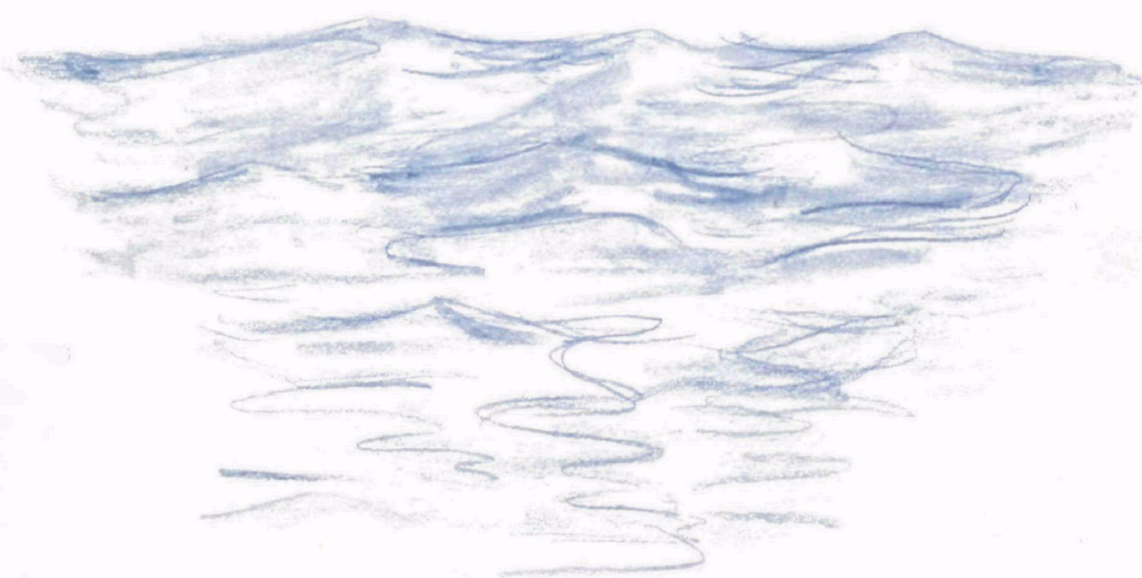
VOLUME
ONE

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

THE ECONOMICS OF CLEAN WATER

U. S. DEPARTMENT OF THE INTERIOR



CLEAN WATER

2792

THE ECONOMICS OF CLEAN WATER

VOLUME I

Detailed Analysis

U. S. Department of the Interior
Federal Water Pollution Control Administration
March 1970

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UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

APR 3 1970

Dear Mr. President:

I am transmitting to the Congress the third report on the national requirements and cost of water pollution control as required under Section 16 (a) of the Federal Water Pollution Control Act, as amended.

The decade of the 1970's, a decade which will address itself to improving the quality of man's environment, will see great strides toward the effort to abate water pollution. The enclosed report entitled "The Economics of Clean Water" represents our current estimates of the investment levels necessary to attain applicable water quality standards.

This report, along with the two previously submitted, contributes to closing the information gap in terms of the overall magnitude, geographical, and financial dimensions, all of which are essential to the development of national policies and programs directed toward achieving water quality standards in an efficient and effective manner.

The alternatives analyzed in the course of this study, especially those aspects contained in Volume I, presented valuable background for development of proposals on aid to municipal treatment works presented to the Congress in the President's Environmental Message and subsequent legislation.

There are four parts to this year's report. The first is a summary of major findings and conclusions of the analysis. The second, Volume I, contains the details of the analysis. The third, Volume II, is a profile of animal wastes. The fourth and last section, Volume III, is an industrial profile of the inorganic chemicals industry.

Sincerely yours,

Walter J. Hickel

Secretary of the Interior

Hon. Spiro Agnew
President of the Senate
Washington, D. C. 20510

Enclosure

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Speaker of the House of
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Washington, D. C. 20515

Enclosure

CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

This is the third in a series of reports to the Congress on the subject of the cost of treating liquid wastes that the Secretary of the Interior is charged to deliver annually, under the terms of the Federal Water Pollution Control Act.

The first report in the series attempted to draw together and evaluate in gross fashion all available information on water-borne waste sources, treatment technology, and control deficiencies. The second report examined the processes of providing physical capital for waste treatment--the interaction of funds over time under the influence of developing technology, shifting regulatory requirements, rising demand, and normal replacement conditions.

This report combines the concept of investment processes developed in the second report with the generally held concept of an investment gap that was evaluated in the first report. Its product is the definition of a rate of investment that will close the gap for municipal and industrial waste treatment within a five year period, given the continued pertinence of today's regulatory and technological conditions. Detailed studies of the pollutional impact of the inorganic chemicals industry and of concentrated animal populations are submitted as separate sub-reports.

The report considers several issues germane to the policy decisions required with the expiration of current municipal grants legislation. The alternatives and conclusions reached in this report are intended to be illustrative and suggestive, not statements of policy. Economic analysis can provide insights into the consequences of alternative actions, but the political process must in the final analysis mold the necessary decisions within the context of total national interests and values.

A number of subsidiary issues are considered, including the influence of industrial waste discharges on public investment outlays, the influence of location on unit investment, the status of broadly integrated regional waste handling systems, the incidence of recapitalization, the influence of price levels on investment, and patterns of change in the real cost (i.e., costs adjusted for price levels changes) of waste treatment facilities. Consideration of these and other sub-questions was consistently pointed to their relationship to the problem of deriving a normative annual level of investment, one appropriate to five year attainment of an investment equilibrium in the public waste treatment sector; and the force of Federal assistance programs on investments is a minor theme that pervades the report.

INVESTMENT TRENDS

Recent Levels of Spending

Total investment for liquid waste handling facilities was little changed in 1968 from its 1967 level, due to pronounced declines in indicated industrial waste treatment investments and in the rate of installation of sewers.

Public investments amounted to $1,111.8 million, a more than $50 million increase over the previous year and a new high for the purpose. That increase was concentrated in areas relating to waste treatment--public investments for collecting sewers were about $44 million lower than in 1967, while spending for waste treatment, transmission, and discharge facilities rose about $102 million over the level of 1967. Inflation, which exerted its pressures with increasing effect through the course of the year, ate up most of the increase in public outlays. Over $30 million of the $50 million increment in year to year public spending is calculated to have been the consequence of higher prices.

Table 1

Comparative Investment Outlays for
Waste-Handling Purposes, 1967 & 1968

Investment Category	Investment (millions of current dollars)	
	1967	1968
New Waste Treatment Plants	149	180
Expansion, Upgrading, Replacement	213	189
Interceptors & Outfalls	188	284
Collecting Sewers	606	550
Industrial Waste Treatment	564	529
Total Capital Outlay	1,720	1,732

Although information for investment in 1969 is not fully available, preliminary indications are that it maintained its upward course. Projections that were made in the first quarter of industrial outlays indicated that over $700 million would be spent for waste-handling facilities in 1969. (The value must be presumed to be highly suspect, in view of the wide divergence between projected and actual investment in 1968, when first quarter projections derived from industrial sources suggested outlays approaching $800 million for a year in which less than $600 million was actually invested.) One may infer, too, that expenditures for installation of sanitary sewers were little, if any, greater than in 1968. There is a pronounced secular downtrend in investments for public sewers; and the steep decline in new housing starts experienced during the year suggests another drop in the level of privately funded sewer installation, which is directly related to subdivision development. But the segment of the market made up of investments for waste treatment plants and ancillary works unquestionably moved to a significantly higher level. The assessment is based on projects receiving Federal construction grants that were actually started through the first ten months of 1969. The value of those projects--about $740 million--is consistent with an $880 million full year investment. Table 2, that contrasts estimated 1969 investments for waste treatment plants and ancillary works with those of other recent years, may be distorted with respect to the interstate distribution of investment for 1969, in that it assumes a constant relationship between ten month and twelve month investment for every State, but the total may be presumed to be approximately accurate.

Because of the acceleration of inflationary forces that went on through 1969, a very significant portion of the year to year increase in investment was dissipated in price increases. Assuming a constant exertion of inflationary effects through the year, $47 million of the $128 million rise in spending was accounted for by higher factor costs.

Influences on Public Investment

New influences on the course of public waste handling investment whose shape began to be discernible in 1967 and 1968 took on sharper outlines in 1969. The prime influence on the level of spending since the Korean war has been the amount of Federal financing assistance that has been made available to local governments. When Federal grants in aid were initiated in 1956, the pace of public investment accelerated noticeably. And as the amount of Federal assistance climbed in successive steps from $50 million a year to $200 million a year, total spending kept pace, in terms of direction and amount if not of proportion. (See Table 3 for a State by State comparison of expenditure levels at periods marked by successive increases in the rate of Federal financial assistance.)

In recent years, however, the impact of the amount of Federal subsidies has been modified by other forces. The maturity of the national investment program has resulted in a sharply altered configuration of capital needs. State financial assistance to local communities has complemented and redirected the force of Federal assistance.

TABLE 2

Estimated Annual Public Investment*
for Waste Treatment Plants and
Ancillary Works, by State

	Average, 1962-66	1967	1968	1969 est.	1967-69 Avge / 1962-66 Avg
Alabama	6.6	12.6	4.3	18.5	179%
Alaska	0.3	0.1	4.0	0.2	478%
Arizona	5.8	5.4	2.9	5.9	82%
Arkansas	6.4	10.7	3.2	10.5	127%
California	34.0	43.0	34.9	41.1	117%
Colorado	7.4	3.0	4.6	10.5	82%
Connecticut	8.2	17.7	7.9	71.5	395%
Delaware	2.2	-	1.0	1.4	36%
District of Columbia	6.8	13.6	3.2	6.4	114%
Florida	10.6	9.4	16.8	29.6	175%
Georgia	8.7	13.2	4.5	22.7	155%
Hawaii	5.5	4.4	-	0.5	30%
Idaho	0.9	1.3	0.7	1.9	144%
Illinois	30.9	45.3	33.5	33.2	121%
Indiana	16.8	24.4	27.1	10.3	123%
Iowa	7.3	8.2	13.1	14.6	164%
Kansas	5.3	5.2	11.1	4.5	131%
Kentucky	7.0	4.0	4.4	10.9	92%
Louisiana	11.2	7.6	4.5	11.0	69%
Maine	3.3	1.4	5.7	10.0	173%
Maryland	7.7	20.2	17.3	31.0	297%
Massachusetts	12.4	6.7	13.4	28.1	130%
Michigan	21.1	7.6	30.4	5.7	69%
Minnesota	10.4	8.6	13.3	13.3	113%
Mississippi	4.3	2.7	2.7	2.4	60%
Missouri	21.1	15.2	26.5	12.8	86%
Montana	1.3	0.5	1.3	1.3	79%
Nebraska	4.8	4.5	2.0	3.0	66%
Nevada	3.5	3.4	0.4	0.2	38%
New Hampshire	3.1	2.0	6.0	1.9	106%
New Jersey	15.9	30.0	10.5	40.2	169%
New Mexico	3.4	4.0	0.4	3.5	77%
New York	40.6	33.3	115.0	97.0	201%
North Carolina	14.8	18.7	10.8	17.3	105%
North Dakota	0.8	0.8	0.3	0.4	63%
Ohio	23.5	26.1	35.1	41.9	146%
Oklahoma	4.0	6.5	5.5	14.6	222%
Oregon	5.5	3.2	3.3	7.6	85%
Pennsylvania	23.8	42.6	65.3	90.2	277%
Rhode Island	2.8	1.0	1.2	1.9	49%
South Carolina	5.2	4.6	10.5	26.0	263%
South Dakota	1.5	2.9	0.2	1.8	109%
Tennessee	10.5	5.1	19.9	18.6	138%
Texas	17.5	14.9	17.1	38.2	134%
Utah	2.8	1.9	0.1	1.2	38%
Vermont	3.4	1.8	2.4	3.9	79%
Virginia	10.7	20.9	10.4	25.0	175%
Washington	20.5	3.8	20.9	4.6	48%
West Virginia	6.2	1.2	3.0	4.0	44%
Wisconsin	18.2	13.4	17.1	20.7	94%
Wyoming	0.2	-	-	0.8	133%
Puerto Rico	1.8	3.8	-	6.5	191%
Totals	508.9	542.4	652.1	880.8	136%

