoons--convinced the district administrator that the estimated cost of $13.5 million for a technology-intensive treatment method could be cut by more than half and the new process could still meet discharge requirements. 2/ Interested design/contractor teams were screened and informed that costs as bid would be final. The lowest bid, $3.6 million (in 1983 dollars), won the contract for a local team of design engineers.

Both fiscal discipline motivated by initial high-cost estimates and the opportunity to explore lower-cost alternatives played a part in the planning of this facility. Certainly the high local costs for the original EPA plan led local officials to seek lower-cost alternatives. The availability of land and appropriate climate for facultative lagoons enabled the use of this technology, circumstances not necessarily present in all situations. Aroostook-Prestile might never have gone ahead on its own in the absence of low-cost alternatives.

The existing primary treatment plant was upgraded to serve as a grit chamber (to remove large particles) and to provide laboratory facilities. A three-mile connector line was installed, linking this facility to another site where three new facultative lagoons would provide secondary treatment. Over the course of project construction, only about $100,000 was spent to change the original plans, of which $20,000 was requested by the contractor and $80,000 by APTD. 3/

Financing Without an EPA Grant

A portion of an outstanding grant from the Economic Development Administration to the Northern Maine Regional Planning Commission provided $1.5 million for APTD. The State of Maine supplied a 25 percent capital grant ($0.9 million) and the remainder of the capital was contributed by the

2. A facultative lagoon is a large basin 8 to 16 ft deep in which wastewater digestion is facilitated by aeration units. Large lagoons are necessary because of the relatively slower reaction of the process compared with more conventional and more costly activated sludge treatment.

3. Generally, "change orders" are unforseen modifications of, or additions to, the design or construction of an ongoing project. Change orders generally raise project costs.

APTD. The local share of the $3.6 million capital cost ($1.2 million) was raised by a municipal revenue bond sold through the Maine bond bank.

User fees were designed to recover operating and maintenance costs and to retire the debt on the revenue bond. The new project raised the annual household user fee by about half, from $85 per year to $125 per year. At the time of start-up in 1983, the annual fee was slightly less than one percent of the median household income. In addition to the household user fee, industrial cost recovery contracts were drawn up for the two potato processors. User fee revenues are expected to be higher than the sum of debt retirement payments and annual O&M expenditures. The excess revenue will build a reserve fund intended to buffer household users from drastic fee hikes that would be necessary to cover annual costs should one or both of the potato processors shut down.

Costs and Controls

The APTD Caribou project is of interest because it included considerable nonlocal support, but no EPA funding. Of the total capital costs, the local utility district contributed $1.2 million, or 33 percent. The project's capital unit cost was 45 percent below comparable projects funded by the EPA. The estimated lifetime unit cost (including O&M) was almost 60 percent lower than comparable EPA projects. Most of the cost savings were attributable to the selection of a new, lower-cost treatment process--a shift prompted entirely by a relatively high local cost burden. Low unit costs were also attributable, in part, to only 22 percent reserve capacity, compared with an average of 81 percent reserve capacity for similarly sized non-EPA plants and 105 percent for comparable EPA plants.

The district administrator identified several reasons for the success of the project, aside from the choice of a low-cost technolgy: selection of local engineering and construction firms with well-established local reputations for good work, incorporation of cost/time reduction incentives and performance requirements into contracts, use of a design/build approach, maintenance of a professional association with contractors and consultants, and knowledgeable project oversight by all participants. [4]

4. The design/build strategy encourages engineering and construction teams to design, bid, and construct projects (subject to design and performance criteria of the client) in a cooperative venture. This shifts the burden of coordination costs from the client to the bidders.

Upon award of the contract the district administrator informed the contractors and consultants that he had two primary concerns: to complete the project as quickly as possible and to stay close to the budgeted cost. He felt that the likelihood of project success was improved because the involved personnel were known to one another and all knew the project in detail. Also, the contract contained certain performance requirements. For example, if, after a two-year audit, total plant costs exceeded estimates, the final payment would be withheld pending a review of the reasons for overruns. A design/build approach permitted flexibility to adjust planning and construction methods to the specific conditions of the project. Its success was credited with minimizing the time and money spent on client/contractor coordination and enabling mid-project changes without incurring large increases in costs. Finally, the district administrator felt that selection of a local firm increased the pressure to fulfill their contractual obligations.

A relatively short period for project design and construction reduced interim financing costs. The APTD project took 14 months to complete compared with an average of 36 months for comparable EPA projects. Also, debt retirement began sooner, as user fee revenues became available sooner. No capital/O&M cost trade-off occurred; the design with the lowest capital cost also produced the smallest operating and maintenance costs.

In summary, the final capital cost of the facility was extremely low and not appreciably different from the initial estimates. Preliminary information collected since the plant began operation in November 1983 indicates that anticipated plant performance and O&M costs have been maintained.

TOLLESON REGIONAL FACILITY, TOLLESON, ARIZONA

The Tolleson wastewater treatment facility is an 8.3 mgd, locally financed regional facility serving four residential communities near Phoenix--Tolleson, Peoria, Sun City, and Youngtown--and a large meat packing plant with high-strength waste. The permanent population in the service area is 65,000, most of whom are connected to sewer lines. Youngtown is the smallest community with 2,300 residents; Sun City the largest with 44,000. The population of Peoria and Sun City more than doubled between 1970 and 1980, and all four towns expect continued growth. The percentage of population over 64 years of age in the last two retirement communities is high--20 percent and 70 percent, respectively. In 1980 median household income ranged from $7,300 per year in Sun City to $15,300 in Peoria.[5] Because many of the retirees live on fixed incomes or in households with few income earners, they were particularly sensitive to utility price increases.

Project Details

In the late 1970s, local planners proposed a regional treatment facility in Tolleson to serve several adjacent communities. This plan was part of the normal water quality planning process that many communities participated in under Section 208 of the 1972 amendments.[6] In the course of the study, interested localities were informed of the potential cost savings of a regional solution. Extremely rapid regional growth necessitated that the facility be built quickly. These planning considerations prompted the participants to proceed without EPA funding, thus avoiding the delays associated with other EPA projects.

Aware of the local population's limited ability to pay high sewer fees, Tolleson officials sought a less expensive treatment process than that in operation and one that would defray the cost of treating their high-strength industrial source (20 times as concentrated as municipal sewage). They were particularly interested in seeing the regional project come to fruition because increased removal efficiency would be possible at reasonable costs by diluting the high-strength industrial waste stream with the combined flows of the region's domestic sewage. Officials finally selected conventional primary treatment (solids removal), followed by biological treatment in biotowers.[7] Tolleson's experience confirms the relationship between a high local cost share (100 percent in this case) and the fiscal discipline imposed by involved local officials who seek lower-cost solutions. On the other hand, these officials had the opportunity to join a regional treatment system, an option not necessarily available to all communities.

5. This compares with a national household median income of $17,700. See U.S. Bureau of the Census, *County and City Data Book, 1983*.

6. Section 208 established areawide planning agencies "for the purpose of encouraging and facilitating the development and implementation of areawide waste treatment management plans . . . ." Such plans were to integrate all of the point source (end-of-pipe) and nonpoint source (runoff from urban and rural lands) water quality management needs into an overall areawide plan.

7. The biotower technology is essentially a modified aerated trickling filter process using a plastic rather than a rock medium. Wastewater is pumped slowly over a plastic medium on which bacteria have grown. The bacteria degrade the organic matter in raw sewage.

Tolleson's plant superintendent and other local personnel were integrally involved in most phases of the project, from developing the regional plan, to purchasing construction materials, to overseeing construction work. Although this helped lower costs by reducing the amount of work contracted out, it would not have been possible without the willingness of the design engineering firm to include local personnel in planning and oversight functions throughout the project.

In order to avoid higher costs from subcontractors purchasing materials separately, the Tolleson superintendent bought the necessary piping, filter media, pumps, and other construction materials ahead of time, so that all materials were on-site when construction began. Construction oversight responsibility was shared by the engineering firm and local personnel. Close planning coordination between local officials and the design engineer as well as prepurchasing materials shortened the time from bid date to project completion to 18 months.

Project Financing Without Federal Funds

Capital costs were apportioned to each community according to its anticipated average contribution of sewage flow. Tolleson, the host community to the major industrial source, paid both the plant and the community share of capital costs. Funds were raised by general obligation bond sales in each community. Hence, all taxpayers in the 20 years following the project will pay for debt retirement. Capital costs averaged $230 per capita, or an average of about $18 per person per year financed over 20 years. [8]

Each community was assessed an O&M sewer surcharge based on metered flow. (Tolleson's industry also pays a share of total O&M costs based on its contribution to total treated flow.) After some experience in operation, it appears that the average household fee of $2.50 per month is much too low to generate sufficient operating revenues. (As noted in Chapter I, O&M costs have risen more rapidly than inflation in recent years.) The estimated annual cost of treatment (debt retirement plus O&M) is now calculated to be $55 per household, or less than one percent of the lowest median household income.

8. This estimate assumes an initial service population of 65,000, a $15 million bond issued for 20 years at 10 percent interest, and a population growth rate of 5 percent per year.

Costs and Controls

The $15 million project (in 1981 dollars) was financed entirely with local general obligation bonds. Local planners believed that, by using local planning and project management, they could build a facility more cheaply and in far less time than was typical for federally funded projects. Results bore them out. Local cost controls helped achieve capital unit costs that were 54 percent lower than the average of six comparably sized EPA projects. Lifetime unit costs were about 60 percent lower than similar EPA-funded plants. The facility was planned and built in about half the time of comparable EPA projects.

Farseeing planners also developed a novel strategy to reuse treated wastewater effluent and designed the plant to accommodate staged capacity expansion in anticipation of rapid regional growth. Effluent is reused in two ways. Most is sold to a nuclear power generating station for use as cooling water. The remainder is provided as irrigation water to a sod farm leased out by the Tolleson project. The benefits of effluent reuse include reduced operating costs, conservation of high-quality water, agricultural use of nutrients in the wastewater, and reduced pollutant discharge to the ultimate receiving waters. Such a strategy may not be available to all communities, especially if industrial flows contribute heavily to the plant's total flow. But these site-specific benefits might never have been explored if local planners had not attempted to control expenses in the face of 100 percent local cost share.

Future capacity expansions at the Tolleson Plant should be far less costly than is typical because certain structural elements needed for expansion--for example, internal piping and pump stands--were constructed at the outset. An expansion project would entail only the installation of additional pumps and piping and the construction of another biotower. This staged expansion plan resulted in only 16 percent initial reserve capacity for the Tolleson plant, compared with an average of 86 percent for similarly sized non-EPA projects and 127 percent for similar EPA projects.