*Millions of dollars

TABLE 3

Current Dollar Investment by States 1952-1968
(Millions of Current Dollars)

	1952-1955	1956-1961	1962-1966	1967-1968	Total for Period
Alabama	11.4	31.9	32.8	16.9	93.0
Alaska	-	2.2	1.7	4.1	8.0
Arizona	1.1	12.8	29.1	8.3	51.3
Arkansas	2.8	16.0	32.1	13.9	64.8
California	46.8	213.9	170.1	77.9	508.7
Colorado	3.6	17.3	36.9	7.6	65.4
Connecticut	4.6	19.8	41.1	25.6	91.1
Delaware	4.9	5.0	10.8	0.9	21.6
District of Columbia	2.0	33.2	33.9	16.8	85.9
Florida	39.2	43.2	53.0	26.2	161.6
Georgia	6.3	32.4	43.5	17.7	99.9
Hawaii	-	5.8	27.5	4.4	37.7
Idaho	0.7	8.6	4.7	2.0	16.0
Illinois	33.3	127.7	154.6	78.8	394.4
Indiana	59.3	97.5	84.2	51.2	292.5
Iowa	10.2	33.0	36.4	21.3	100.9
Kansas	15.1	35.3	26.6	16.3	93.3
Kentucky	12.9	38.7	35.0	8.4	95.0
Louisiana	4.2	25.0	55.9	12.1	97.2
Maine	0.7	3.8	16.6	7.1	28.2
Maryland	6.7	28.4	38.7	37.5	111.3
Massachusetts	14.3	31.6	62.0	20.1	128.0
Michigan	34.2	83.4	105.6	38.0	261.2
Minnesota	16.5	36.3	52.2	21.9	126.9
Mississippi	1.7	11.1	21.5	5.4	39.7
Missouri	8.6	26.2	105.6	41.7	182.1
Montana	0.8	8.2	6.4	1.8	17.2
Nebraska	1.4	26.0	24.1	6.5	58.0
Nevada	2.5	6.0	17.7	3.8	30.0
New Hampshire	0.9	4.6	15.5	8.0	29.0
New Jersey	81.1	75.6	79.7	40.5	276.9
New Mexico	3.0	12.2	17.0	4.4	36.6
New York	66.7	171.0	203.2	148.3	589.2
North Carolina	12.2	51.5	74.2	29.5	167.4
North Dakota	1.0	8.8	4.1	1.1	15.0
Ohio	61.5	166.0	117.5	61.2	406.2
Oklahoma	9.5	19.7	20.0	12.0	61.2
Oregon	10.5	20.1	27.6	6.5	64.7
Pennsylvania	51.1	208.4	119.2	107.9	486.6
Rhode Island	5.5	7.3	13.8	2.2	28.8
South Carolina	3.4	9.9	25.8	15.1	54.2
South Dakota	1.7	5.3	7.3	3.1	17.4
Tennessee	24.3	36.0	52.3	25.0	137.6
Texas	24.1	60.8	87.6	32.0	204.5
Utah	4.9	17.9	14.2	2.0	39.0
Vermont	0.7	6.2	17.0	4.2	28.1
Virginia	17.9	37.0	53.3	31.3	139.5
Washington	6.6	37.5	102.5	24.7	171.3
West Virginia	8.2	32.7	30.8	4.2	75.9
Wisconsin	12.4	52.0	90.9	30.5	185.8
Wyoming	0.6	6.5	1.2	-	8.3
Puerto Rico	-	0.5	9.3	3.8	13.6
Totals	753.6	2107.8	2544.3	1192.0	6597.7

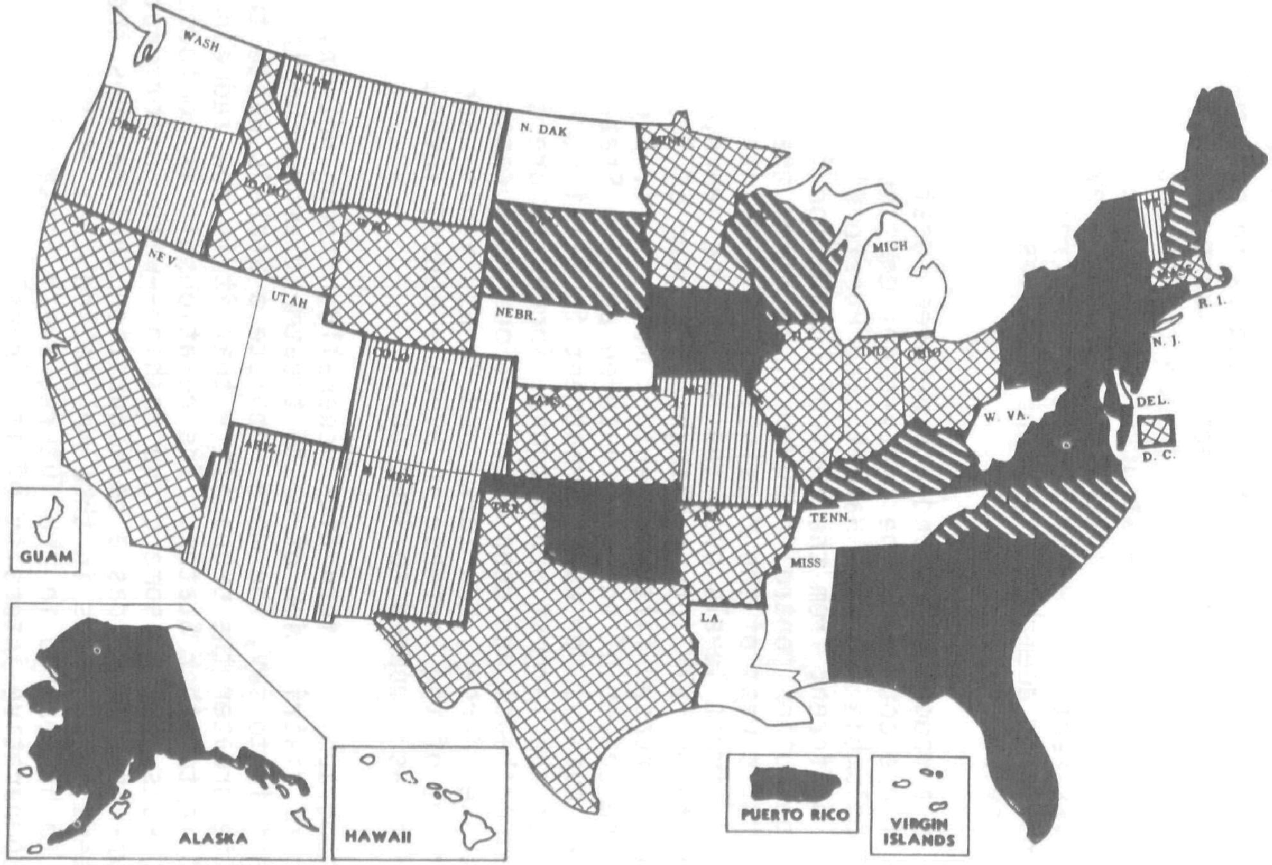
Public awareness of water quality problems has developed a sense of urgency and a heightening of the investment effort in some cases. Out of the inter-action of assistance programs, needs patterns, and local preference, an alteration of the investment structure has emerged. Where almost every State in the past moved its investment levels uniformly upward from period to period (subject to year to year lumpiness imparted by intermittent new starts on extremely large projects), divergent trends have become evident over the last three years. Some States continue to increase the amount of their investment--some at fairly constant, some at accelerating rates--others appear to have reached at least an interim equilibrium level with respect to public investments for water pollution control, and still a third group appears to be deemphasizing public investment for protection of the aquatic environment.

There is a rough correspondence between location and investment behavior. If one considers the forty-eight contiguous States and the District of Columbia (Alaska, Hawaii, and Puerto Rico are special cases, quite different from the rest of the nation in the condition of their water pollution control programs), he finds that thirteen of the twenty-two States west of the Mississippi have maintained stable or declining investment levels over the last three years, and only two of the western States fall into a category composed of States whose spending has increased fifty percent or more. (cf. Figure 1.) Conversely, seventeen of the twenty-seven eastern States have increased their capital outlays for waste treatment facilities; and the class of States with the largest proportional increases are concentrated in the extreme northeast and deep south. (Four northeastern States--Connecticut, New Jersey, New York, and Pennsylvania--account for almost seventy percent of the increase in average annual investments for the period 1967-69 as compared to 1962-66.)

That geographic pattern fits generally, though not invariably, the pattern of distribution of waste treatment among the individual States. That is to say, the more complete a State's waste treatment services, the greater the probability that it is now reducing investment, relative to other States. The relationship is comforting, in that it suggests that in some crude fashion--with, unfortunately, gaps and overlays--investment has a configuration that matches the occurrence of needs, as well as in the implication that at some point of attainment to be reached in the future, every State will be able to relax the comparative intensity of its investment effort.

There are also disturbing elements in the distribution of investment intensity. On the one hand there are the cases of apparent laxness, States that show a pronounced relative deficiency in waste treatment services with no corresponding increase in investment effort. On the other hand, there are indications of pronounced relative inefficiency, in that the level of a State's past effort may be related

STATES CLASSIFIED ACCORDING TO RECENT INVESTMENT BEHAVIOR



= STATES INCREASING INVESTMENT 50% OR MORE
= STATES INCREASING INVESTMENT 11-49%
= STATES WITH STABLE INVESTMENTS
= STATES WITH INVESTMENTS DECLINING 11-25%
= STATES WITH INVESTMENTS DECLINING 25% OR MORE

Figure 1

only slightly to its current status. Marked increases in expenditures have been initiated in cases where per-capita spending was equal to or greater than that of States whose relative needs are slighter and whose spending has been controlled or reduced in recent years.

The broad outlines of the developing investment structure come into sharper focus if States are categorized according to their recent investment behavior. Table 4 presents such a classification, with all values reduced to relative terms--percentages or per-capita values--to provide an element of comparability. It should be stressed that what is true of a class of States, as they are distinguished in the table, is not necessarily true of every State within the class. The only distinction recognized in setting up the groupings was investment behavior, and distinct differences may be found among units whose investment behavior is similar. Thus in the group of States with stable investment, New Hampshire, with only 4.5% of the sewered population of the grouping, includes 50.3% of its population with untreated wastes, 7.1% of its population with wastes receiving only primary treatment, and 27% of the amount of its investment requirements. Similarly, in the group of States with modestly declining investments, the State of Vermont has only 2.9% of the group's population, but contains 9.7% of its population without waste treatment, 8.5% of its population with only primary treatment, and 15.7% of the value of the group's investment requirements. Obviously, each group would compare even more favorably with the other three groups if the atypical component were removed. The intra-classification discrepancy is acute in the case of the grouping of states whose investments in the last three years have sunk below 75% of the rate of the previous five years. That discrepancy is discussed below.

1) That group of States in which investments were being accelerated most vigorously during the last three years--50% or more over the average annual level of the five years before--includes more than a third of the sewered population of the United States. Those States' emphasis on waste-handling investment will, then, have a strong influence on the level of total investment.

The sharp acceleration of investment by these particular States would appear to be desirable, in that the group contains a relatively large proportion of the waste treatment needs of the nation. No matter how needs are viewed in comparison with the population base--proportionate discharge of raw sewage, proportion of sewered population with only primary waste treatment, proportion of evaluated investment needs--it would appear that these States, as a group, are behind the rest of the nation and should be increasing their share of national investment. That very general conclusion is supported by a review of comparative investments: as a group, they have invested less, on a per-capita basis, over most of the last fifteen years than most other States.

TABLE 4

Comparative Categorization of States
by Recent Investment Behavior

	Percent of National Total						Average Annual Per-Capita Investment*			
	Sewered Population	Sewered Pop. w/o Treatment	Sewered Pop. w/Primary Trtmt.	Investment 1952-66	Investment 1967-69	Current Investment Requirements	1952-55	1956-61	1962-66	1967-69
States with major increases (150% or more of 1962-66 average) in investment in 1967-69:										
Alabama, Alaska, (Connecticut), Florida, Georgia, Iowa, (Maine), (Maryland), (New Jersey), (New York), Oklahoma, (Pennsylvania), South Carolina, Virginia, Puerto Rico	35.6	42.1	38.0	32.9	48.9	40.2	(1.95) 1.60	(2.40) 2.42	(2.88) 3.20	(5.37) 6.98
States with increases (111-149% of 1962-66 average) in investment in 1967-69:										
Arkansas, California, District of Columbia, Idaho, Illinois, (Indiana), Kansas, (Massachusetts), Minnesota, Ohio, Tennessee, Texas, Wyoming	42.6	30.2	38.1	39.4	33.9	32.0	(1.64) 1.34	(2.57) 2.60	(2.85) 3.16	(3.11) 4.04
States with substantially unchanged (90-110% of 1962-66 average) investment in 1967-69:										
Kentucky, New Hampshire, North Carolina, South Dakota, Wisconsin	5.1	3.3	3.3	7.7	6.4	6.7	(1.77) 1.45	(3.63) 3.67	(5.82) 6.46	(4.91) 6.38
States with declining (75-89% of 1962-66 average) investment in 1967-69:										
Arizona, Colorado, Missouri, Montana, (New Mexico), (Oregon), (Vermont)	5.3	4.8	3.9	6.9	5.8	7.0	(1.21) 0.99	(2.37) 2.39	(6.02) 6.68	(4.29) 5.58
States with sharply declining (74% or less than 1962-66 average) investment in 1967-69:										
(Delaware), Hawaii, Louisiana, (Michigan), Mississippi, Nebraska, Nevada, North Dakota, (Rhode Island), Utah, (Washington), West Virginia	12.6	20.0	17.5	14.3	6.8	14.1	(1.34) 1.10	(2.56) 2.59	(4.50) 5.00	(2.12) 2.76
United States Totals	100.0	100.0	100.0	100.0	100.0	100.0	(1.67) 1.37	(2.54) 2.56	(3.33) 3.70	(3.91) 5.08

* Per-capita investment based on 1968 sewered population, Constant (1957-59) Dollars in Parentheses

Note: States which provide financial assistance are underlined and States with funded assistance programs are indicated by parantheses.

That investment deficiency may have been in part a result of Federal policy. These are in many instances the high population, big city states that, because of grant limitations, received effectively less per-capita Federal assistance under the terms of the Federal Water Pollution Control Act as it was structured between 1956 and 1966. Though per-capita investment in these States showed a response to the availability of Federal grants after 1956, the amounts of the increases in per-capita expenditures were well below that of other groups of states before 1967. Those States now demonstrating the greatest increase in investment are, however, the same group that provided the highest per-capita investment before Federal construction assistance programs were initiated. In a sense, the major 1966 amendments of the Federal Water Pollution Control Act tended to redress maldistribution of Federally supplied resources and to allow these States to step up their investments sufficiently to begin to close gaps that had opened between them and others.

But increased amounts of Federal assistance and less discriminatory Federal allocation procedures have probably been of lesser moment in levering investments of at least some States within this group upward than has the initiation of State financial assistance for construction of waste treatment facilities. Most of these States provide such assistance, and have fully funded their assistance programs. In at least two instances--New York and Maryland--State capital inputs over the last three years have matched or exceeded the amount of Federal assistance.

2) Another group of States, one that contains over 40% of the Nation's sewered population, is also undergoing a marked expansion of capital emplacement rates. Almost four out of five Americans, then, live in States that are still in the process of increasing public expenditures for water pollution control.

The class of States in which investment is rising at rates that approximate rather than exceed the degree of increase experienced in the decade and a half before 1967 tend to have achieved far more effective control of wastes than have the States that are undertaking a more pronounced expansion of investment. The group of States under consideration have invested less, on a total and on a per-capita basis, than the class of States whose annual expenditures are registering a more marked increase, yet they display lower than proportional shares of population without waste treatment or only primary treatment; and evaluation of their waste treatment deficiencies shows them to be less than proportional to population.

Relatively efficient use of capital, then, distinguishes them, in that their per-capita expenditures have been consistently lower than those in the other investment categories, while their indicated deficiencies in level of service contrast favorably with the others. In spite of those efficiencies, it has proved necessary for them to increase their level of investment continuously. These are, as a group, States whose population growth is distinctly above the national average. They are also States that have consistently provided an above average level of waste treatment services. It would appear that pressures of growth, recapitalization, and upgrading will continue to operate on these States, and that their expenditures may continue to rise--perhaps ultimately attaining a per-capita level somewhat closer to the national average.

It is notable in this regard that the group of States characterized by moderately rising investment has in the past shared, at least in some cases, the disadvantaged position with respect to Federal financial assistance of the States whose investments have been rising most rapidly; and that--though some of the States involved provide financial assistance to communities--their expenditures have generally followed the regulator of investment intensity provided by Federal grants.

3) Federal grants would seem to have served as the principal regulator in the case of the small number of States who have, on the basis of investments during the last eight years, reached some sort of equilibrium position for waste treatment investments.

They are States that have, as a group, achieved a high level of control of public wastes. They are not, it would appear, extremely efficient as compared to others. Though they have achieved an interim equilibrium level of per-capita investment, it is at a rate that has been consistently higher than that of other groups of States until very recently.

Low population, non-metropolitan States, they have been so structured as to achieve maximum per-capita assistance from Federal construction grants. With Federal assistance at $100 million a year, these States achieved a level of per-capita spending close to twice that of more heavily populated States, and the rise in amount of Federal grant allotments to $200 million a year induced no investment response on their part.

4) The group of States whose investments are declining moderately but perceptibly is in many respects much like the group whose investments are stable. These, too, are States with a relatively small metropolitan population component who were able to materially accelerate their investment under Federal assistance totalling $100 million a year. Per-capita capital application in this group of States, too, has been similar to that of States with stable investment--though their investment is currently lower, it was somewhat higher in the previous period; and over the eight year period 1962-69, the two groups of States mounted constant dollar per-capita investment efforts that were within 2% of one another in amount. The parallel investment experience of

these two groups of States that have largely overcome their waste treatment deficiencies is, perhaps, indicative of what the nation as a whole can anticipate in terms of sustained investment needs. If so, annual investments of more than five 1957-59 dollars for each person receiving sewer services may be some sort of an underlying investment base for a mature waste treatment sector.

5) States whose investments have declined steeply in the last three years do not fall into a single pattern. They are widely distributed with respect to location; they include both industrial and agricultural economies; some include predominantly small town and rural populations, others are metropolitan in character.

More significant with respect to this discussion of investment behavior is the relative prevalence of waste treatment among the members of the group. There are twelve States whose waste treatment investments have been cut back sharply over the last three years. Six of these--Delaware, Nevada, North Dakota, Rhode Island, Utah, and Washington--are much like the groups of States with stable or moderately declining investments in terms of past performance. The other six combine a drop in investment with a high proportion of untreated or inadequately treated wastes and a low level of investment in the past. They are, in short, much like the States who are now increassing investments most sharply. (cf. Table 5.)

TABLE 5

Declining Investment States: Relative Condition and Past Performance

	I	II
	Delaware, Nevada, N. Dakota, Rhode Island, Utah, Washington	Hawaii, La., Michigan, Nebr., West Virginia
Percent of Nation's sewered population	3.6	9.0
Percent of Nation's sewered population without waste treatment	1.0	19.0
Percent of Nation's sewered population with only primary waste treatment	3.6	13.9
Percent of national investment: 1952-66	5.0	9.3
1967-69	2.1	4.7
Constant dollar per-capita investment: 1952-69	$64.34	$48.76

The behavior of the first group is expectable in terms of their situation and might have been predicted; the decline in their activity comes after a period of intense investment, and occurs in situations marked by a high level of waste control. The second group is an anomaly. Investments in the past have been near or below the national average on a per-capita basis; they contain an abnormally large proportion of the nation's population without waste treatment or with only primary treatment; and their investment needs--in terms of physical facility needs defined by the States themselves--are disproportionately great. Yet in circumstances that include those indications of likely to be rising or at least stable outlays, and in the face of a doubling of the level of Federal grant assistance, they have cut back on investments.

One may assume, perhaps, that there are special local circumstances in every case that help to explain the investment decline. And it is not unreasonable to suppose that these particular States may simply be demonstrating in extreme form the effects of high interest rates and constraints on the supply of money, and may in fact preview similar investment declines in other areas as such financial constraints become extensively operative. Another mechanism, too, may be partially responsible for these States' declining investment. Removal of the dollar limitations on Federal grants have made them applicable to communities of all sizes, and where State financial assistance becomes available to communities, the major portion of the financial load is removed from their shoulders. Under those conditions, the amount of Federal and State grants would constitute the principal limiting factor in determining level of investment. No community could be expected to begin a project in the absence of a full share of Federal and State assistance. Thus the potential availability of assistance may--when it is inadequate to conditions-- serve to reduce rather than increase the level of local effort. Inadequate Federal allocations, unfunded State assistance programs, even the possibility of the introduction in a State legislature of a bill to provide assistance, can have the effect of limiting local investments; and such mechanisms may well be operative in the cases of these six States. Arguing for such a phenomenon is the fact that those States whose outlays are increasing most rapidly include several cases where State government has agreed to pre-finance the Federal share of local projects, thus eliminating the level of Federal allocations as a constraint on investment.

Relative Efficiency and Public Investment

The data on per-capita investment by classes may offer some inconclusive but useful insights into the relative efficiency of the various investment groupings, as well as into the level of investment to be anticipated under a condition of complete treatment services.

Table 6 summarizes the constant dollar per-capita investment of each of the classes of States for the period 1952 through 1969 and contrasts that amount with the constant dollar value of current investment needs listed by each State. (cf. Chapter Two: Development of Investment Needs for derivation.) It may very reasonably be concluded that the eighteen year investment plus the value of the investment remaining to be made provides an accounting of the per-capita burden associated with attainment of water quality standards at this time.

TABLE 6

Per-capita Investment Associated with Attainment of Water Quality Standards, 1952-1969

(All values in 1957-59 dollars)

Investment Status	Per-capita investment since 1952	Per-capita amount of remaining needs	TOTAL
Sharply Increasing	49.23	32.25	81.48
Increasing	45.56	20.98	66.54
Stable	69.63	36.88	106.51
Declining	62.03	37.10	99.13
Sharply Declining	49.58	25.05	74.63

The values obtained by the exercise are extremely surprising. If they are to be taken at face value, they suggest that there are extremely wide variations in investment efficiency, that the least efficient users of capital have achieved the highest level of control of their wastes, and that the less capital a State has provided in the past, the smaller the burden waste treatment will mean to its citizens in the future.

Although there are known to be wide variations in investment efficiency (the point is discussed later in this report), the implications to be drawn from the values presented in the table seem to be distorted, particularly when geography is taken into account. Many of the States that are found in the investment groupings that represent increasing investment, as well as several among the six poorer performing States in the category of sharply decreasing investments, are located in the regions where capital efficiency has been demonstrated to be low. A more realistic analysis of the situation may well be that there is a tendency for States whose deficiencies are great to underestimate the extent of those deficiencies. Evaluation of waste treatment deficiencies may depend to some degree on relative accomplishment, so that States with effective and well advanced pollution control programs may list as needed improvements situations that less effective states would find quite satisfactory. If this is in fact the case, then those States who are now increasing their investments--not to mention those whose investments should be increasing when they are in fact declining--may find the job that they have set out to accomplish considerably more expensive than is indicated by their view of current conditions.

Industrial Water Pollution Control Expenditures

In sharp contrast to 1968, when the high degree of visibility given to water pollution control by institution of water quality standards caused a flurry of industrial analyses, information with regard to industrial pollution abatement expenditures was scarce in 1969. The only available source of comprehensive data was the annual McGraw Hill Survey of Business Plans for Plant and Equipment. According to the Survey, industrial investments for pollution control in 1968 were well below first quarter projections. And the planned investment level for 1969, though higher than actual 1968 expenditures, was significantly lower than the rate of spending initially projected for 1968, as shown in Table 7.