In summary, there were several reasons for the low project cost and rapid completion: involvement of knowledgeable local personnel, coordination with design engineers, prepurchase of construction materials, use of an efficient treatment process, revenues from selling treated effluent, and low reserve capacity through a staged expansion plan. Advanced designs like the biotower generally embody state-of-the-art improvements in pollutant removal performance as well as efficient use of electricity and chemicals, the highest cost components of O&M expenditures. Although capital costs for off-the-shelf technologies might have been lower, it was estimated that

O&M costs would be reduced with the biotower. Building elements needed for future capacity expansion during the original construction period should result in further savings when expansion is finally undertaken.

The region's high growth was a mixed blessing. High growth necessitated rapid construction and the flexibility to expand in the future. But expected growth in the service area also increased the marketability of locally issued bonds because of the region's enhanced ability to repay the debt as service connections, and thus sewer revenues, were expected to increase.

VALLEY FORGE SEWER AUTHORITY (VFSA), PHOENIXVILLE, PA

The Valley Forge wastewater treatment facility is an 8.0 mgd regional plant serving about 40,000 of the 65,000 residents in eight communities 20 miles northwest of Philadelphia, Pennsylvania. Water usage is largely residential; a single industrial office park, a small amount of light industry, and commercial use account for the remainder. As bedroom communities to metropolitan Philadelphia, the service area has experienced growth and development over the last decade, which is expected to continue for the next 10 to 20 years. Generally, the residents are wealthier than the nation as a whole. According to the 1980 census, the median household income of the participating municipalities ranged from the national median of $17,700 to $31,800 per year. 9/

Project Details

A growing number of septic system failures as well as planning estimates of future population growth prompted several of the area's larger localities to investigate the feasibility of constructing new conveyance and treatment works. A regional solution was chosen because of limited access to receiving waters (site limitations) and, more significantly, because of the expected savings in each community's total project cost share. In order to facilitate project assessment, each community received an estimate for household user charges to cover all project costs before detailed facility design was started. Approval was unanimous and design began.

Planning for the VFSA project began in the late 1950s under the Water Pollution Control Act of 1956, which offered 30 percent federal grants. Subsequent amendments in 1966 increased the federal share to 50 percent

9. U.S. Bureau of the Census, *County and City Data Book, 1983*.

for certain projects, among them VFSA. Although the major construction grants were awarded on December 29, 1972, five years elapsed before final EPA approval was received. After passage of the 1972 amendments, VFSA received federal and state grants equal to about 75 percent of project capital costs.

A conventional activated sludge treatment process was selected by the engineering firm and approved by VFSA. Because the effluent standards promulgated by the regional EPA office were not yet final, the facility design included a pressure filtration unit to meet more stringent discharge requirements should they be imposed. The VFSA facility also included a computerized monitoring system, which was eventually disconnected because it was difficult to maintain and operate. This innovative but complicated system demonstrates the need to ensure that all parts of a treatment plant are compatible with the skills of local management personnel.

In the VFSA case, the eight communities clearly sought low costs by adopting the regional plan. Since, at the time the plan was initiated, the local share was 70 percent, there is reasonable evidence to conclude that fiscal discipline played a role in early planning decisions. As the project spanned changes in the federal program and as the local share fell to 25 percent, the project design became more costly and more sophisticated--witness the unused computer. In addition, the VFSA fell victim to a moving regulatory target and added extra equipment that ultimately proved unnecessary. The 25 percent local share may have influenced these decisions.

Financing Through the Construction Grants Program

After the size of the facility was determined, each municipality was responsible for supplying enough funds to cover its share of the local construction and contingency costs. The total local share--about $4.0 million (in 1975 dollars)--was raised through sales of guaranteed revenue bonds by the eight municipal participants. Three of the localities combined to sell a single issue for their collective share and the remaining five issued bonds individually. Because all the localities were experienced in the bond market and found it an easy way to raise capital, they did not consider alternative financing methods. Nor did they try to include the sources of industrial wastewater in the capital financing scheme because the industrial flow was minimal. As did individual users, industrial sources paid user fees to their communities to cover their portion of capital costs.

The Valley Forge authority planned to cover operating, maintenance, and repair expenditures with revenues from two sources: municipal user fees and state support for O&M. Each municipality was required to pay for its share of plant capacity. Most municipalities chose to apportion this cost as a user fee. The state also provides an annual O&M subsidy equal to 2 percent of the local share of project construction costs. 10/

Once in operation, however, actual revenues from the user fee system were lower than expected because of slower than projected growth in the service area. To meet this shortfall, two other sources of revenue were used: investment earnings on retained capital and profits from commercial operation of a septic dump station, designed to accept the service area's remaining septic waste.

The current average user fee is $275 per household annually, which is applied towards both annual O&M costs and capital debt retirement. Annual user charges range from 0.7 percent to 1.3 percent of the median household income of the participating communities.

Costs and Controls

Unit costs for the VFSA project were representative of comparably sized EPA projects, but greater than comparable locally financed projects. Lifetime unit costs--about $1.00 per 1,000 gallons--are roughly three times those of comparably sized locally financed projects. The project's capital unit costs--about $0.47 per 1,000 gallons--are about one quarter lower than the average of seven comparable EPA projects.

The federal subsidy probably promoted the selection of relatively costly technologies without any complementary savings in O&M expenditures. Because O&M expenditures are future outlays, the true cost of O&M is often not realized by planners who direct much of their attention to capital decisions. In addition, both the computer monitoring system and the pressure filtration unit were expensive additions that ultimately proved to be unnecessary. Even though the VFSA was satisfied with the project and its performance, it acknowledge that, in retrospect, the EPA Construction Grants program could be improved.

The VFSA found several reasons for the delays and increased costs incurred by participation in the Construction Grants program. Specifically, delays partly stemmed from the inexperience of VFSA consultants in the

10. These funds are provided under State of Pennsylvania Act 339 (Public Law-1217, August 20, 1953).

preparation of the Environmental Impact Statement and from review of the statement by the EPA. Higher costs were attributed to inclusion of the pressure filtration unit and the computer monitoring system.

Finally, as with any major construction project, delays were costly. In all, the VFSA project took about six years to complete. Resubmittal of the project under the 1972 amendments and construction delays because of confusion over treatment requirements extended the period in which the municipalities paid interim financing costs without the benefits or revenues of an operational water pollution control facility. In this case, increased costs resulting from changing statutory and regulatory requirements were beyond the control of local officials.

WAREHAM, MASSACHUSETTS

The town of Wareham, located at the head of Buzzards Bay, owns and operates a 2.87 mgd advanced secondary treatment facility, the result of extensive modifications of an existing facility. The improvements permit handling of the sewage and septage of both the permanent population of 18,500 and the summer population of 48,000. 11/ The town's permanent population increased by 61 percent between 1970 and 1980. Tourism, commercial business, service industries, and cranberry farming make up the area's economic base. Wareham's permanent household income is about 25 percent less than the national median, with 13 percent of all households below the poverty level. 12/

Project Details

Wareham's original treatment facility was built in 1970 to accommodate wastewater from the residences and businesses that were connected to sewer lines. At that time, three-quarters of the town used on-site septic tanks, and Wareham disposed of septage waste through a simple technology --lagoon impoundment with seasonal effluent discharge into the Agawam River.

11. Septage refers to the solids that are retained in on-site septic system settling tanks. To prevent clogging, septage must be pumped out periodically and disposed of offsite.

12. U.S. Bureau of the Census, *County and City Data Book, 1983*.

The lagoon system did not meet the state's discharge requirements, however, and its temporary operating permit was nearing expiration. In addition, townspeople complained about odors from both the lagoon and treatment plant. Septage from several surrounding communities as well as from Wareham's residents needed more treatment, for which the most likely solution was to use the town's existing plant. Additional hauled septage, however, would exacerbate the already serious sludge dewatering and odor problems at the plant's sludge drying beds.

Capital improvements at the plant enabled all septage to be treated along with flows from sewer lines. Modifications included a septage discharge station, a mechanical dewatering process (vacuum filters), and effluent perculation beds. Enough excess capacity remained to treat the added flows of newly sewered sources and all hauled septage. On a volume basis, the plant operates at about 42 percent of capacity during peak flow months and about 25 percent of capacity the rest of the year. The addition of vacuum filters and construction of sand percolation beds along the Agawam River resulted in dramatic improvements in effluent quality. After plant improvements, the quality of the effluent reaching the Agawam river was two-thirds better than the federal standard. The septage lagoons and sludge drying beds were subsequently shut down and odor complaints from nearby residents ceased.

Like many communities of its size, Wareham does not employ a permanent technical staff to carry out sophisticated planning and financing of its public works projects. Instead, these tasks are often contracted out to the same firm that handles design, engineering, and construction work. In Wareham's case, the town's design engineering firm was responsible for project design, applications for grant reimbursement, financing logistics, subcontracting, and billing. Although this relieved municipal management of project-related work, a large measure of project oversight was sacrificed. In the opinion of town officials, the dependence on consultants' judgment contributed to the problems arising from the 1970 project: costly overdesign in anticipation of future needs and inappropriate separation and faulty design of the septage and sewage treatment projects.

While capital-intensive remedies, such as those used in Wareham, tend to be more costly than proper design and construction in the first place, state and EPA cooperation helped reduce interim financing costs by accelerating project approval and reimbursements. Because the project design called for "innovative/alternative" (I/A) technology, it may have attracted more attention than usual at the review level, thus ensuring prompt turnaround times.

Financing Through EPA's Construction Grants Program

Wareham officials and engineering consultants felt that the project would not have been financially possible without EPA's support. Both parties were satisfied with their participation in the program. Of the total $3.9 million capital costs (in 1979 dollars), the EPA Construction Grant program provided $3.2 million (82 percent) and the Commonwealth of Massachusetts added a grant of $431,000 (11 percent). The local share--about $287,000 (7 percent of capital costs)--was raised by a general obligation bond sale to be repaid through local taxes. Because the local capital share was so low, repayment of local debt amounted only to about $2.50 per household per year. As all taxpayers paid equally for the improvements used primarily by sewered customers, septic-system households, in effect, subsidized services for other citizens within the community.

It was intended that all O&M costs were to be recovered by user fees, and this has proved to be the case. Prior to the current project, the annual user fee was approximately $100 per sewered household. This fee did not change appreciably. However, septage customers, who had previously paid private septage haulers a flat fee of $25 per load bore a fee increase of 60 percent following modifications to the facility. Total wastewater user fees amounted to 0.75 percent of the median income for the sewered population and less than 0.4 percent of the median income for the unsewered population.