The report may--though it is not certain--be reason for concern. Of the total $776 million of manufacturing investment, 50 to 55% may be consigned to water pollution control, on the basis of past investment relationships. That amount--$390 to $425 million--represents a sharp drop in the level of industrial water pollution control investment from the $500 to $600 million of 1967, during a year of record capital spending. Strong inflationary pressures during the year may be thought to have reduced the effectiveness of the investment. The amount--even without adjustment for the greater than expected inflation of construction costs that occurred--is well below the mean goal of $502.6 million for industrial waste treatment investments in 1968 that was established in the first report of this series.

Finally, the forty percent increase in investment planned for 1969 must be considered to be suspect, in view of the wide (49%) difference between actual expenditures in 1968 and report plans.

Unfortunately, the area of certainty is so small with respect to industrial water pollution control that is is impossible to evaluate the real significance of the indicated drop in investment during 1968. Certainly, deviation from the targeted goal is not in itself enough to cause concern. The range of target expenditure levels--$328 million to $677 million--is so great as to indicate that, in spite of the drop in spending, industry may still be making acceptable progress toward the goal. The gap between projected and actual expenditures in 1968 may well be traceable to slow deliveries and extended construction schedules, problems that plagued all types of construction in the super-heated capital spending atmosphere of

TABLE 7
Industrial Pollution Control Investments,
as Reported by McGraw Hill
(Millions of Dollars)

INDUSTRY	Projected 1968	Actual 1968	Planned 1969
Iron & Steel	$ 144	$ 123	$ 184
Nonferrous metals	37	13	51
Electrical machinery	116	38	47
Machinery	41	58	83
Autos, trucks & parts	66	29	49
Aerospace	8	14	15
Other transp. equipment (RR Equipment., ships)	3	12	17
Fabricated metals & instruments	41	40	57
Stone, clay & glass	40	33	56
Other durables	89	28	93
TOTAL DURABLES	585	388	652
Chemicals	112	104	126
Paper & pulp	91	91	104
Rubber	6	6	11
Petroleum	102	157	160
Food & beverages	32	15	31
Textiles	26	13	19
Other nondurables	40	2	10
TOTAL NONDURABLES	409	388	461
ALL MANUFACTURING	994	776	1,113
Mining	83	49	71
Electric & gas utilities	481	223	284
ALL INDUSTRY	$1,558	$1,048	$1,468

the last two years. Nor is it unlikely that a number of industrial pollution control projects were revised to take advantage of public waste handling facilities, a practice that appears to be increasingly prevalent. (The practice could conceivably have reduced the level of industrial investment in two ways: 1) substitution of public facilities for planned treatment plants would cause a positive shift of investment to the public sector; 2) delays encountered in public investment would cause postponement of industrial investments for connection and transmission facilities.)

The lack of reliable information on industrial water pollution control activities might be considered to be intolerable, if the nation had not become quite habituated to it. The guessing process has gone on for so long that it is considered quite normal; and every effort to initiate an industrial waste inventory has been frustrated without noticeable public comment.

In an effort to reduce the area of uncertainty, FWPCA has contracted with the National Industrial Conference Board to survey a substantial number of manufacturing firms during 1970 with respect to their water pollution control practices and expenditures. It is the hope of the Federal Water Pollution Control Administration that the use of a private contractor with an impeccable reputation for discretion and accuracy will reduce management fears of disclosure--fears based, apparently, on a desire to maintain integrity of proprietary kinds of data as much as on the possibility of the use of such data for enforcement purposes if Federally collected--and assure the agency of reliable information of a breadth and point beyond anything previously attained for the industrial waste treatment activity. Given industrial cooperation with the proposed survey, FWPCA should be able to report to the Congress in 1971 with authority beyond anything previously attempted in connection with industrial waste treatment.

Special Studies

In late 1968 and early 1969, the American Petroleum Institute and the Manufacturing Chemists Association published papers on pollution control expenditures relating to broad surveys of their memberships. Those reports, interesting in themselves, are also of value for their corroborative properties. In general, they support the findings of the 1968 report to Congress on The Cost of Clean Water, as those findings relate to the specific industrial sectors; and the investment rates indicated are of an order to magnitude that is compatible with the estimates of capital emplacement rates presented in the 1969 report on The Cost of Clean Water and Its Economic Impact.

The petroleum industry data summarized in Table 8 is based on responses to questionnaires submitted to 39 firms, 35 of whom responded. The respondents are credited with 97% of refinery throughput of

TABLE 8
Summary of Data Reported for the Petroleum Industries
by The American Petroleum Institute*

	Thousands of Dollars				
Capital Expenditures	Total	Manufacturing	Production	Transportation	Marketing
1966	79,016 1/	18,138 1/	57,968	786	2,124
1967	133,728 1/	40,000 1/	70,318	1,017	2,393
1968	122,679 4/				
Operating Charges					
1966	45,797 2/	18,339 2/	25,423	1,419	616
1967	53,246 2/	21,030 2/	30,103	1,377	736
1968	56,800 4/				
Administrative & Research Expenditures					
1966	20,903	12,759 3/	6,833	82	1,229
1967	23,842	14,681 3/	7,757	101	1,303
1968	26,200 4/				

*Source: Report on Air & Water Conservation Expenditures of The Petroleum Industry in the United States, Crossley S-D Survey, Inc., New York, August 1968.

1/ Includes $1,491,000 in 1966 and $6,770,000 in 1967 at chemicals plants
2/ Includes $3,375,000 in 1966 and $3,609,000 in 1967 at chemicals plants
3/ Includes environmental research and testing that cuts across functional lines.

4/ Estimated

the industry, so results may be considered to include substantially all of the manufacturing segment of the United States petroleum industry. Given the predominant integration of the industry, it may be inferred that a majority of crude oil and gas production is also represented. The data is unsatisfying in some respects. It fails to provide an assessment of total value of capital in place, and it provides no indication of the effectiveness of expenditures.

It does provide some very useful new insights into the total industrial pollution abatement situation, however. Surprisingly, expenditures in connection with petroleum extraction have exceeded those in manufacturing activities. Another surprising relationship is the high ratio of research and administrative charges to operating charges. Even allowing for public relations motivated padding, it would appear that hidden costs of pollution control are significant enough to warrant considerable industrial interest.

The Manufacturing Chemists Association data summarized in Table 9 are in several ways more useful than that available for the petroleum industries. In addition to information concerning recent investment and operating charges, it provides a comprehensive look at total investment, water use, and investment efficiency that is based on 987 plants operated by 129 firms that represent 90% of the chemicals production capacity of the nation.

Interestingly, the industry's reduction of organic wastes--about 57%--is almost precisely the same as the 59% calculated for the aggregate public waste treatment plant of the nation. The report also notes that of the industry's total surface water discharge, 38% required no treatment, 45% met all regulatory treatment requirements, and only 17% involved some kind of waste treatment deficiency. In this connection, it should be noted that the limited reduction of inorganic wastes--only 27%--does not take into account the effects of neutralization, a widely used treatment technique that does not involve actual materials reduction.

A detailed report on waste disposal in the inorganic chemicals industry was prepared for the FWPCA under contract by Cyrus William Rice Co. in cooperation with W. Wesley Eckenfelder, Jr., Resource Engineering, Inc., and Datagraphics, Inc., (separately printed as Volume III of this report). It presents a description of the industry, and the costs it would incur in attaining various levels of pollution abatement over a five year period through 1974. The cost estimates have been based upon published data, general data derived from information in the files of the Contractors' on industrial waste treatment methods and costs, and specific data from 59 inorganic chemical plants, some of which were supplied by the Manufacturing Chemists Association.

The inorganic chemical industry was defined to include establishments producing alkalies and chlorine, industrial gases, inorganic

TABLE 9
Summary of Data Reported for the Chemicals Industry
by the Manufacturing Chemists Association

Water Use (Gallons/Day)		
Total		11,695,875,000
Cooling water only		9,301,262,000
Water Discharged (Gallons/day)		
Total		11,192,385,000
Through public sewers		191,735,000
Inorganic Wastes (Pounds/Day)		
Total		205,088,000
Discharged to water		146,911,000
Discharged to public sewers		2,348,000
Organic Wastes (Pounds/Day)		
Total		11,481,000
Discharged to water		3,943,000
Discharged to public sewers		1,005,000
Water Pollution Control Expenditures		
Capital investment through 1966	$	385,268,000
Operating charges, 1966	$	59,638,000
Average Annual investment, 1962-66	$	28,128,000
Average Annual investment projected, 1967-71	$	47,140,000

Source: Toward A Clean Environment, A 1967 Survey of the Members of the Manufacturing Chemists Association.

pigments, paints and allied products, fertilizers (excluding ammonia and urea), inorganic insecticides and herbicides, explosives, and other major industrial inorganic chemicals. The complex relationship which exists between various products and industries, however, make it extremely difficult to arbitrarily associate certain products with one category. The overall output of the industry, since its products are used for a wide variety of purposes well removed from the final consumer, depends upon the level of total economic activity rather than the economic activity in any one segment of the economy. Since new mineral sources are discovered infrequently and usually involve large development expenditures, wide fluctuations in the gap between demand and readily available supply are quite common.

Total production in the inorganic chemical industry is estimated to be 328.7 billion pounds in 1969 and is projected to be 455.5 billion pounds in 1974. While certain segments of the industry are growing as rapidly as 18% per year, the historical growth is 1.5 to 2.0 times that of the gross national product. The overall price index of inorganic chemicals, however, has fallen 2.5 percent in the recent past. Thus, expenditures for pollution control may be of greater relative significance than in other industries where rising prices more readily absorb increased costs.

Regional growth rates reflect a continuing trend to move production facilities closer to raw materials and markets. The industry, as a whole, is tending to concentrate in the Midwest and Southwest.

Inorganic chemical plants vary greatly in size, level of technology, product mix, and age. The report presents in considerable detail the description of the various production processes, the waste treatment methods practiced, and the possible impact that changes in processes might have on the volume and character of the wastes produced. A typical or average plant exists only in the statistical sense. Total costs given in the report are for the construction and operation of waste treatment facilities for the industry as a whole, and cannot be used to determine costs for individual plants. The costs given are for the waste treatment facilities only, and do not include costs entailed in process changes, restriction of plant operations, or sewer segregation. Treatment system construction and operating costs for a particular plant can only be estimated by detailed engineering studies.

Projections based upon the chemical industry data in the 1963 Census of Manufactures, the 1967 Manufacturing Chemists Association survey, the 1968 FWPCA study of the organic chemicals industry, and the costs of treatment for the two levels of 27% (the current rate of removal, according to the MCA) and 100% removal of contaminants show the following projected operating costs and cumulative capital investment for wastewater treatment.

TABLE 10

PROJECTED CUMULATIVE INORGANIC CHEMICAL INDUSTRY CAPITAL COSTS FOR WASTE TREATMENT

% Removal	Costs in Millions of Current Dollars 1/ 1969	1970	1971	1972	1973	1974
27	299.3	325.4	359.9	400.1	445.4	494.7
100	1808.4	1964.0	2173.2	2416.3	2689.0	2970.0

PROJECTED INORGANIC CHEMICAL INDUSTRY ANNUAL OPERATING COSTS FOR WASTE TREATMENT

% Removal	Costs in Millions of Current Dollars 1/ 1969	1970	1971	1972	1973	1974
27	82.0	89.1	98.6	109.6	122.0	135.5
100	157.5	171.0	189.2	210.5	234.2	260.2

1/ Based on an average 3.6% annual increase in the price level plus anticipated growth.

Contaminated wastewater from the inorganic chemicals industry comes primarily from electrolysis and crystallization brines, washings from filter cakes, spent acid and alkalies, and washings from raw materials. These wastewaters are generally characterized by dissolved solids and suspended solids. In addition to contaminated waste streams, process cooling discharges occur, accounting for 40 to 80% of the total discharge on the average. Treatment practices vary but involve in-plant segregation of contaminated wastes from uncontaminated cooling waters. Equalization, neutralization, sedimentation and lagooning processes are most widely used. Biological treatment is not applicable, since the contaminants are primarily dissolved or suspended inorganic materials. Plants with small discharges tend to employ only equalization and neutralization, with total discharge to municipal sewer systems for joint treatment. It is estimated that between 10 and 20% of the process wastewater discharge of the industry is to municipal systems (4.2% of the total discharge). No significant percentage changes in this regard are expected through 1974. The inorganic chemicals industry has generally found that in-plant, separate treatment has economic advantages, particularly when significant quantities of wastewater are involved.