Costs and Controls

It appears that the unusually low local cost share at Wareham provided little, if any, incentive to seek out low-cost solutions to their wastewater treatment problems. Instead, local, state, and even federal officials seemed to be satisfied with the technology choices and integral role of contractors. The type of problem experienced by the town, however, may have limited the technological choices. Thus it appears that low local costs obviated the need for fiscal discipline but also that the uniqueness of the project attracted state and federal attention that encouraged the development of appropriate and cost-effective technology.

As a participant in the Construction Grants program, the Wareham improvement project was subject to the program's guidance and regulations. But the town also enjoyed a 93 percent combined state and federal capital subsidy that resulted in the selection of a more costly solution than comparably sized non-EPA projects. The project's lifetime unit cost is $1.00 per

1,000 gallons--about average for comparable EPA projects, but 50 percent greater than similar non-EPA projects. The capital unit cost--$0.50 per 1,000 gallons--is 13 percent lower than comparable EPA projects.

Most unusual were the rather sophisticated modifications that the town obtained with very low local capital outlays. This occurred because virtually all project costs (99.5 percent) were considered eligible for grants with higher than normal federal and state subsidies for the innovative/alternative technology. Because the project included the I/A technology of septage handling facilities, portions of the project qualified for an 85 percent federal grant rather than the customary 75 percent grant. The costs of land acquisition, ineligible under EPA's program, were avoided as all improvements were carried out at the existing treatment plant site.

EPA cooperation was cited as crucial to rapid project approval and short reimbursement turnaround time. This attention may have occurred because the regional construction grants administrator wanted the innovative septage handling facility completed quickly to serve as a demonstration project in his district.

Wareham's Department of Water Pollution Control now treats all wastes at advanced secondary levels. The facility complies with state discharge requirements, treats septage, and maintains excess capacity for future growth.

CHAPTER IV

POLICY OPTIONS

The purpose of EPA's Construction Grants program is best understood in terms of the overriding objective of the Clean Water Act: to restore and maintain the chemical, physical, and biological integrity of the nation's waters. One major component of the national program to achieve this goal is federal assistance to all publicly owned wastewater treatment plants to help them remove harmful pollutants from their discharges into waterways. With only about half of all plants now upgraded to produce the required quality of discharged wastewater, the Congress is reconsidering EPA's program. Current legislative proposals deemphasize federal aid and impose new financial and administrative responsibilities on state and local governments. In order to preserve the objective of the Clean Water Act, however, any such reorientation should address the following concerns:

- How rapidly will the most needed facilities be built?
- Is local financial self-sufficiency promoted, ensuring future sources of capital without federal aid?
- To what degree will investment efficiency characterize future construction of wastewater treatment plants?
- Is equitable treatment of low-income or rural communities considered?
- Are new institutions or administrative arrangements established for a smooth transition?

This chapter analyzes four options that would reorient EPA Construction Grants program, taking into account the emerging Congressional goals and concerns noted above. These options include:

- **Current Policy**. Continue federal grants of 55 percent for capital costs, subject to annual appropriations and distributed according to state priority lists.

- **Four-Year Phase-Out.** Essentially as proposed in the Administration's 1986 budget, federal grants would be restricted to on-going projects and would no longer be available after fiscal year 1989.

- **State Revolving Funds.** Over a five-year period, federal and state contributions would help capitalize state revolving funds to finance future projects, replacing the current project grant program.

- **Current Policy with Regulatory Reform.** Fewer communities would be required to meet strict national standards, with more ocean discharge waivers, relaxed discharge standards or water quality requirements in some streams, and greater use of innovative permits.

CONTINUE CURRENT POLICY

With a continuation of current policy, the Congress would reauthorize the provisions of the Clean Water Act that deal with federal wastewater treatment grants. Specifically, the Congress would reauthorize annual appropriations of $2.4 billion for distribution to localities, either as 75 percent project grants (for projects already in the funding stream and new projects using innovative technologies) or as 55 percent project grants (for new projects). The current allocation formula would be preserved to distribute annual federal appropriations among the states on the basis of population and outstanding needs. Current policy would probably promote more efficient wastewater treatment investments once the 1981 amendments to the Clean Water Act take full effect in the early 1990s. While this course might be the simplest policy administratively, it would neither provide an assured long-term source of local financing nor guarantee construction of needed treatment facilities.

Efficiency

Although investment efficiency might be reduced because of the construction delays associated with any intergovernmental grant program, the changes made in 1981 should significantly enhance the cost effectiveness of new wastewater treatment investments. As indicated in the appendix to this study, the 1981 reduction in the federal grant share from 75 percent to 55 percent, effective in 1985, could result in construction cost savings ranging from 17 percent to almost 70 percent of current costs. On average, costs could be cut by about 30 percent, although the exact savings would vary with plant size (potential savings increase as plant size increases) and initial reserve capacity (potential savings decrease as initial reserve capacity increases).

But increases in the local cost share above the level legislated in the 1981 amendments would not appear to offer significant improvements in investment efficiency. Reduction in unit costs cannot be predicted confidently at local cost shares above this level.

The changes to current policy resulting from the 1981 amendments are expected to enhance investment efficiency in several other ways. The case studies presented in Chapter III indicated that local decisionmakers had a greater incentive to capture cost savings when localities paid more of the capital costs of their treatment facilities. Although some savings resulted from site-specific opportunities rather than these economic incentives, low capital costs were associated with treatment plant projects with relatively simple treatment technologies, limited construction of excess capacity, a high degree of involvement on the part of municipal personnel, rigorous local cost oversight, and short project duration. Higher-cost projects generally were disassociated from municipal government control, took longer to complete, involved more sophisticated technologies, and were often oversized.

The changes made in 1981 allow simpler technologies to qualify as the equivalent of secondary treatment. The Congress expanded the definition of secondary treatment by instructing the EPA to consider as equivalent secondary treatment "... such biological treatment facilities as oxidation ponds, lagoons and ditches, and trickling filters . . ." 1/ Government regulators and wastewater engineers alike previously had settled on a relatively costly technology--activated sludge--as the preferred method that would qualify for EPA grants. The EPA estimated that some 3,900 small communities (with flows less than 1 mgd) would save a total of about $2.2 billion as a result of the new equivalency language. 2/

The Aroostook-Prestile case study demonstrated that secondary effluent quality was achievable with low-cost facultative lagoons (large holding ponds in which natural physical and biological processes remove pollutants).

1. See Section 23 of 1981 amendments (P.L. 97-117, December 29, 1981).

2. See Kevin C. Flynn, "Secondary Treatment: Regulatory Reality," *Journal of the Water Pollution Control Federation*, 56:3 (March 1984), pp. 204-208.

The facility is currently meeting all discharge standards after reducing capital needs to just $3.6 million from the original estimate of $13.5 million under an EPA-approved project. Although such dramatic savings may not be available to every community, EPA grantees could not use the Aroostook solution without the newer, less restrictive interpretation of secondary treatment.

The amendments also disallowed federal funding of capacity beyond that needed for current populations. Communities may still build as much initial reserve capacity as they find technically necessary, however, as long as extra capacity is paid for locally. This provision could result in greater consideration of more cost-effective staged expansion plans at local expense rather than initial over-construction at federal expense.

Timeliness

The major drawback to continuing current policy is the length of time it will take to provide adequate wastewater treatment facilities. Under current policy, the EPA estimated in 1984 that the $53.1 billion in all outstanding eligible needs would require about $36 billion in federal outlays and about $17 billion in state and local outlays by the year 2000 (all in 1984 dollars). Needs, or expected future costs of building wastewater treatment plants, were based on actual unit costs experienced by past participants in the program. But these localities constructed plants with federal capital grants of 75 percent, which have now been reduced to 55 percent. The regression results presented in Chapter II, therefore, can be used to reestimate needs based on the reduced unit costs that the higher local share implies.

Capital unit costs were shown to be associated with size of the facility, percent of initial reserve capacity, and local cost share.3/ Simulating expected changes in capital costs from higher local cost shares results in estimated savings ranging from 17 percent to almost 70 percent (see Table 3). Using the distribution of facility sizes found in the EPA needs

3. The actual regression equation presented in the appendix is:

Capital Unit Cost = 1.3758 + .0015 Reserve Capacity -.0131 Local Cost Share -.0093 Design Flow + .1568 Treatment Code -.1691 EPA Code

Neglecting the effect of the last two dummy variables, capital unit cost may be reestimated as:

Capital Unit Cost = 1.1468 + .0014 Reserve Capacity -.0103 Local Cost Share -.0095 Design Flow survey (assuming for simplicity, that all plants have 100 percent reserve capacity) results in a nationwide savings of some 30 percent. This could reduce EPA's 1984 needs estimate for ***secondary*** treatment facilities from about $32.6 billion to $22.8 billion (in 1984 dollars). [4] Similar savings might be available in other needs categories--advanced tertiary treatment

TABLE 3. ESTIMATED REDUCTION IN CAPITAL UNIT COSTS OF NEW SECONDARY TREATMENT PLANTS UNDER A REDUCTION IN FEDERAL CAPITAL GRANTS FROM 75 PERCENT TO 55 PERCENT

Plant Design Flow (In mgd)	Initial Reserve Capacity (In percents)	Percent Reduction in Capital Unit Costs
0.1	50	22.2
	100	20.2
	200	17.2
0.5	50	22.4
	100	20.4
	200	17.3
1.0	50	22.5
	100	20.5
	200	17.4
10.0	50	25.7
	100	23.1
	200	19.2
50.0	50	69.4
	100	53.2
	200	36.4

SOURCE: Congressional Budget Office.

4. Note that these numbers represent costs only for secondary treatment plants, not all eligible costs.

plants or wastewater collection systems, for example--although it would be difficult to estimate their magnitude solely on the basis of the statistical analyses presented in this study. At the current $2.4 billion annual federal appropriations, therefore, it appears that eligible needs could be met by 2001. State and local governments, however, would have the sole responsibility for spending another $56 billion--the amount EPA estimates as necessary to meet ineligible needs--collector or large sewers, combined sewer overflow problems, and needs of future populations.

Considering current state and local spending levels, it appears likely that only a small portion of these ineligible needs would be met. In 1984, for example, state and local governments combined spent about $0.8 billion to match $2.4 billion in federal grants and an estimated $2.2 billion for other capital improvements to local wastewater systems, primarily to build large sewer lines. If EPA grants are continued through the year 2001 at $2.4 billion a year, state and local governments would have to spend about $1.1 billion a year to match them. Assuming state and local spending does not increase, this would leave about $1.9 billion a year for state and local spending on ineligible needs. At that rate, total municipal wastewater treatment needs would remain outstanding until 2015. Even if state and local spending were doubled, it would take at least 15 years to meet EPA's estimate of $108.9 billion in total municipal wastewater treatment needs.