Data from 59 inorganic chemicals plants were obtained and formatted according to the Industrial Waste Treatment Practices Data Form, which was developed for the study "The Cost of Clean Water and Its Economic Impact, Volume IV," United States Department of the Interior, January, 1969. The data obtained are given in some detail in the report in terms of bar graphs and various calculated parameters relating wastewater volumes, plant production, and costs.

Key parameters of interest regarding waste treatment costs are the following:

Average capital cost	$223/1000 gpd
Average operating cost/yr.	$59.49/1000 gpd
Average wastewater flow	16.73 gpd/annual ton of production
Average capital cost	$3.74/annual ton of production
Average operating cost	$0.98 per year/annual ton of production

An examination of the survey data showed that the reported bases of waste treatment decisions were generally least cost, or minimum compliance with pollution control regulations.

The costs of unit wastewater treatment methods were developed and are presented in the report as a series of mathematical models and cost function graphs. These data were used to calculate capital costs of waste treatment facilities versus two levels of pollutant removal for a series of typical plants. Treatment level I was chosen because it represents the reported average treatment employed in the industry at this time and is judged to be equivalent to 27 % removal of suspended and dissolved solids. Treatment level II represents complete removal of contaminants. Only two levels were selected, because the industry's wastes are principally inorganic solids that respond only to physical treatment processes. Because there are no intervening technologies, intermediate levels of efficiency are not distinguished. The two levels, then, may be viewed as a range bounded on the one side by the current level of efficiency and on the other by universal application of exotic treatment practices. An almost infinite number of intermediate positions are possible within the range, but only as the conditions that apply to individual units of the population change. Unlike the case of organic wastes, there is no series of technological plateaus through which the whole population may progress.

The following summarizes the capital and operating costs in 1969 dollars for the two levels of treatment chosen:

% Removal Contaminants	Capital Cost $/1000 gpd	Operating Cost ¢/1000 gal
27 (SS and Acidity)	300	26.0
100 (TDS)	2185	51.5

DEVELOPMENT OF INVESTMENT NEEDS

It is widely recognized that the pollution control effort, in spite of the advances made in the last fifteen years, is inadequately funded, but there is a high level of uncertainty with respect to what may be an appropriate amount of funding.

That uncertainty must be ascribed to two factors, an inadequate grasp of the constituents of demand and failure to establish a time frame. The question that is most often posed is "how much must we invest?" That question cannot be answered unless we establish finite terms of accomplishment--including both a time schedule and a prevailing level of control of public wastes. It must be recognized, too, that the terms of accomplishment cannot be fixed indefinitely. One time period is followed by another; and the necessities of control levels will be dictated by successive economic and population situations, by the dynamics of technological capabilities, by the effective public preference for unpolluted water; and these will--as they bear upon investment--be conditioned by price level changes.

Recognizing that problems of definition have tended to obscure every assessment of investment need that has been made in the past, the economic staff of the Federal Water Pollution Control Administration devoted a major portion of its efforts during 1969 to isolating and examining the major constituents of public waste-handling investment behavior. While subsidiary questions--notably the trend of real construction costs over time and regional variation in unit costs--force themselves to attention, the prime focus of the study was the rate of formation of demand for waste-handling capital.

The result of that year of study--which depended heavily on the previous analyses reported upon in The Cost of Clean Water (January, 1968) and The Cost of Clean Water and its Economic Impact (January, 1969) as well as upon supplemental studies conducted in the Federal Water Pollution Control Administration and elsewhere--is the conclusion that the nation is currently forming demands for public investment capital at a rate very close to a billion dollars a year. Under the existing set of technological competences and regulatory conditions, the level of waste treatment required of local governments implies the expenditure of about a billion dollars a year in addition to any amount that must be invested to get the current stock of capital up to the stipulated level of waste treatment.

An Evaluation Model

The evaluation is significant enough to warrant a generalized description of the analysis upon which its rests, even at the risk of some tedium.

Two analytical procedures were conducted in parallel, one based upon normative influences, the other upon recorded situations. The basic analytical tool was, in either instance, the same, a mathematical simulation of investment in public waste handling systems.

Extremely simple in concept, that mathematical modelling of the value of physical capital has proved to be very complex in the construction. Indeed, at this writing it remains a crude--but hopefully reliable--evaluation technique that is still undergoing extensive refinement. In its present form, the model correlates a series of equations that define size to average cost relationships (in constant dollars) for basic waste-handling procedures and equipment with the current Municipal Waste Inventory. Two separate modelling programs are employed. One involves scanning the inventory and assessing for each recorded sewerage system the cost of constructing or installing component elements--other than collecting sewers--of the size and description of those included in the system. The second program ignores--except for their sizing qualities--installed facilities. It scans the inventory for the needs recorded by the State governments who are the prime source of the Municipal Waste Inventory. For each category of need, the program calculates the average cost of installing or constructing the particular facilities--sized according to a normal statistical distribution of capacity to indicated load.

The aggregated results for the two programs are presented in both constant and September, 1969 dollars in Table 11.

The Analytical Procedures

The fact that $4.4 billion worth of needed improvements were listed in the most recent compilation of public waste handling systems is of less than conclusive importance, in that it does not reflect the development of such needs. It does not mirror the formative imperatives of time, change, economic growth; the fact that as one set of conditions is met, new problems arise--or are created by the resolution of the old ones.

The rate of formation of such needs must be understood if a purposeful program of investment in water pollution control is to be formulated. The evaluation model, with the introduction of the element of time, provides enough information to define at least an order of magnitude view of annual investment needs development.

TABLE 11

Evaluation of Capital in Place and of Defined Needs, 1969

	Value of Works in Place		Value of Needed Works	
	1957-59 Dollars	Current Dollars	1957-59 Dollars	Current Dollars
Alabama	139.0	191.8	89.0	122.8
Alaska	1.1	1.5	6.0	8.3
Arizona	45.6	62.9	14.8	20.4
Arkansas	107.0	147.7	32.2	44.6
California	769.1	1061.4	273.3	377.2
Colorado	165.9	228.9	31.3	43.2
Connecticut	89.0	122.8	53.2	73.4
Delaware	25.0	34.5	2.5	3.5
District of Columbia	33.6	46.4	20.4	28.2
Florida	312.4	431.1	35.1	48.4
Georgia	204.2	281.8	89.7	123.8
Hawaii	16.8	23.2	18.8	25.9
Idaho	58.0	80.0	24.3	33.5
Illinois	497.2	686.1	141.2	194.9
Indiana	313.0	431.9	100.9	139.2
Iowa	206.5	285.9	32.1	44.3
Kansas	184.5	254.6	59.8	82.5
Kentucky	140.5	193.9	11.8	16.3
Louisiana	140.1	193.3	57.4	79.2
Maine	17.9	24.7	66.5	91.8
Maryland	88.3	121.9	20.5	28.3
Massachusetts	102.2	141.0	151.6	209.2
Michigan	252.3	348.2	98.3	135.7
Minnesota	205.2	283.2	39.4	54.4
Mississippi	109.9	151.7	36.2	50.0
Missouri	229.0	316.0	107.8	148.8
Montana	54.7	75.5	16.4	22.6
Nebraska	124.0	171.1	27.7	38.2
Nevada	29.6	40.8	12.3	17.0
New Hampshire	16.3	22.5	44.6	61.5
New Jersey	304.4	420.1	117.4	162.0
New Mexico	71.6	98.8	7.4	10.2
New York	580.4	801.0	200.0	276.0
North Carolina	248.3	342.7	73.7	101.7
North Dakota	56.4	77.8	4.8	6.6
Ohio	484.7	668.9	166.6	229.9
Oklahoma	171.7	236.9	23.0	31.7
Oregon	124.4	171.7	46.5	64.2
Pennsylvania	424.2	585.4	262.5	362.3
Rhode Island	38.1	52.6	16.6	22.9
South Carolina	113.1	156.1	48.5	66.9
South Dakota	58.7	81.0	10.0	13.8
Tennessee	168.5	232.5	52.0	71.8
Texas	639.1	882.0	117.0	161.5
Utah	87.5	120.8	20.3	28.0
Vermont	20.8	28.7	29.6	40.8
Virginia	166.2	229.4	47.5	65.6
Washington	143.2	197.6	65.3	90.1
West Virginia	73.9	102.0	54.3	74.9
Wisconsin	254.3	350.9	90.2	124.5
Wyoming	38.2	52.7	6.4	8.8
Puerto Rico	34.1	47.1	23.6	32.6
Virgin Islands			2.7	3.7
Totals	8979.7	12392.0	3201.1	4417.5

The first of the two procedures used to determine the rate of formation of demand for investment capital consisted of a simple comparision of recorded needs over time, applying the same modelling procedures to the 1962 Municipal Waste Inventory that were used to evaluate the 1968 Inventory, and taking into account the investment that occurred between inventories. The analysis took the form:

$$A = \frac{(X - Y) + I}{T}$$

Where:
- A= average annual investment demand developed during the period,
- X= investment demand, as defined by the Inventory at the beginning of the period,
- Y= investment demand at the end of the period,
- I= actual investment, adjusted to base period prices, over the period,
- T= number of years between inventories.

It is recognized that there is a measure of over-simplification in the equation. It implies an effective identity of replacement with depreciation, not at all a good assumption in a period like the present when most of the physical capital involved is of relatively recent origin; and it neglects changes in real costs that have occurred between 1962 and 1968 by evaluating the earlier period's needs in terms of current cost functions. The basic formula, however, is considered to be logical; and adjustments are possible. Expressed numerically, it provides a value of about 500 million (1957-59) dollars a year for the capital requirements posed by depreciation, growth, and system improvement:

$$\frac{(3201.1 - 3001.7) + 2759.3}{6} = 493.2$$

The second analytical procedure involved the use of normative standards (rather than regulatory/engineering determinations) in conjunction with the evaluation model. Established rates of depreciation were applied to the estimated replacement value of waste treatment plants (4% based on a twenty-five year average life), and to the estimated value of ancillary works such as interceptor sewers, outfalls, pumping stations, and force mains (2%, based on a fifty year average life--presumably somewhat greater than fifty years for the sewer component, somewhat less for other facilities). In similar fashion, growth of demand was assessed by projecting a continuation of the rate of increase in the hydraulic loading of municipal waste-handling systems that took place in the period 1957 to 1968, or 3.3% a year.

The exercise produced a set of values that were incredibly close to those derived from point by point evaluation of recorded needs. As presented in Table 12, they show a set of annual investment requirements rising from $425 million in 1962 to $584 million in 1968. The average value for the period, $504 million, is within 2.3% of the mean value developed by the first procedure, and well within the range lying within one standard deviation about the mean.

Table 12

Normative Assessment of Annual Capital Needs Generated in 1962 and 1968

	Millions of 1957-59 Dollars			
	1962		1968	
Replacement Value of Trtmt. Plants	2975.2		4132.7	
recapitalization at 4%		119.0		165.3
Replacement Value of Assctd. Works	3498.9		4847.0	
recapitalization at 2%		69.8		96.9
Loading growth at 3.3%		213.3		296.3
incremental recapitalization for plants to be upgraded at 4%		22.9*		25.5*
Annual Needs developed in year		425.0		584.0

*Value considered to be associated with primary treatment capacity required to be upgraded to secondary treatment.

Elements of the Investment Requirement

Table 13 summarizes, State by State, the computed value associated with the various categories of investment needs, as these were listed in the 1968 Municipal Waste Inventory and assessed by the evaluation model.

The most obvious needs for investment are posed by those 1500 sewered communities that discharge raw wastes to waterways. Given the existing size distribution of those communities, normal design standards, and the assumption of treatment through the activated sludge process, these plants pose a need for about $1.4 billion (1957-59 dollars) of investment--about $950,000 per community, including the investment in transmission facilities and in outfalls that is probably required for these communities, on the basis of their size distribution and the historical relationship between plant and ancillary costs for communities of various sizes.