Local Self-Sufficiency

Continuing current policy would contribute relatively little toward establishing long-term, financial self-sufficiency for localities. Until very recently, localities have relied almost exclusively on the tax exempt municipal bond market to raise the local share of wastewater treatment investments. Local capital needs were modest and local borrowing experienced relatively few constraints. The expansion of the bond market to meet future local borrowing needs is uncertain, however. This, in addition to volatile interest rates, crowding in the market, and increased local capital needs, has caused both states and local jurisdictions to begin to explore other financing alternatives. [5] But most of the emerging financing alternatives do not appear to address the long-term needs of future rehabilitation and expansion of existing treatment works. Instead, they serve the immediate shortfalls caused by reduced federal shares and lower federal appropriations levels.

5. See Environmental Protection Agency, *Study of the Future Federal Role in Municipal Wastewater Treatment: Report to the Administrator* (December 1984).

Nondebt local financing, privatization, and state assistance programs provide three good examples of financing alternatives. Nondebt financing--connection charges, special assessments, developer requirements, and the like--is appropriate only for rapidly expanding municipalities, and then only for a short period of time during expansion. More often than not, these sources of capital are used to defray operating shortfalls rather than to build a sinking fund for future capital investment. Despite the generally favorable view toward privatization, private financing and operation of wastewater facilities is still a new concept, with only a handfull of examples. The Deficit Reduction Act of 1984 limited the applicability of private financing and the prospect of additional changes in the tax code could prevent widespread acceptance of this financing technique. 6/ Though many states now offer some form of financial assistance to localities, only one state--California--has established a long-term, permanent revolving loan fund. 7/ About 40 states have relied on matching grants or temporary loan programs financed out of annual state appropriations. When state budget surpluses exist, as they now do, this form of assistance may be appropriate; in the long-run, however, annual funding programs are subject to fiscal shortfalls and are therefore unreliable.

Equitable Consideration of Disadvantaged Communities

The equity issue concerns whether current policy allows for the distribution of federal funds to all communities, regardless of their ability to meet local financing requirements. Specifically, rural communities or financially troubled urban municipalities might be less able to shoulder the burden of financing new facilities than growing, financially sound cities and towns. Current policy accounts for these concerns in two ways. First, under section 205(h) of the Clean Water Act, the EPA is required to set aside 4 percent of each year's allotment to states with "rural" communities. A rural state is defined as any state with at least 25 percent of its population living in rural areas--that is, communities of fewer than 50,000. In 1984, 34 states met the rural definition. In these states, federal funds were set aside

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6. The Deficit Reduction Act of 1984 restricted privatization arrangements to private ownership and operation of facilities. Municipalities could no longer lease and operate privately financed treatment facilities. The President's 1985 tax simplification proposal (and indeed, other proposals) could further limit the tax-related incentives for privatization by extending depreciation periods, limiting investment tax credits, and disallowing tax-exempt municipal bond financing of privately owned wastewater treatment plants.

7. Three other states--Georgia, New Hampshire, and New Jersey--are planning to set up a revolving fund similar to the one in California. See Environmental Protection Agency, *Study of the Future Federal Role* (December 1984).

strictly for plant construction in small communities or in highly dispersed sections of larger communities. Without this set aside, such communities would not have received any federal aid in some instances, because they were low on state priority lists. Small communities within "urban" states do not receive this preference.

Second, current policy allows states to determine their own priorities for distributing remaining state allocations and many, though not all, states target funds to communities with financing difficulties. EPA regulations, which set forth a range of factors that states must consider in ranking projects, stress such concerns as the severity of the pollution problem, the affected population, and the need to preserve high quality waters. The EPA, however, also allows the consideration of "other criteria," including the special needs of small and rural communities. Though there are no statistics summarizing the criteria used by each state to rank projects, information about the distribution of grants indicates that many more small communities have received federal grants (though in smaller amounts) than have large communities (see Table 4). Although part of this emphasis on small com-

TABLE 4. DISTRIBUTION OF EPA CONSTRUCTION GRANTS BY SIZE OF COMMUNITY, FISCAL YEARS 1973-1983

Community Size	Number of Communities Receiving Grants	Percent of Total Number	Obligations (In billions of current dollars)	Percent of Total Obligations
Under 3,500	11,059	47	3,865	11
3,501-10,000	4,412	19	4,280	12
10,001-50,000	4,558	19	8,226	23
50,001-125,000	1,470	6	5,359	15
Over 125,000	2,197	9	14,297	39
Total	23,696	100	36,027	100

SOURCE: Environmental Protection Agency.

munities derives from the greater proportion of small communities eligible for grants than large ones, many consider the state priority list system a major contributing factor.

Feasibility

No major administrative changes would be needed to continue current policy. Federal, state, and local roles have been well-established over the last 14 years and continuing current policy would cause no disruption of a relatively well-run intergovernmental program. A higher local share of the capital costs of wastewater treatment facilities, however, could result in higher sewer fees for some users. This, of course, would be offset to the extent that cost reductions were possible. Therefore, the estimates in this section are worst-case estimates. Actual increases in user fees would probably be lower than those cited here and could even be lower than those under 75 percent federal grants.

For example, an 8 million gallon per day project serving 50,000 people could cost about $15 million (see the Tolleson, Arizona case study, for example). If capital costs were amortized over 20 years at 12 percent and operating costs were about $50 per person per year, sewer fees under EPA's 75 percent grant program would average about $60 a year per person over the 20 year period. Under a 55 percent federal grant, sewer fees would rise to about $68, or a 13 percent increase. In contrast, if the project were funded entirely locally, sewer fees could increase to $90 per person per year. While an increase of this magnitude appears to be manageable for relatively well-off communities (those with an average annual household income above the $17,700 national median), it could be more burdensome for less affluent communities.

PHASE-OUT FEDERAL GRANTS BY 1990

The Administration has proposed elimination of EPA's Construction Grants program by fiscal year 1990. In 1986 authorizations would be identical to those in 1985--$2.4 billion. But they would decline over the next three years--to $1.8 billion in 1987, $1.2 billion in 1988, and $0.6 billion in 1989. During this period, federal funds would be limited to completing projects currently under way. After 1989, localities would be expected to pay the entire costs of building new facilities and expanding existing ones to meet effluent treatment standards.

The Administration's proposal might ultimately stimulate more efficient local investments, although the statistical basis for this result is uncertain. But it would not promote a secure, long-term source of locally available funds for plant expansions or improvements, thereby jeopardizing clean water goals. Moreover, the budgetary effects of a cessation of construction grants are unclear, since localities might substitute tax-free bonds for the federal share of construction costs, thus resulting in a loss of federal revenue.

While the Administration's proposal would require no new administrative changes at the federal level (except for normal program close-out procedures), states might find that their current institutions are unable to meet the administrative and financial demands of localities. Moreover, it is not at all clear that the Administration is correct in assuming that a four-year phase-out is long enough to complete all the on-going federally assisted projects. (Once obligated, typical project construction funds are spent over a four- to six-year period.)

Efficiency

The statistical evidence presented in Chapter II indicates that the efficiency of secondary wastewater treatment plant investments will increase as more local investment capital is contributed up-front. However, this relationship seems to hold only up to a local share of about 40 percent to 50 percent of treatment plant construction costs. Thus, 100 percent local financing probably would yield investments no more efficient than those financed with 45 percent local funds.

If federal project grants were eliminated and localities financed future wastewater treatment plants with tax-exempt bonds, direct federal outlays would fall, but federal tax expenditures--lost tax revenue from the tax-exempt bonds--would increase. The net effect would be lower federal costs in the aggregate (direct outlays plus tax expenditures), but the federal government would lose control over future limits on federal costs as municipal borrowing could increase. For example, a $15 million plant financed with a tax-exempt local bond would cost the federal government an estimated $6.5 million over 20 years (discounted at 10 percent) in lost tax revenue. This would be the total cost to the federal government since direct federal outlays would be zero. By comparison, if only the current 45 percent local share was financed with a local bond, federal tax revenue losses over 20 years would be $2.9 million. Adding the direct federal grant of $7.3 million (or $8.25 million for a 55 percent grant over four years, discounted to present value) would result in a federal cost of $10.2 million--

greater than the $6.5 million incurred under complete municipal bond financing.

Timeliness

If federal aid were eliminated after 1989, remaining capital needs, as estimated by the EPA, would total some $90 billion. More efficient local investing, brought about because of the 100 percent local share, might reduce this estimate to $84 billion in total remaining needs. At the 1984 rate of nonfederal capital spending--about $3.0 billion a year--meeting these needs would take 28 years, or until 2018. Even if state and local governments stepped up wastewater treatment spending to $4.8 billion a year (in 1984 dollars)--the most spent in any year (1972) by these governments--it would take until 2008 to meet remaining needs.

Local Self-Sufficiency

Eliminating federal aid by 1990 would shift long-run financing responsibilities to state and local governments. As of 1984, 40 states had established local financing assistance programs. But generally, they have provided only short-term aid, such as grants or loans from annual state appropriations or periodically issued state bonds. These sources are secure only so long as state budgets remain healthy. Long-term financing assistance--available despite annual fluctuations in state fiscal conditions--is relatively rare. In 1984, for example, only seven states operated bond banks (Arkansas, Maine, Minnesota, Montana, Nevada, New Hampshire, and Vermont) and only one operated a state revolving loan fund (California). Three more states have established such funds and plan to begin operations in 1985 (Georgia, New Hampshire, and New Jersey).

States are now searching for new sources of revenue to replace federal grants. Some states already are exploring new funding mechanisms, such as dedicated taxes and special set-asides. In Idaho, for example, inheritance and tobacco taxes are dedicated to treatment plant loans and grants. Mineral royalties in Wyoming and oil and gas revenues in California help fund the construction of local treatment plants. In 1984, 12 states began special studies to explore new sources of revenue to replace diminished federal grants (Arizona, Connecticut, Georgia, Iowa, Maine, Minnesota, Montana, New Jersey, New York, Pennsylvania, Virginia, and West Virginia). 8/

8. For details, see Environmental Protection Agency, *Study of the Future Federal Role* (December 1984).

Equitable Consideration of Disadvantaged Communities

Though the federal mandate for secondary treatment was never conditioned on the receipt of federal grants, withdrawing federal support now, after helping only half of all eligible municipalities build the required treatment works, could put an inequitable burden on the remaining localities. Because of economies of scale, residents of the smallest communities--accounting for 30 percent of remaining needs but just 15 percent of remaining population--would pay much more for new facilities than would those of the largest communities with 53 percent of outstanding needs and 68 percent of the remaining population. 9/ The relatively high burden on small and rural communities could discourage investment in treatment facilities, delaying the achievement of cleaner waterways.

Feasibility

In the absence of federal grants, localities probably would first rely on the municipal bond market to raise capital, and then on state programs (where they exist) and on emerging alternatives such as privatization. Aside from privatization, these mechanisms are familiar to most localities and would require no new institutions. A $2.4 billion a year expansion of the tax-exempt bond market (to compensate for the loss of federal grants) is well within yearly fluctuations in market activity in past years, but that alone is no guarantee that the market will meet the needs of all communities.

Those localities inexperienced in debt financing might require financial management or bonding assistance from the states before they can undertake this option. In addition, any changes to the tax-exempt status of locally issued debt could jeopardize the feasibility of 100 percent local financing. Privatization appears to hold long-term promise for some communities, but the tax-related uncertainty surrounding this technique could prevent widespread local acceptance in the short term.

In 1990 and thereafter, this option might cause small communities to attempt to save treatment costs by examining regional treatment plans more carefully. Economies of scale could offer lower unit costs, but regional facilities could cause other problems. In the early years of the Construction Grants program, regionalization was actively promoted as the most cost-effective way to provide secondary treatment to groups of communities. Indeed it generally was. By the late 1970s, however, planners'

9. See Environmental Protection Agency, Office of Municipal Pollution Control, *1984 Needs Survey to Congress* (February 1985).

attitudes changed somewhat. The undersirable and uncontrolled growth or sprawl induced by the availability of sewer service (long sewer lines underlying largely undeveloped rural areas) was seen as a major drawback to regional facilities. Also at about the same time, engineers and planners began to promote on-site or small community facilities employing land-based treatment (spraying partially treated wastewater on feed crop fields, for example) as cost-effective alternatives to regional plants. These site-specific solutions can be less expensive for rural communities while inhibiting unintended population growth. Although the absence of federal aid could induce communities to reexamine large regional facilities, communities could face difficult trade-offs between reducing costs and increasing the potential for growth.

STATE REVOLVING LOAN FUNDS

State revolving loan funds, capitalized with federal and state contributions, could provide a reliable, long-term financing mechanism and ensure the construction of a great number of needed treatment facilities in the short-term. These funds would promote local, self-sufficient financing of projects and create strong incentives for efficient decisionmaking since the loans would have to be repaid. This option would require new federal legislation to replace current project grants to localities with block grants to states. New legislation would also be required within each state to set up institutions to manage the program.

Method of Operation

Although capitalization rates and shares could vary, both the federal government and the participating state governments would make annual payments to state funds over a fixed period--perhaps five years. [10] The federal contribution would be phased in as current construction grants were phased out. Federal appropriations could be apportioned to the states using the current grant allotment formula. Each year, the funds would make loans to localities for all or part of the construction costs of wastewater treatment plants. Each state could choose its own loan terms and priorities for

10. Proposals in both the Senate (S. 1128) and the House (H.R. 8) call for state revolving loan funds. The Senate proposal would require a 15 percent state match to a total federal contribution of $8.4 billion from 1989 through 1994. Construction grants would be phased out between 1986 and 1990. The House proposal would require a 20 percent state match to a total federal contribution of $9.0 billion over the 1986-1994 period. The House proposal also would end federal grants after 1990.

distribution of loans. Both federal and state capitalization contributions would be repaid in 20 to 25 years.

Either of two types of capitalization could be used: unleveraged and leveraged. An unleveraged fund would simply lend combined state and federal contributions directly to localities. A leveraged fund would use the combined contributions as collateral for state bond sales, the proceeds from which would be lent to localities. While the former arrangement might require less state administration, the latter method would allow the fund to finance annually about twice the total value of the original capitalization, depending on the structure of the state bond issue. Because a leveraged fund could lend more money, it would also have more capital from loan repayments to use for subsequent relending. As the leveraged fund issued tax-exempt bonds, however, proportionately more of the program's cost would be transferred to the federal government in the form of lost tax revenue.

The characteristics of revolving loan funds can vary. For the purposes of this option, a baseline, or model, unleveraged fund is assumed to have the following characteristics:

- The federal and state governments contribute $2.4 billion a year each for five years (the current level of federal grant appropriations). The $2.4 billion state contribution is prorated equitably among the states.

- Loans are made to localities for 55 percent of project costs, to be repaid with 5 percent interest over 20 years.

- The funds repay both the federal and state capital contributions in years 20 through 25.

- Operations of state funds are assumed to begin in 1986.

Efficiency

This option offers only marginal improvements in local investment efficiency compared with current policy, but it would allow the federal government to phase out its financing responsibilities within five years. As the analysis presented earlier indicated, the switch from a 25 percent to 45 percent local share is expected to result in more efficient wastewater treatment investments. But the analysis also indicated that an even higher local share, as implied by 55 percent loans under this option compared with

55 percent federal grants under current policy, might not yield significantly greater gains in efficiency.

The revolving fund mechanism, operated by independent state authorities, does offer other advantages. For example, the fund would repay the original state and federal contributions within 25 years, as well as the interest on state contributions. Under current policy, neither federal nor state grants to localities are repaid. The fund would continue to accrue loan repayments that would then be available for relending, regardless of future federal or state budgetary pressures to cut funding. Thus, localities could plan for the most cost-effective single or staged expansion improvements, without pressure to overbuild today in case funds are no longer available tomorrow.

Timeliness

This option could enable more projects to be built in a shorter period of time than under current policy. The actual rate at which new investments were made would depend on loan terms, degree of leveraging, the capitalization rate, and whether or not the states helped capitalize the funds. For example, if the federal and state governments each contributed $4.0 billion a year for five years to unleveraged funds and 20-year loans were made at 5 percent interest for 55 percent of the construction costs, $100 billion would be available to build new treatment plants through the year 2000 (see Table 5). If instead, the fund were capitalized at the current level of federal outlays--contributions of $2.4 billion a year each by federal and state governments--with all other terms the same, new projects costing about $60 billion could be built by the year 2000. A completely leveraged fund--with both federal and state contributions used to secure bonds issued by the fund--could finance about $112 billion in new projects if it were capitalized by contributions of $2.4 billion a year for five years by the states and the federal government. In all the above variations, direct federal budget authorizations could be eliminated after the initial five-year capitalization period. (All dollar amounts are in current dollars.)

Local Self-Sufficiency

State revolving loan funds would set up a reliable source of development capital that would be available to localities for as long as the fund operated. Consider, for example, an unleveraged fund, capitalized with federal and state contributions of $2.4 billion a year each for five years. Using the model fund assumptions, some $45 billion in wastewater treatment projects could be financed within the first five years of the program; by the year 2000, some $60 billion in new projects could be financed. In that year, the fund would be receiving project repayments and would thus be able to make expansion or rehabilitation loans of about $2.3 billion. For as long as the fund operated, growing fund equity would allow an even larger sum to be lent each year for these purposes, reaching about $4.3 billion a year in 2010. Higher rates of capitalization would provide even greater long-term, financing capabilities, of course.

TABLE 5. DOLLAR VALUE OF NEW PROJECTS FINANCED THROUGH THE YEAR 2000 UNDER DIFFERENT ASSUMPTIONS ABOUT THE REVOLVING FUND (In billions of current dollars)

Fund Capitalization	Project Loans for 100 Percent of Construction Costs	Project Loans for 55 Percent of Construction Costs
Unleveraged		
Equal federal and state contributions		
$2.4 billion a year for five years	33	60
$4.0 billion a year for five years	55	100
Federal contributions only		
$2.4 billion a year for five years	28	51
$4.0 billion a year for five years	47	85
Leveraged a/ b/		
Equal federal and state contributions		
$2.4 billion a year for five years	62	112
$4.0 billion a year for five years	103	187
Federal contributions only		
$2.4 billion a year for five years	35	63
$4.0 billion a year for five years	58	105

a. The fund issues bonds each year for the first five years equal in face value to twice the total capital contributed to the fund. This ensures a minimum coverage ratio (annual income/annual debt service) of 1.5 throughout the life of the fund.

b. These estimates do not take into account transaction costs, interest during construction, or debt service reserves, which, on average, can account for 20 percent to 30 percent of bond proceeds.

Equitable Consideration of Disadvantaged Communities

While all states would be responsible for ensuring compliance with clean water standards, each state fund could offer loans at a wide range of terms, based on their localities' ability to pay. For example, loan terms that could be adjusted to reflect variations in local wealth include the percent of total costs covered by the loan, loan interest rates, payback periods, or grace periods.

Of course, as lending terms become more lenient, leveraging might be reduced and the amount of loan repayments would decrease, reducing the long-term lending potential of the fund. For example, a $4.0 billion fund balance used to make 55 percent loans would pay for about $7.3 billion worth of projects. The same balance used to make 85 percent loans would pay for only $4.7 billion worth of projects. Similarly, interest rates significantly affect the number of projects that can be funded, as illustrated in Table 6. For example, if the fund made loans at 10 percent interest instead of 5 percent, total projects financed in the first five years would increase by 9 percent from $45 billion to $49 billion. Long-term lending potential by the

TABLE 6. EFFECT OF INTEREST RATES ON FUNDING POTENTIAL (In billions of current dollars) a/

Loan Interest Rate	Projects Funded 1986-1990	Projects Funded Through 2000	Equity In Fund In 2000	Long-Term Annual Lending Activity 2000	Long-Term Annual Lending Activity 2010
2 b/	42.9	44.1	18.1	0.2	0.7
5	45.0	60.5	34.7	2.3	4.0
10	49.2	107.0	81.6	10.3	25.8
12	51.2	135.5	110.0	16.1	47.3

a. This table assumes an unleveraged fund capitalized by equal federal and state contributions of $2.4 billion a year for five years. Twenty-year loans are made for 55 percent of project costs at the indicated interest rates.

b. Repayments from loans bearing interest rates less than 2 percent would fail to cover the fund's debt service requirements.

year 2000 would also increase from $4.0 billion a year to nearly $26 billion a year, because of the higher repayments. Repayments from loans bearing interest rates less than about 2 percent would fail to cover the fund's debt service requirements, and would thus be inappropriate unless debt service terms were restructured.