A second fairly clearly defined category of need occurs in those approximately 2500 situations in which only primary waste treatment exists. Although primary treatment is permitted by water quality standards in some cases due to the capacity of receiving waters to assimilate wastes, the prevailing policy in the United States has come to be one that requires secondary treatment. The consequences of that policy in terms of investment, then, can be calculated on the basis of

TABLE 13

Computed Values for Various Categories of Investment Needs by State
Millions of 1957-59 Dollars

	New Plants	Upgrading	Enlargement	Disinfection	Connection to Existing System	Other Improvements	Total	One Standard Deviation
Alabama	$75.35	$5.95	$7.62			$0.12	$89.03	$13.44
Alaska	4.32	1.66					5.98	1.40
Arizona	10.80	0.20	3.76			0.05	14.81	1.99
Arkansas	9.29	10.54	6.89		$5.59		32.32	7.77
California	16.40	61.44	181.47		13.96		273.27	17.41
Colorado	5.86	5.40	19.96	$0.09			31.30	5.14
Connecticut	6.86	39.22	4.45		2.64		53.16	6.45
Delaware	0.32	2.18					2.51	0.43
District of Columbia			20.38				20.38	11.37
Florida	0.72	0.89	33.46				35.07	4.94
Georgia	36.41	21.59	22.81	0.51	8.06	0.31	87.70	10.20
Hawaii	12.62	1.20	0.61		4.34		18.78	2.86
Idaho	8.47	10.44	4.63			0.78	24.32	3.18
Illinois	22.67	56.88	49.52	2.82	9.25	0.03	141.15	15.36
Indiana	32.14	12.22	46.43	6.39	3.68		100.86	8.92
Iowa	9.84	2.29	16.07	3.93			32.14	4.32
Kansas	40.19	9.03	10.33			0.22	57.77	20.75
Kentucky	3.86	6.81	1.04	0.14			11.84	3.63
Louisiana	41.65	4.18	11.53			0.02	57.38	19.25
Maine	60.57	5.79			0.13		66.49	19.17
Maryland	2.29	2.97	12.37	0.12	2.76		20.51	7.54
Massachusetts	88.50	22.63	12.46	0.11	26.30	1.64	151.64	37.01
Michigan	19.83	61.44	12.30	0.01	3.90	0.81	98.29	10.95
Minnesota	7.21	26.92	2.44	0.02	2.74	0.02	39.35	10.14
Mississippi	28.00	1.09	7.13	0.01			36.23	9.55
Missouri	98.19	5.01	4.28			0.30	107.78	31.85
Montana	5.65	9.09	1.49			0.16	16.40	3.34
Nebraska	12.35	12.34	2.94			0.09	27.72	4.08
Nevada	3.62	4.65	4.06				12.33	1.54
New Hampshire	40.18	0.56	3.87				44.61	10.38
New Jersey		101.67	15.73				117.41	15.59
New Mexico	1.75	2.79	2.87			0.02	7.42	0.95
New York	103.19	92.17	4.65				200.01	50.67
North Carolina	49.37	13.10	9.94		1.17	0.17	73.72	9.00
North Dakota	4.09	0.73					4.83	0.48
Ohio	30.81	78.61	48.55	3.58	5.07		166.62	14.51
Oklahoma	4.35	11.09	6.05		1.50	0.03	23.02	3.08
Oregon	15.88	13.56	14.50	0.29	2.01	0.23	46.46	5.63
Pennsylvania	190.93	36.05	33.48	0.24	1.80	0.04	262.52	57.25
Rhode Island	4.35	3.14	2.55		0.15	6.37	16.57	2.33
South Carolina	42.84	4.08	1.61			0.01	48.54	5.77
South Dakota	6.50	2.52	0.32	0.66			10.00	1.04
Tennessee	21.89	28.54	1.56			0.02	52.01	11.97
Texas	3.06	20.97	93.01				117.04	7.62
Utah	11.46	1.77	7.04				20.27	1.84
Vermont	18.23	10.52	0.83				29.58	4.94
Virginia	5.80	21.97	2.51	0.02	17.18	0.02	47.51	6.24
Washington	7.82	17.40	14.21	0.43	25.32	0.12	65.30	9.85
West Virginia	37.99	16.26					54.25	8.81
Wisconsin	0.91	73.29	9.36	0.53	6.13		90.23	7.76
Wyoming	4.47	1.31	0.48	0.16			6.42	2.14
Puerto Rico	14.06	9.52					23.59	6.10
Virgin Islands	2.66						2.66	1.26
Totals	$1286.56	$965.67	$773.55	$20.06	$143.68	$11.60	$3201.12	$539.19

historical cost factors to require an investment of about $900 million of (1957-59) dollars, or an average of $360,000 per project.

Another $800 million worth of miscellaneous kinds of projects completes the list of current needs. In total, they indicate a most likely investment need of $3.1 billion in a range of $2.6 billion to $3.7 billion constant dollars--or, in current dollar terms, a most likely investment need for 4.4 billion September, 1969 dollars in a range of $3.6 billion to $5.0 billion.

But this fixed, presumably diminishing with time, set of values represents no more than a point on a scale. They are the current combination of those dynamic elements that underlie basic demand for capital in this economic sector. Those elements will persist; and even a vigorous public effort to reduce the accumulation of investment requirements will not end the continuing need for capital. Indeed, as the waste-producing qualities of our growing economy assert themselves, the annual capital requirements of the waste-controlling activity may be expected to increase.

It is not paradoxical that requirements expand as our level of controls expand. Before a facility is constructed its need represents a contingent liability: once built, it must be kept in operating condition, modernized, expanded, upgraded to meet conditions. Such investment requirements may be less obvious and less dramatic than the need for a plant where none exists, but they are no less real--and are often far less postponable. It follows, then, that as the level of waste control grows, so does the magnitude of the annual investment associated with waste control. There is no better means of demonstrating the compounding effect of past investments on future needs than to review the recorded needs associated with sewer systems at each of the last three municipal waste inventories. (cf. Table 14.) While the number of persons attached to sewers increased forty-two percent between 1957 and 1968, the raw number of recorded investment needs increased ninety-two percent. A different kind of investment requirement was engaged--various major and minor ungrading projects steadily replacing new plant needs over time--but both the total number of needed projects and the number of persons affected has risen.

Rising investment demand, then, is not only consistent with the general rules for a growing economy, but equally consistent with the pattern of events in the particular economic sector under consideration. Moreover, it is possible to distinguish the influences that form that demand. They may, for purposes of discussion, be considered under four general categories: 1) recapitalization, 2) growth, 3) prices, and 4) "changes in the rules of the game."

TABLE 14

Increase in State Government-Defined
Waste Treatment Needs Over Time*

Kind of Need	Number of Systems			Population Served (000's)		
	1957	1962	1968	1957	1962	1968
New Plants	2549	2143	1586	13,504.0	13,058.4	9,575.3
Replacement	973	853	625	3,101.6	3,888.2	1,719.9
Enlargement	688	809	1003	15,315.9	24,849.0	27,861.6
Additional Treatment	753	821	2130	7,687.0	8,215.8	36,327.5
Chlorination	41	42	723	598.1	201.4	2,937.8
Improved Operation	329	332	209	887.3	1,068.2	888.8
Connection	57	45	123	676.4	482.3	1,019.7
Total No. Needs	5390	5045	6399	41,770.3	51,763.3	80,330.6
Total Systems	10,511	11,006	13,849	98,361.9	118,371.9	139,726.7
% w needs	51.3	45.8	46.2	42.5	43.7	57.5
New Facilities 1/	3579	3311	2334	17,282.0	17,428.9	12,314.9
Major Upgrading 2/	1441	3071	3133	23,002.9	33,064.8	64,099.1
Minor Upgrading 3/	370	374	932	1,485.4	1,269.6	3,826.6

*Source: Municipal Waste Inventory, 1957, 1962, 1968

1/ New Plant, replacement, connection
2/ Enlargement, additional treatment
3/ Chlorination, improved operation

Recapitalization

Table 12 presents an effort to quantify and evaluate the dimensions of annual recapitalization needs as they exist in mid-1969. The constant dollar replacement value of all public waste transmission and treatment facilities is calculated to be about $8.9 billion. In the real world, recapitalization needs tend to occur in staggered fashion, so that investments for any particular system (except, perhaps, for a few of the very largest) are characterized by a considerable lumpiness. For the aggregate system of the nation, however, it is reasonable to assume that recapitalization needs will reflect in fairly precise measure normal design standards. The analysis, then, has assigned a replacement factor of four percent for treatment plants and two percent for ancillary works, adopting as points of departure the twenty-five year and fifty year design lives that civil engineers ascribe to such facilities. Basic physical capital, then, is depreciating at a combined rate of about 2.9% a year. In 1969, the calculated recapitalization need created amounted to about $260 million 1957-59 dollars.

Misconceptions often surround the theory of depreciation or replacement. As these factors are viewed in this paper--and as they occur in the real world--they apply as a series of intermittent investments that duplicate the original cost of an installed facility within a given period of time. Recapitalization factors, then, are not intended to reflect some theoretical wearing out or mere bookkeeping transactions; they represent tangible outlays incurred in connection with existing facilities.

(There may be some question about the accuracy of the assigned depreciation rates. They depend on design factors rather than empirical data. Information on replacement is scarce, and its interpretation is obscured by the overlap of replacement, upgrading, and improvement that is involved in the usual project that involves an installed facility. The information that we do have--covering just over ten percent of all recorded sewerage systems--indicates that ten percent of all plants undergo a <u>major</u> revision within five years of their construction date; and that within fifteen years of their construction, forty-five percent of all plants undergo some major revision. (cf. Table 15.) On this basis, the four percent recapitalization factor is, if anything, conservative.)

Growth

The growth rate built into the calculation of annual investment need is high, indicating a demand for capacity that is compounding at 3.3 percent per year. The rate is based on recorded increases in average daily flow between 1957 and 1968. It includes both the period of maximum treatment plant construction in the nation's history, and more recent intensive industrial connections to public facilities.

TABLE 15

Frequency of Major Treatment Plant Revisions

Last Revision Since	No. of Plants Identified	Plant Built								
		1964-68	1959-63	1954-58	1949-53	1944-48	1939-43	1934-38	1929-33	1928 or before
1963	775	78	153	118	67	21	119	103	54	62
1958	453		30	51	42	15	84	85	56	90
1953	133			9	11	4	32	27	23	26
1948	36					2	8	8	7	11
1943	3						1	2		
1938	4									4
1933	2								1	1
TOTALS	1406	78	183	178	120	42	244	225	141	194

It may be expected to moderate in the future. This paper, however, relates only to needs to be anticipated over the next five to ten years; and within that time frame, there is no reason to expect a decline in the rate of growth. If anything, the trend toward broader industrial connections may effectuate an interim increase in the growth of demand.

There are three processes of accommodating growth. Newly sewered communities or subdivisions--wholly new sewer systems--are the least significant source of demand, though they are also the easiest to quantify. On average, about 280 new sewer systems come into being in the United States every year. The second, and more significant, growth process involves an expanded demand on an existing system. In this case, newly sewered residential areas or newly connected factories add their demands to those of a system already in place. They can be accommodated in either of two ways, either through the construction of new facilities or by taking up previously unused capacity provided to accommodate just such growth. In either of these last two conditions, growth will ultimately require construction. Indeed, the first case, where additional capacity must be installed, is simply an extension in time of the second. Growth can be accommodated in an existing plant to the point that all capacity is taken up; at that point, an investment need is created.

Because it is customary to design plants to provide for the growth of service anticipated within the life of the plant--normally a period of twenty-five years--most of the $300 million a year need for expansion is currently being met out of existing capacity. Since the age composition of the nation's stock of treatment plants is conditioned by high investment in the last decade, the nation has been able to continue to extend its total level of waste control over the last few years. It should be noted, however, that not all of the capacity now available for growth will be usable within the normal life of the present stock of plants. Almost all waste treatment plants are built to accommodate enlarged demands, but not all communities grow. The naive projection techniques employed by consulting engineers have tended to create a pool of excess capacity that will never be used in small, static communities. Conversely, treatment plants built to conventional sizing standards in other places have proved entirely inadequate to meet the demands of recent industrial connections. The aggregate supply of treatment services probably exceeds the aggregate demand for such services. Unfortunately, the supply is not entirely located at the same places as is the demand; and with time, the dislocation will become more significant. That fact is one of the pressing reasons for increasing the level of investment in public waste handling facilities at the earliest possible date.