Feasibility

Both federal and state legislation would be required before state revolving loan funds could be created. First, federal law would have to establish funding arrangements for the transition from federal grants to state funds. Currently some 2,000 treatment plants are in the federal funding pipeline. These plants might have to continue construction under current 55 percent project grants, while new construction would be subject to state funds. This approach is taken in current Senate and House versions of the Clean Water Act reauthorization--S. 1128 and H.R. 8, respectively.

Second, state legislation would be necessary to establish institutions to manage the loan funds. Although the exact institutional arrangements to accommodate the revolving funds could vary, some form of independent state authority would seem requisite to assure the continuity of funding. Since states would have to assume the financial responsibility for loan defaults, however, some states might be hesitant to create such authorities.

CURRENT POLICY WITH REGULATORY REFORM

Although this paper is principally concerned with the efficiency of investments in wastewater treatment facilities, these investments should also be considered in the context of EPA's total water quality program to achieve "fishable and swimmable" waterways. Therefore, this section considers regulatory strategies that would achieve this goal while promoting local efficiency under the current federal program.

Though regulatory reforms offer no new funding sources or financial management systems, they could obviate the need for some types of costly investments, allowing more efficient targeting of limited federal grants. Both relaxed standards and innovative permits might allow some localities to meet water quality standards at less cost. Specifically, the EPA could continue to encourage local applications for ocean discharges in place of secondary treatment. In 1981, the General Accounting Office (GAO) estimated that between $5 billion and $12 billion (in 1984 dollars) could be saved if coastal communities were allowed to use primary treatment and ocean discharges rather than secondary treatment.[11] The GAO estimate is probably high for a variety of reasons, but the net savings arising from this practice could still be sizable.

In addition, more innovative permitting practices might also save money in the long run.[12] Though applicable only for discharges into limited streams in which water quality standards cannot be met despite minimum federal discharge limitations, the following practices have been shown to reduce both capital and operating costs of municipal treatment facilities:[13]

- Seasonal Permits. Levels of pollutants in treated wastewater effluents (discharges) are allowed to vary according to the season. In summer, streamflows are low and temperatures are high, necessitating cleaner effluents than in winter when the reverse is true.

- Flow-Variable Permits. Similar to seasonal permits, these permits vary allowable levels of pollutants on a monthly or perhaps weekly basis in direct proportion to measured flow of receiving streams.

- Seasonal Standards. Water quality standards are varied to match stream uses during different seasons. In summer, high water quality is appropriate to support swimming, while in winter, noncontact recreation would require water of less pristine quality.

- Site-Specific Standards. Standards are adjusted to reflect ambient water quality conditions. To protect pristine waters, stringent water quality standards are set, but in naturally polluted streams not used for drinking or other high-quality uses, less stringent standards are more appropriate.

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11. See General Accounting Office, *Billions Could Be Saved Through Waivers for Coastal Wastewater Treatment Plants* (May 22, 1981).

12. For additional details, see Donna Downing and Stuart Sessions, *Innovative Water Quality-Base Permitting: A Policy Perspective*, presented at the 57th Annual Conference of the Water Pollution Control Federation, New Orleans (September/October 1984).

13. In some streams, natural pollution (transfer of organic material from adjacent marshland) or man-made pollution from nonpoint sources (pesticides or nutrients from farmer's fields) can so degrade water quality that cleaning up point-source discharges will not achieve stream water quality standards.

- o <u>Interplant Tradeable Discharge Permits</u>. Within a stream segment, minimum levels of wastewater treatment are not required of any particular plant. Instead a maximum level of pollutants is apportioned to all dischargers who trade among themselves the rights to discharge different levels.

- o <u>Point/NonPoint-Source Tradeable Permits</u>. Point-source dischargers may clean up a stream by installing nonpoint-source controls (erosion control or sedimentation basins) in lieu of more stringent point-source effluent controls.

- o <u>Permit Banking</u>. Dischargers receive "credit" for reducing the level of pollutants below that required by effluent standards. Credits may be used for future plant expansion or sold to other dischargers. Banking is often used in conjunction with permit trading.

The first four innovations--seasonal permits, flow-variable permits, seasonal standards, and site-specific standards--make greater use of the natural capacity of a body of water to purify conventional pollutants. The remaining three encourage more efficient allocation of a stream's total wasteload through trading mechanisms among multiple dischargers. Results of such innovations vary, but they usually provide net cost savings for dischargers, compliance with minimum effluent standards, and maintenance of water quality standards consistent with anticipated stream uses.

It has been estimated that a seasonal permit system in North Carolina, for example, would save about $2.9 million a year in waste treatment costs, mostly for municipal dischargers. [14] With flow-variable permits, the allowable limit of pollutants released to a stream is varied with the ability of the receiving stream to degrade wastes. For example, higher flows or lower temperatures allow natural degradation of more wastes.

Interplant permit trading allows several dischargers to work together in the following way. Several point-source dischargers (municipal treatment plants, for example), which use the same receiving water, are faced with meeting a common regulatory standard, but some plants in the group can treat their wastewaters at less cost than others. The group then devises a scheme for plants with high control costs to purchase additional discharge

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14. See Hargett and Seagraves, *Benefits and Costs of Seasonal Effluent Limits in North Carolina*, North Carolina Water Resources Research Institute, Raleigh, North Carolina (no date).

rights from the plants with low control costs, providing total stream water quality equal to the original standards but at less expense. 15/

Substituting nonpoint-source controls for point-source controls takes the innovative permitting and standards concepts one step further. Recent reports have estimated that a substantial portion of the remaining water quality problems in the nation stems from nonpoint sources. 16/ For example, nonpoint sources--runoff from farmland, feedlots, or urban areas--are now thought to contribute 50 percent of the total pollution load to U.S. lakes and rivers. 17/ Some 37 states report that they will be unable to achieve the goals of the Clean Water Act because of uncontrolled nonpoint-source problems. 18/ Controlling these pollution sources might be far less expensive and improve local water quality to a greater degree than additional treatment of municipal wastewater discharges. If nonpoint pollution is natural (tidal wash on and off a marsh, for example), there may be little opportunity to control it and secondary treatment standards might be relaxed. If the nonpoint-source pollution is man-made (run-off from a feed lot, for instance) trading municipal point-source controls for nonpoint-source controls might reduce the cost of the local treatment works and improve local water quality.

In Summitt County, Colorado, for example, Dillon Reservoir is protected from pollution with settling ponds that cost about $9,000 each and hold runoff from surrounding urban development, removing about 70 percent of the pollutants that would otherwise contaminate the reservoir. The only other alternative to maintain the quality of drinking water would have been to install additional wastewater treatment equipment, ranging in cost from $350,000 to $3,900,000, at four municipal treatment plants. The program, now in full operation, has been approved by the EPA and by the state. 19/

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15. For details, see Congressional Budget Office, *Environmental Regulation and Economic Efficiency* (March 1985).

16. See for example, Environmental Protection Agency, Office of Water Program Operations, *Report to Congress: Non-Point Source Pollution in the U.S.* (January 1984).

17. See Congressional Research Service, *Water Quality: Implementing the Clean Water Act*, Issue Brief IB83030 (August 1983).

18. See Council on Environment Quality, *Environmental Quality 1981, the 12th Annual Report of the Council on Environmental Quality* (1981).

19. For additional details, see the Skylonda Group, Inc., *Achieving Water Quality Standards with Non-Point Source Trading: The Case of Dillon Reservoir* (prepared for the EPA, September 30, 1984).

Currently, the EPA is sponsoring a study to determine if a similar trading permit program could benefit the water quality of the Chesapeake Bay and save treatment costs for the surrounding communities.

Efficiency

The potential for gains in investment efficiency under this option derive from the 1981 amendments to the Clean Water Act and not from the regulatory reforms, per se. If efficiency were redefined, however, in terms of the unit achievement of clean water per dollar invested, this option would present definite advantages over current policy. The regulatory reforms are designed to meet applicable standards with lower net investments compared with current policy. An ocean discharge waiver, for example, would only become the local option of choice if it required less capital investment than a conventional treatment plant. Thus, the savings could be reallocated to other projects that would not have received funding under current policy. In effect, this option makes the process of compliance with standards more efficient, allowing greater leveraging of federal resources.

Timeliness

Regulatory reforms could allow some communities, which have yet to meet secondary treatment standards, to comply with them faster than under current policy, though estimating exact improvements would be difficult. Federal resources could be redistributed to remaining communities to the extent that they were made available through regulatory reforms. For example, for 75 municipal treatment plants in Georgia which needed to construct new facilities, the state estimates that $30 million in capital cost savings and $4.5 million a year in operating cost savings will be possible with the seasonal, flow-based permitting system.[20] In the Dillon Reservoir case, four treatment plants together saved almost 90 percent of the cost of conventional treatment. These savings, plus the $5 billion or so in savings from ocean discharges discussed above, could be reallocated to communities with few opportunities to make similar savings.

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20. See Reheis, Dozier, Word, and Holland, "Treatment Cost Savings Through Monthly Variable Effluent Limits," *Journal of the Water Pollution Control Federation*, 54:8 (August 1982).

Feasibility

Most of the regulatory reform proposals are feasible from legal and technical points of view. Today, some 40 states issue seasonal permits, at least three states issue flow-variable permits, and four administer experimental permit trading programs. But some analysts might contend that these regulatory reforms are counterproductive from an environmental point of view, despite the fact that many ocean discharge waivers have already been granted, with no adverse environmental effects.

Ocean discharges and innovative permitting can be designed to comply with water quality standards for conventional pollutants. But the release of toxic constituents pose the greatest environmental threat. One way to prevent the release of toxics would be to use a screening procedure. This process would disqualify ocean discharge or innovative permit applications if toxics data indicated potential hazards. An urban treatment plant with a large industrial flow component would be the most likely candidate to be rejected under such a procedure. States and the EPA could implement regulatory reforms only in situations that offered environmental safeguards that were equivalent to those provided under conventional permit procedures.

Some of the components of this option could increase federal and state administrative or enforcement efforts. Ocean discharge waivers and innovative permitting schemes would require added staff review and water quality modeling during permit development. Once the reform is in place, additional effluent and stream quality monitoring might be necessary. Some or all of the added costs of these activities could be defrayed with permit fees. Currently, some 21 states charge such fees.

APPENDIX

APPENDIX

REGRESSION EQUATIONS AND STATISTICAL RESULTS

This appendix presents the regression equations used to describe the relationship between four independent (explanatory) variables and the three measures of investment efficiency introduced in Chapter II. Three groups of equations are presented. The first includes data from all 68 wastewater treatment plants included in the data base (N (number) = 68). The second set of equations group the data by size of plant. The third set groups the data by local cost-share quartile.