Prices

One of the central economic perceptions of the last five years has been growing discomfort caused by price increases; prices have been rising at accelerating rates.

For municipalities, with their ultimate responsibility for installing and operating waste handling systems, increased prices have entailed a more direct constraint on pollution abatement activities than have more substantive national economic problems. Business cycle fluctuations, structural unemployment, and accommodation of a growing labor force have impinged on the operations and finances of local government, but only indirectly. But the resumption of the rate of price increases experienced in the nineteen-fifties has had an enormous impact on local government funding capacities. Even during the relative respite from inflationary pressures experienced from 1960 through 1964, county and municipal governments were unable to meet out of relatively inflexible tax bases increasing pressures of real demand for social and environmental services. In that context of inadequacy, rising prices have had a serious effect. Throughout the economy, the only sector that has suffered more from price increases than local governments is probably the very poor; and even their difficulties stem in part from State and local governments' losing struggle to maintain their share of welfare services.

It is customary to consider the problem of rising prices rather offhandedly as "inflation". But for local waste handling needs, the problem has three aspects; and of these, inflation has probably not been as serious in itself as through its effects on the cost and availability of money. While the prices of labor and materials consumed in constructing and operating a waste handling system have advanced quite steeply, the advance in the cost of monies has had an even more pronounced effect on expenditures, and the scarcity of funds--even at advanced prices--has constrained capital outlays for treatment and collection systems even where willingness to construct was strong. Not inflation so much as the money rationing procedures of financial markets have reduced local government's ability to come speedily to grips with its waste handling problems.

It is difficult to document the observation except by example, since there is no register of bond issue cancellations or deferrals. Examples are plentiful, however. At the close of its 1969 fiscal year, the State of California reported deferral of a billion dollars of voter-approved bond issues--80% of them for financing of water resource projects. Federal Water Pollution Control Administration regional offices have reported a number of instances of postponement of municipal financing of treatment works in cases in which a Federal grant has been solicited. The June 8, 1969 issue of The New York Times (1:2) mentioned in a feature article on the effect of interest rates no less than fifteen cases of municipal projects cancelled or delayed by financial constraints--and these apparently represented not an attempt at comprehensive reporting, but simply random examples, probably chosen for their dramatic nature. In many cases, the absolute shortage of funds is reinforced in its impact on local financing by statutory interest rate ceilings or limitations on indebtedness.

While reduction of the relative supply of funds may be the most serious source of inflationary constraints on pollution abatement, direct effects are not to be slighted. Over the last twenty years, the cost of constructing a waste treatment plant--as measured by factor costs--has almost doubled. Opportunity costs, as measured by interest rates, have nearly quadrupled--which, working on the inflated construction cost base, has increased the cost of financing a plant more than six-fold. In combination, these factors have caused it to cost three times as much to finance and build a waste treatment plant today as the same plant would have cost in 1950; and half of that increase in cost has taken place in the last five years. (cf. Table 16).

TABLE 16

Escalation of the Cost of A $1,000,000
Waste Treatment Plant, 1950-1959

Year	Interest Rate*	Const. Cost Index**	Cost Rise over Previous Period: Interest	Cost Rise over Previous Period: Construction	Total Cost (25 yrs.)
1950	1.56	69			$1,195,000
1955	2.18	89	$ 148,350	$260,000	1,603,350
1960	3.26	105	276,050	260,000	2,139,400
1965	3.16	113	28,400	120,000	2,287,800
1967	3.74	120	165,650	100,000	2,553,450
1968	4.28	124	149,550	60,000	2,763,000
1969	5.91	132	448,000	110,000	3,321,000
Cumulative Cost Increases			$1,216,000	$910,000	$2,126,000

* Moody's State and Local Aaa, June 30.
** Sewage Treatment Plant Cost Index, FWPCA

Those increases can be quantified and projected for our evaluation model. The $3.2 billion evaluation of current year investment requirements amounts to $4.4 billion when base year costs are escalated to September, 1969 price levels, and it is only reasonable to assume further increases in prices. Over the last five years the annual increase in factor costs has amounted to 3.2% to 3.7%; and this paper will project future costs to include a 3.5% annual cost increase coefficient.

Changes in The Rules of the Game

The area of evaluation that presents the greatest difficulty is the problem of definition. The evaluation model, and the proposed investment schedule developed at a later point in this paper, rest upon a given set of conditions, the rules of the game as it is generally played today. But there is nothing sacred about those rules--today's are very different than those of five years ago, for example--and any basic change must have a fundamental effect on investment conditions.

Some possible changes are almost predictable. There is, for example, a very pronounced tendency to require treatment of sewage for removal of phosphate. No price tag has been attached to that type of treatment in this paper for two reasons: at this time, phosphate removal is a specialized and localized kind of requirement; and there is no preferred--or even accepted--technique of accomplishing it. The most likely treatment methods appear to involve very slight incremental investments, but extremely large increases in operating costs for purchase of chemical additives. Should a capital-intensive method of treatment become available, should phosphate removal become a universal requirement, investment requirements might be expected to shift powerfully upward. Conversely, if soap producers were to find an acceptable alternative for phosphorus-based detergents (and there is increasing pressure in western Europe to require such a course), then this particular influence on costs might diminish.

An example of the way in which a shift in the rules of the game has already influenced costs may be adduced by reference to Table 14. Between 1957 and 1962, the total number of needs associated with public sewerage systems declined, in spite of an increase in the number of systems. Between 1962 and 1968, however, needs increased sharply, even though investments were much greater between those years than in the preceding period. Interposition of water quality standards and application of the secondary waste treatment requirement, a major change in the rules, created an entirely new definition of what might constitute a need, forcing required investment levels sharply upward.

Nor are changes always determined administratively, or applied across the board. The internal pressures of engineering practice condition the rules of cost; and local preference may dictate specialized sets of rules.

Engineering practice has certainly been changing as money has become increasingly available for water pollution control investments. There has been a growing tendency to use the more expensive of the secondary waste treatment processes, to construct plants of larger size relative to current loading demand, and to utilize additional mechanical operating components. Treatment plants that are being built today are quite different from those of a decade ago in a number of ways. The underlying technology is the same, including a mixture of physical and biochemical reactions that take place in a series of tanks connected by piping and pumping; but there has been a strong effort to improve the engineering of those reactions, to build into facilities greater reliability and longer life. More stages are automated. Monitoring has become more sophisticated. More durable materials are being employed. Much more attention is being paid to sludge handling and incineration is being employed in a growing number of instances. As a result, the cost of treatment systems has been going up, quite apart from price level increases. Indeed, the increase in real costs has matched or exceeded the increase suffered as a result of inflation over the last five or six years, judging from a statistical study of comparative pricing patterns in 1961-63 and in 1967-69. (R.L. Michels: Construction Costs of Municipal Wastewater Treatment Plants, 1967-69 .) In terms of construction put in place between 1962 and 1968, those increases in real costs are estimated to have added about $400 million to the investment associated with waste treatment plant construction.

TABLE 17

Constant Dollar Investment Per Unit Capacity
Activated Sludge Plant, 1961-63 and 1967-69

Capacity of Plant (Pop. Eqvlts.)	Investment/P.E. Capacity ($1957-59)	
	1961-63	1967-69
1,000	66.00	87.50
10,000	29.50	43.00
100,000	13.00	21.50

The effects of local preference can result in substantial differences in waste treatment investment. The water quality standards adopted by the State of Indiana call for the construction of 45 advanced waste treatment plants--representing the majority of the standards-required advanced waste treatment needs for the entire United States. In the western States, waste stabilization ponds are the most prevalent treatment measure; and the low cost installations serve to reduce unit costs to a fraction of the amount required by mechanical treatment plants. In the Northeast, however, such facilities are almost unknown. In the Southwest, the treatment of industrial wastes in municipal facilities is a rarity; in the Pacific Northwest, and increasingly in New England, it is becoming standard practice. New York and New Jersey, in connection with their extremely vigorous pollution control programs, seem to be engaged in major rehabilitation of sewerage systems already in place, scheduling very large sums for replacement and integration of existing facilities. Without casting judgements on the relative effectiveness of these or other expressions of differing local interpretations of the rules of the game, one can conclude that they have an enormous power to influence investment totals.

Locational Influences on Plant Cost

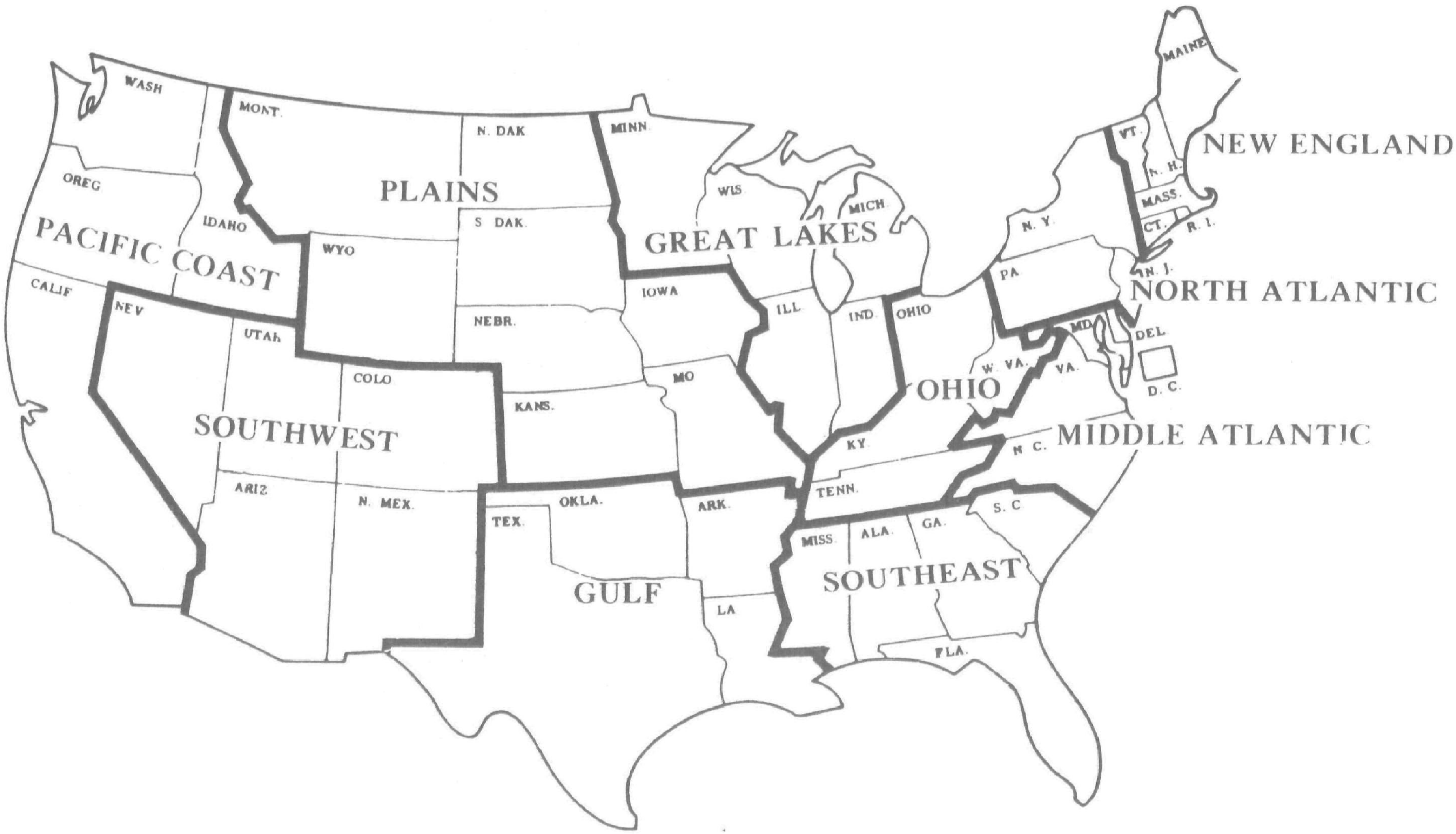
Reported investment data, when related to municipal waste treatment inventories, indicate that there are enormous differences between regions of the United States in the capital efficiency of public waste-handling.