For each of the equations, t statistics are presented below the estimate of each coefficient. This t statistic is a measure of whether the coefficient is statistically different from zero. The larger the value of t, the less likely it is that the true coefficient is zero. Coefficients that are statistically significant at the 5 percent level are presented in bold type. Coefficients significant at lower levels are provided in regular type. Presented to the right of each equation is its coefficient of determination, r^2. Because all relationships are linear and estimated using ordinary least squares, r^2 represents the percentage of variation in the dependent variable (measures of efficiency) explained by variation in the independent variables.

MODEL VARIABLES

Table A-1 defines the variables that appear in the regression equations. As discussed in Chapter II, three measures of investment efficiency--the dependent variables--are regressed against five independent or explanatory variables. The underlying relationship used to motivate the choice of these variables is that investment efficiency--the inverse of unit cost--is affected by a number of factors, both measurable and unmeasurable. The three dependent variables are three measures of investment efficiency. Though each may be examined individually, lifetime unit cost (UCLT) is the algebraic sum of unit capital costs (UCCAP) and unit operation costs (UCONM).

The most important measurable factors--independent variables--appear to include size of the facility (DESFLOW); local funds at stake (LTLCS); some measure of building extra capacity for whatever reason

(RESRCAP); and level of technology (TREAT). TREAT accounts for any differences between plants with secondary treatment and those with advanced secondary treatment. EPACODE is a dummy variable to account for any differences in projects constructed under the EPA program and those constructed without EPA grants. To a large degree, EPACODE measures the same effect captured by LTLCS. These variables are included in the regression. Nonmeasurable factors affecting unit costs could include strong local management, rigorous cost oversight, and timely completion of projects. These are not included in the regressions, but they are examined in the case studies presented in Chapter III.

TABLE A-1. DEFINITIONS OF VARIABLES USED IN REGRESSION EQUATIONS

Variable	Definition	Unit of Measure
Dependent Variables		
UCLT	Lifetime unit cost = 1/investment efficiency	1983 dollars per 1,000 gallons treated
UCCAP	Capital unit cost	1983 dollars per 1,000 gallons treated
UCONM	Operation and maintenance unit cost	1983 dollars per 1,000 gallons treated
Independent Variables		
DESFLOW	Design flow of facility	Millions of gallons per day (mgd)
LTLCS	Lifetime local cost share	Percentage of total project costs paid by the locality (0-100)
RESRCAP	Percent reserve capacity	Percentage excess flow (design-initial)/initial flow (0-760)
TREAT	Treatment code- treatment process dummy variable	0 if secondary 1 if advanced secondary
EPACODE	Dummy variable designating an EPA or non-EPA project	0 if non-EPA project 1 if EPA project

ORDINARY LEAST SQUARES EQUATIONS BASED ON ALL DATA (N=68)

This set of equations regresses each of the efficiency measures against the five independent variables. Ordinary least squares regression across the entire data set yielded the following relationships:

$$\text{UCLT} = \underset{(t=3.50)}{.9514} + \underset{(t=7.50)}{.0030}\,\text{RESRCAP} - \underset{(t=-2.66)}{.0078}\,\text{LTLCS} + \underset{(t=2.34)}{.2223}\,\text{TREAT}$$

$$- \underset{(t=-2.75)}{.0113}\,\text{DESFLOW} + \underset{(t=1.35)}{.2052}\,\text{EPACODE} \qquad r^2 = .67$$

$$\text{UCCAP} = \underset{(t=6.05)}{1.3758} + \underset{(t=4.56)}{.0015}\,\text{RESRCAP} - \underset{(t=-5.35)}{.0131}\,\text{LTLCS} + \underset{(t=1.98)}{.1568}\,\text{TREAT}$$

$$- \underset{(t=-2.69)}{.0093}\,\text{DESFLOW} - \underset{(t=-1.33)}{.1691}\,\text{EPACODE} \qquad r^2 = .60$$

$$\text{UCONM} = -\underset{(t=2.39)}{.4244} + \underset{(t=7.45)}{.0015}\,\text{RESRCAP} + \underset{(t=3.65)}{.0053}\,\text{LTLCS} + \underset{(t=1.39)}{.0655}\,\text{TREAT}$$

$$- \underset{(t=-1.00)}{.0020}\,\text{DESFLOW} + \underset{(t=4.98)}{.3743}\,\text{EPACODE} \qquad r^2 = .67$$

In the equation for lifetime unit costs (UCLT is the dependent variable), all independent variables are significant except EPACODE. (With 68 degrees of freedom, a t statistic greater than 1.65 indicates a value statistically different from zero at the 5 percent significance level.) The same holds true for the regression equation for capital unit costs (UCCAP). In the equation for operating unit costs (UCONM is the dependent variable), neither the design flow (DESFLOW) nor the treatment level (TREAT) variables are significant, while all other variables appear significant at the 5 percent level. The r^2 for all the equations above appear reasonable considering the cross-sectional nature of the data.

Results of a separate stepwise regression analysis showed that percent reserve capacity (RESRCAP) explained the greatest percent variation in UCLT. Lifetime local cost share (UCLT) was next, followed by design flow (DESFLOW) and, finally, treatment code (TREAT). LTLCS explained the greatest percent variation in capital unit costs (UCCAP), followed by RESRCAP, DESFLOW, and TREAT. RESRCAP explained the greatest percent variation in operating unit costs (UCONM), followed by EPACODE and LTLCS.

The relatively strong inverse relationship between lifetime local cost share (LTLCS) and capital unit costs (UCCAP) outweighs the weaker direct relationship between LTLCS and operating unit costs (UCONM). In the aggregate--that is, summing these effects in the calculation of lifetime unit costs (UCLT)--a strong inverse relationship prevails. As lifetime local cost share increases, lifetime unit costs decrease.

For secondary treatment plants, depending on the size and the reserve capacity of the plant, reductions in unit costs can be substantial (see Table A-2). For the average 10 mgd secondary plant, for example, the relationship just described indicates that lifetime unit costs could fall by some 16 percent if the federal capital grant is reduced from 75 percent to 55 percent and reserve capacity is held to 100 percent of current flow.

TABLE A-2. EFFECT OF INCREASING THE LOCAL SHARE OF CAPITAL COSTS FOR SECONDARY TREATMENT PLANTS FROM 25 PERCENT TO 45 PERCENT [a]

Plant Design Flow (In mgd)	Initial Reserve Capacity (In percents)	Percent Reduction in Lifetime Unit Costs	Percent Reduction in Capital Unit Costs
1	50	16.5	22.5
	100	14.2	20.5
	200	11.0	17.4
10	50	18.6	25.7
	100	15.7	23.1
	200	11.9	19.2
50	50	42.6	69.4
	100	29.9	53.2
	200	18.8	36.4

a. On average, this is equivalent to an increase in lifetime local cost share from about 50 percent to about 65 percent.

Smaller plants would experience less of a percentage reduction in lifetime unit costs while larger plants would enjoy much higher percent reductions.

All other things being equal, building additional reserve capacity limits the percent reduction in lifetime unit costs that would otherwise be available regardless of plant size. For example, regression results indicate that a 10 mgd secondary plant with 50 percent initial reserve capacity could reduce lifetime unit costs by nearly 19 percent if faced with a 20 percent increase in local capital share from 25 percent to 45 percent. The same plant with 200 percent initial reserve capacity could cut lifetime unit costs by only 12 percent. A similar relationship is evident for all size plants.

GROUPING DATA BY DESIGN FLOW

Sample data were grouped into four flow categories, within which design flow had no statistically significant effect on unit costs. This is one way to hold constant the effects that economies of scale have on unit costs. The first category--0.3 mgd to 0.5 mgd--constitutes relatively small plants serving municipalities up to 5,000 in population. The EPA estimates that some 9,000 new secondary plants in this category will be needed by the year 2000. Plants in the second category--2.5 mgd to 3.0 mgd--serve communities as large as 30,000 in population. In this low- to mid-sized range, the EPA estimates that about 1,200 new secondary plants will be needed by 2000. Plants in the third, or mid-sized category--7.1 mgd to 8.3 mgd--serve populations up to 80,000. Only 262 plants of this size will be needed by 2000. Plants in the final category--20 mgd to 28 mgd--are large plants serving up to 250,000 people; 220 will be needed by 2000.

In each category, the relationship between investment efficiency and local cost share established for the entire data set was preserved--that is, lifetime and capital unit costs were inversely related to local cost share. Unit costs decreased when localities had a greater percent of local capital at stake. For some flow categories, however, small sample sizes cast doubts on the significance of the regressions or of individual coefficients. Though not always significant at the 5 percent level, building reserve capacity inflated unit costs. Excess reserve capacity seemed to affect operating costs more than capital costs.

Flow Category 0.3 Mgd to 0.5 Mgd (N=8)

$$\text{UCLT} = \underset{(t=1.78)}{1.6707} + \underset{(t=5.88)}{.0031}\ \text{RESRCAP} - \underset{(t=-1.50)}{.0144}\ \text{LTLCS} - \underset{(t=-0.59)}{.3075}\ \text{EPACODE} \qquad r^2 = .92$$

$$\text{UCCAP} = \underset{(t=3.47)}{1.8291} + \underset{(t=3.91)}{.0012}\ \text{RESRCAP} - \underset{(t=3.18)}{.0169}\ \text{LTLCS} - \underset{(t=-1.45)}{.4307}\ \text{EPACODE} \qquad r^2 = .87$$

$$\text{UCONM} = \underset{(t=-0.22)}{-.1291} + \underset{(t=5.98)}{.0020}\ \text{RESRCAP} - \underset{(t=-0.42)}{.0025}\ \text{LTLCS} + \underset{(t=.37)}{.1232}\ \text{TREAT} \qquad r^2 = .94$$

Although the r^2 for the UCLT equation is relatively high, only the coefficient of the variable for the percent reserve capacity appears to be statistically significant at the 5 percent level. LTLCS is significant in the UCCAP equation but it is not significantly different from zero in the UCONM equation. The effect of LTLCS on UCCAP is relatively weaker than its effect on UCONM, and thus it would not be appropriate to accept the hypothesis that the coefficient of LTLCS in the UCLT equation is significantly different from zero. In this flow category (the smallest of the four), almost all the explanatory power of the independent variables on UCLT comes from variation in the percent reserve capacity variable. Variation in LTLCS, however, does explain a significant portion of variation in unit capital costs. The variable, TREAT, does not appear in these equations because all plants in this flow category employ simple secondary processes.

One interpretation of these equations is that reserve capacity has such a strong influence on the operating unit costs of plants in this flow category that little else seems to affect lifetime unit costs. If capital unit costs are considered alone, however, the influence of local cost share is important. Thus, for these small plants, an increase in local capital share could reduce EPA's needs estimate, but local costs over the life of the facility would be affected (and could be reduced) more by reducing initial reserve capacity.

Flow Category 2.5 Mgd-3.0 Mgd (N=12)

$$\text{UCLT} = \underset{(t=4.30)}{1.3157} + \underset{(t=1.82)}{.0013}\ \text{RESRCAP} - \underset{(t=-2.79)}{.0099}\ \text{LTLCS} - \underset{(t=0.22)}{.0423}\ \text{EPACODE}$$

$$+ \underset{(t=2.14)}{.3490}\ \text{TREAT} \qquad r^2 = .81$$

UCCAP = 1.3799 + .0009 RESRCAP -.0127 LTLCS -.1571 EPACODE
(t=3.75) (t=1.02) (t=-2.98) (t=-0.68)

+ .1235 TREAT $r^2 = .68$
(t = 0.63)

UCONM = -.0641 + .0004 RESRCAP - .0028 LTLCS
(t=-.52) (t=1.50) (t=-2.00)

+ .1994 EPACODE + .2254 TREAT $r^2 = .84$
(t=2.60) (t=3.45)

Only LTLCS in the first two equations and EPACODE and TREAT in the last are significant at the 5 percent level. Almost all of the explanatory power of the independent variables in both the UCLT and UCCAP equations derives from variation in the lifetime local cost share (LTLCS) variable. On the other hand, LTLCS adds only a small increment to the already significant explanatory power of TREAT and EPACODE in the UCONM equation. UCONM is particularly sensitive to variation in TREAT--the level of treatment.

One interpretation of these equations is that the relatively strong influence that local cost share exerts on capital unit costs could result in significantly lower capital needs and lifetime unit costs for plants in this flow range if the local capital share of projects remains at the 45 percent level. The EPA projects with advanced secondary technologies might cause higher operating unit costs than would non-EPA projects with simpler secondary technologies.

Flow Category 7.1 Mgd-8.3 Mgd (N=10)

UCLT = 3.2011 + .0041 RESRCAP - .0336 LTLCS - 1.1856 EPACODE
(t=3.42) (t=5.65) (t=-3.42) (t=-2.22)

+ .3422 TREAT $r^2 = .94$
(t=3.02)

UCCAP = 3.222 + .0029 RESRCAP - .0336 LTLCS - 1.401 EPACODE
(t=4.42) (t=5.10) (t=4.38) (t=-3.38)

+.2455 TREAT $r^2 = .92$
(t=2.79)

$$UCONM = .0213 + .0012\ RESRCAP - .0001\ LTLCS$$
(t=-0.04)(t=2.97) (t=-0.01)

$$+ .2152\ EPACODE + .0967\ TREAT \qquad r^2 = .88$$
(t=0.71) (t=1.51)

All the independent variables, except EPACODE, have statistically significant coefficients at the 5 percent level in the equation for UCLT. All variables are significant in the equation for UCCAP while only RESRCAP appears significant in the equation for UCONM.

For plants in this mid-sized category, variations in capital unit costs seem to dominate variations in lifetime unit costs. One interpretation of these equations is that the independent variables that help to explain variations in lifetime unit costs do so because of their influence on capital unit costs. This argues that the local share of capital costs could have stronger influence on local capital outlay decisions than on decisions that determine future operating costs.

Flow Category 20 Mgd-28 Mgd (N=9)

$$UCLT = .8382 + .0035\ RESRCAP - .0098\ LTLCS - .3108\ TREAT$$
(t=3.87) (t=8.17) (t=-4.63) (t=-3.28)

$$+ .2003\ EPACODE \qquad r^2 = .98$$
(t=1.66)

$$UCCAP = 1.1206 + .0020\ RESRCAP - .0127\ LTLCS - .2237\ TREAT$$
(t=4.60) (t=4.21) (t=-5.31) (t=-2.10)

$$- .1245\ EPACODE \qquad r^2 = .95$$
(t = -0.92)

$$UCONM = - .2824 + .0015\ RESRCAP + .0029\ LTLCS$$
(t=-1.05) (t=2.77) (t=1.08)

$$- .0871\ TREAT + .3247\ EPACODE \qquad r^2 = .82$$
(t=-0.74) (t=2.17)

In the equation for UCLT, all variables are statistically different from zero at the 5 percent level, except EPACODE. Neither TREAT nor

EPACODE appears significant in the equation for UCCAP. None of the variables in the equation for UCONM appears to be significantly different from zero. Like the mid-range flow category, the significance of the relationship estimated for UCLT seems to derive from the strength of the relationship for UCCAP. Operating unit costs would appear to have little influence on wastewater investment decisions.

Analysis by Local Cost-Share Quartile

The following set of regressions was run to determine whether the inverse relationship between local cost share and lifetime unit costs held over the entire range in local cost shares. The data were disaggregated into the following quartiles:

Quartile	N	Range in Lifetime Local Cost Share (In percents)	Equivalent Range in Local Share of Capital Costs (In percents)
1	17	18-47	8-28
2	17	48-55	10-38
3	17	56-69	13-57
4	17	70-100	25-100

The coefficients for the regression of lifetime unit costs (UCLT) against four independent variables appear in Table A-3.[1] For the first two quartiles, there is both a reasonable fit of the model to the data and statistical significance in the regression at the 5 percent level. The coefficients for LTLCS and RESRCAP are significant at the 5 percent level, while the others are not. Thus, up to lifetime local cost shares of roughly 55 percent, an increase in LTLCS is associated with decreases in lifetime unit costs or increased investment efficiency. In the third quartile, the model does not fit the data as well, nor is the regression significant at this level. In the fourth quartile, the fit is good and the regression is significant. All coefficients except TREAT are significant. But more than half the data (11 of 17 data points) are grouped at 100 percent LTLCS. This would tend to improve the fit and reduce the variance of the estimates of the coefficient for LTLCS. Thus, the regression results suggest that there is considerably

1. The fifth independent variable, EPACODE, was dropped for this exercise to eliminate the potential error that could be introduced because of multicolinearity between EPACODE and lifetime local cost share.

more uncertainty over the inverse relationship between LTLCS and UCLT in the third and fourth quartile then in the first two. Although this uncertainty makes generalization difficult, it would appear that increases in lifetime local cost shares above the 50 percent to 65 percent range (local capital cost shares of roughly 20 percent to 45 percent) would not result in more efficient investments.

Another way to view this relationship is the following. For the entire data set, the regression of UCLT against the four independent variables noted in Table A-2 yields the following equation:

$$UCLT = 1.0977 - .0048\ LTLCS - .000045\ LTLCS^2 - .0119\ DESFLOW$$

$$+ .0032\ RESRCAP + .2436\ TREAT \qquad r^2 = .66$$

Taking the first derivative of UCLT with respect to LTLCS and setting it equal to zero allows the determination of the value of LTLCS that maximizes UCLT: -.0048 - .000090LTLCS = 0 or: LTLCS = 53.3 percent.

TABLE A-3. COEFFICIENTS AND RELATED STATISTICS FOR THE REGRESSION OF LIFETIME UNIT COSTS AGAINST FOUR INDEPENDENT VARIABLES FOR DATA DISAGGREGATED BY LOCAL COST SHARE QUARTILE

Quartile	Value of the Coefficients					F Statistic [a]	r^2
	INTERCEPT	LTLCS	RESRCAP	DESFLOW	TREAT		
1	1.6810 (t=4.72)	-.0203 (t=-2.56)	.0024 (t=2.35)	-.0082 (t=-1.20)	-.0471 (t=-0.24)	7.06	.70
2	5.6837 (t=2.60)	-.0998 (t=-2.35)	.0047 (t=3.94)	-.0156 (t=-1.68)	.2808 (t=1.22)	6.38	.70
3	1.1445 (t=0.51)	-.0071 (t=-0.21)	.0031 (t=1.65)	-.0102 (t=-1.04)	.1664 (t=0.60)	1.97	.40
4	2.7986 (t=3.86)	-.0255 (t=-3.54)	.0025 (t=5.33)	-.0257 (t=-2.23)	.0257 (t=1.74)	23.46	.88

a. An F statistic is a measure of the statistical significance of the regression equation. For N=17 (each quartile), the equation is statistically significant at the 5 percent level if F is greater than 3.0.

The implication of this result is that, within a range of error of perhaps plus or minus 20 percent, increases in LTLCS above about 53 percent would not appear to imply decreases in lifetime unit costs. In terms of the Construction Grants program, these results indicate that the current local share--45 percent of capital costs (or about 60 percent to 65 percent LTLCS)--is about as high as needed to promote the most efficient types of investment decisions. Further increases in LTLCS would not necessarily be expected to result in additional gains in investment efficiency.

ANALYSIS OF ERROR TERMS [2]

One assumption of the ordinary least squares regression model is that the error terms have an expected value of zero and a constant variance. Thus, there should be no relationship between the absolute value of the error terms and any of the independent variables. A simple visual inspection of the residuals (estimated value of the dependent variable minus actual value) plotted against each of the independent variables confirmed that no apparent relationships exist. Furthermore, an analysis of the distribution of residuals reveals that there is no evidence to reject the hypothesis that the errors are normally distributed.

RELATIONSHIPS AMONG INDEPENDENT VARIABLES

A linear relationship among independent variables, or multicollinearity, is often enough to cause estimation problems. Multicollinearity is easily detected using a correlation matrix (see Table A-4). This matrix presents simple correlation coefficients between all pairs of independent variables. The off-diagonal elements contain the simple correlation coefficients for the data set; the diagonal elements are all unity since each variable is perfectly correlated with itself. A high absolute value--0.8 and above--indicates high correlation between the two independent variables and thus a high chance of multicollinearity. From the coefficients presented in Table A-4, it is clear that LTLCS and EPACODE appear to be mildly related. This alone should not cause serious estimating problems, nor should it cause serious problems in the calculation of t statistics. Moreover, the inverse relationship between LTLCS and UCLT is preserved when EPACODE is dropped.

2. This section analyzes the set of regression equations derived from all data (N = 68).

TABLE A-4. SIMPLE CORRELATION MATRIX FOR INDEPENDENT VARIABLES (Correlation Coefficients)

	RESRCAP	LTLCS	DESFLOW	TREAT	EPACODE
RESERCAP	1.00	-0.01	-0.21	-0.08	0.20
LTLCS	-0.01	1.00	-0.08	0.08	-0.74
DESFLOW	-0.21	-0.08	1.00	-0.02	0.01
TREAT	-0.08	0.08	-0.02	1.00	0.03
EPACODE	0.20	-0.74	0.01	0.03	1.00