Between 1962 and 1968, local governmental units invested, on average, about $120 for each person reported to be added to a public sewer system. About $187 more was invested in waste treatment and transmission for each additional population equivalent of biochemical oxygen demand from domestic sources that was reduced in waste handling systems. (The figures are not adjusted for additions or subtractions from excess capacity. They were derived by dividing total investments made in the period 1962 to 1967 by the incremental waste collection and reduction calculated to be achieved during the same period. To the extent that total capacity was increased beyond the level of actively utilized capacity and to the extent that wastes from industrial sources were added to the system, unit investments are overstated. They do, however, provide an adequate measure for comparison of regional expenditures, since they weigh on a consistent basis the investment associated with an homogeneous incremental product.) Application of the technique to investments made by blocks of States thought to be economically, politically, and geographically similar produced results that point to wide regional variations in waste handling costs. At the extremes, it cost $2.75 in the highest cost area to buy the incremental waste handling effectiveness purchased for a dollar in the lowest.

The numerical results of the analysis are not reproduced here for several reasons. It is recognized that the basic data are not in all respects compatible or reliable. The analysis concerns itself with total costs but incremental efficiencies in a situation where much of the investment that was made is recognized to have been for purposes of replacement rather than for new or upgraded facilities. Differing regional propensities to treat industrial wastes have a distorting effect on results. And by the very nature of the analysis, regions with high rates of population growth tend to appear distinctly more efficient, in that their more rapid uptake of excess capacity has the effect of applying a lower apparent rate of discount. To describe unit cost differences under these conditions might be thought to stigmatize unfairly the regulatory or construction competencies of the higher cost areas; and the results of the analyses are felt to be too hazy in detail to be presented in quantitative forms. However, the conclusion that unit costs vary substantially with location is too firmly founded to be doubted, regardless of definition difficulties. Moreover, the pattern of difference is quite clear. Cost rises as one moves eastward and northward: they tend to be highest in New England and States bordering the Great Lakes, lowest in the southwestern and Gulf Coast States. (Groups of States are ranked according to relative costs at several points in the discussion that follows, and the composition of the various groupings is defined in Figure 2.)

Figure 2

Regional Definitions for Analysis of Comparative Unit Investment for Incremental Waste-Handling Capabilities, 1962-1968



Examination of investment programs on an aggregate basis has failed to produce satisfactory explanations of cost differentials of the magnitude indicated. A number of possible explanations have been adduced by the analytical staff and by observers in Federal Water Pollution Control Administration regional offices, State government, and the consulting engineering industry. In some cases, information was available to allow a proposed explanation to be tested in broad fashion. In some cases, the reason proposed for cost differences was so intangible or so illogical (e.g., criminal domination of construction activities) as to allow it to be discarded, even when investigation could not be attempted. A number of very reasonable propositions remained after preliminary consideration eliminated the obviously misdirected and the intangible; but whether any of these, or any combination of them, accounts fully for the spread in observable returns on investment remained a problem. The array of proposed explanations of unit investment differences presented from various sources included all of the following:

(1) Data deficiencies. Information on the prevalence and methods of waste treatment and on population connected to public sewers is reported individually by the States. Although a common format is utilized, there is great variation in estimating techniques employed and in the completeness of reports. Similarly, investment data is gathered directly from State agencies, as well as from various economic reporting services, so variation in reporting practices may influence results. It should be noted, however, that unit cost variation within any of the groups of States considered was consistently found to be less than between the various groups, so that anomalies attributable to data variability must be presumed to include regionally consistent reporting deviations.

There is, in addition, independent analytical work that suggests that regional cost differences are a very real phenomenon, and not the result of reporting freaks. The State of New York, through the operations of its grant programs, has compiled a great deal of information on the capital cost of waste treatment facilities. The State's analysis of that information indicates that construction costs in New York State are consistently above national costs--and in the same general magnitude indicated by FWPCA's investigation of regional cost variation.

(2) Institutional constraints. It has been suggested that design practices that result either from administrative requirements or local habit strongly influence the relative cost of facilities in some locations. The concept must certainly receive some credence. Those States adhering to the "Ten State Standards"--i.e., States bordering the Great Lakes, Iowa, and the New England States--do include the groups that account for high unit investment requirements.

Unfortunately, it is not possible to come to any meaningful judgement as to the ultimate affect of such procedures on cost. While those responsible for their development will defend the long term economy of "high standards", the economist will generally deplore rigid standards in any field as being conducive to formalism and a barrier to innovation or improvement.

If one can conclude that institutional constraints do in fact add to costs in States of the Northeast, it is nonetheless impossible to assign more than a contributory effect to them. The effective range of technical alternatives is simply not so great as to account for the gross disparity found in regional unit costs.

(3) Industrial Loadings. Authorities in New England have suggested that one of the principal factors influencing per-capita construction costs in their region is the high incidence of public agency responsibility for treating wastes of industrial origin.

There is certainly a rough logic to the explanation, and the figures tend to bear out the assertion that industrial requirements tend to inflate per-capita costs in some areas more than in others. Because the capital requirement associated with industrial wastes is influenced by the quantity of wastewater involved more than by qualitative differences in treatment procedures, the major impact of addition of manufacturing wastes to the system can be measured through its impact on plant size.

Table 18 bears out the fact that treatment plants tend to be larger with respect to population served in New England than in other areas, and to be smaller in the Gulf and Southwest areas, where unit investments have been lowest. However, the table also indicates that greater capacity per unit of population served can by no means be considered the only--or even a principal--source of higher costs. While the smallest capacity to population served ratios occur in the areas of lowest per-capita costs, the Pacific Coast and Southeastern States combine low unit costs with a large median capacity; moreover, these States have a very significant component of plants in the largest size to population served categories. In fact, half of the regional groupings (Pacific Coast, Southeast, Middle Atlantic, North Atlantic and Ohio-Tennessee) demonstrate a precisely inverse correlation in a plotting of unit capacity ranking vs. unit cost ranking. It is clear, then, that larger construction costs per person can be only partially explained on the basis of construction of greater capacity per person.

(4) Wage Rates. It has also been suggested that regional labor cost differentials have a strong impact on unit costs. The proposal has a certain attraction that is dispelled pretty thoroughly by a review of relative costs and of wage rate differentials. About 18% of the cost of the average sewer project is attributable to direct labor (Sewer and Sewage Treatment Plant Construction Cost Index, Table VI, p. 28); and for the hypothetical waste treatment plant, the labor cost component amounts to about 25.3% (p. 12). From the region of highest labor wage rate to that of lowest wage rate, there is

TABLE 18

Normal Plant Size Related to Relative Regional Unit Costs

Regions, Ranked in Order of Ascending Unit Cost	Median Design Size to Population Served Multiple	Percent of Plants: 2.5 X Pop. Requirement	Percent of Plants: 4 X Pop. Requirement
1 Southwest	1.0 - 1.2	14.3	6.8
2 Gulf	1.0 - 1.2	6.2	3.2
3 Pacific Coast	1.8 - 2.0	38.5	13.4
4 Southeast	1.8 - 2.0	36.3	14.1
5 Middle Atlantic	1.6 - 1.8	31.9	9.5
6 Plains	1.4 - 1.6	15.2	4.5
7 North Atlantic	1.4 - 1.6	26.5	7.3
8 Ohio-Tennessee	1.4 - 1.6	22.0	4.6
9 Great Lakes	1.6 - 1.8	24.3	4.9
10 New England	2.0 - 2.5	41.3	8.5

a variation of some 50% in unit charges, or enough to explain about a nine to twelve percent variation in final costs, assuming equal productivity in all parts of the nation. Not only is the variation in labor compensation rates of several orders of magnitude less than the variation in unit costs, the relative ranking of high wage and low wage regions has only a slight correlation with high and low unit investment rankings. (cf. Table 19). At any rate, it is impossible to ascribe to wage scale differentials the kinds of cost variation that exist among the various parts of the nation unless there are also differences in labor productivity and labor application rates far more profound than has been imagined.

(5) Climate and Geology. One of the more likely explanations of a part of the cost differences centers upon the basic physical conditions found in the several regions of the nation. High unit costs cluster in areas where severe winters reduce the effective period of construction. Furthermore, grade and soil type may be expected to exert a heavy impact on ultimate costs--certainly there can be no parity between excavation requirements in the flat, sandy soils of the Southwest and in the granite hills of New England.

(6) Industry Diseconomies. It is, perhaps, not surprising, but explanations for unfavorable relative cost position advanced from the northeastern cluster of States have in no case included engineering or contractor deficiences. Rigid administration, political corruption, and union wage scales have all been indicated by engineers; but no one has seen fit to suppose that unfavorable cost comparisons may trace to the groups ultimately responsible for system design and construction. Yet design and overhead charges make up a significant portion of the total cost of any project (cf. Table 20). Moreover, sharp increases in national allocation of resources to waste handling--in 1957, in 1961, in 1963, in 1967--have in every case resulted in a marked inflation of project costs that most authorities agree to be traceable to constraints on the supply of engineering and construction services. Professional qualification standards, trade groups, and other mechanisms intended to restrain supply--either for the purpose of controlling the quality of services or with the deliberate (if unstated) intent to reduce competitive market operations--may conceivably be regionalized to a degree that costs are affected.

TABLE 19

Wage Rates Related to Comparative Unit Costs

Region	Index, Total 1/ Cost Per Unit Reduction	City Measured	City Rate/20 City Average Rate 2/: Bldg. Labor	Cstcn. Labor	Strctl. Iron Workers	Elec-trical Workers	Steam-Fitters	Power Shovel	Mean Wage 3/ Cost Index (Rank)
Southwest	43.1	Denver	.881	.868	.887	.879	.909	.767	.865 (3)
Gulf	58.1	Dallas	.674	.684	.807	.696	.828	.750	.784 (1)
		New Orleans	.811	.718	.878	.830	.865	.864	
Pacific Coast	68.8	Los Angeles	1.176	1.195	1.172	1.067	1.209	1.139	1.183 (10)
		San Francisco	1.316	1.336	1.176	1.228	1.453	1.220	
		Seattle	1.236	1.255	1.010	.987	1.026	1.093	
Southeast	72.2	Atlanta	.751	.763	.885	.906	.883	.855	.825 (2)
		Birmingham	.764	.776	.854	.831	.878	.758	
Middle Atlantic	81.9	Baltimore	.868	.805	1.003	.889	.869	.965	.899 (4)
Plains	102.6	Kansas City	.951	.968	.857	.968	.919	.838	1.018 (5)
		St. Louis	1.231	1.250	1.000	1.094	1.138	1.005	
North Atlantic	132.9	New York	1.503	1.526	1.362	1.221	1.170	1.362	1.137 (9)
		Pittsburgh	1.070	1.055	1.016	1.039	.920	1.035	
		Philadelphia	.997	1.000	1.087	1.008	.994	1.109	
Ohio-Tennessee	141.1	Cincinnati	1.101	1.087	1.031	.943	.899	.944	1.073 (7)
		Cleveland	1.321	1.303	1.123	1.050	1.016	1.060	
Great Lakes	159.3	Chicago	1.166	1.184	1.122	1.034	.981	1.102	1.078 (8)
		Detroit	1.238	1.258	1.157	1.077	1.081	1.090	
		Minneapolis	1.075	1.105	.913	.955	.903	.963	
New England	455.2	Boston	1.075	1.013	1.043	1.092	1.057	1.055	1.056 (6)

2/ Base Hourly Rate and Fringe Benefits for Indicated Classification as Reported in Engineering News Record, 2-29-68:
$3.86 $3.80 $5.75 $5.96 $6.16 $5.67

1/ U.S. = 100
3/ Subsidiary indices/No. values included

TABLE 20

Major Components of Construction Cost

	PERCENT OF TOTAL COST			
	Material	Labor	Contractors Plant	Overhead and Profit
Sewage Treatment Plants	54.5	25.3	6.5	13.7
Sewers	35.5	18.5	31.3	14.7

(Source: Sewer and Sewage Treatment Plant Construction Cost Index p. 32)

(7) Urban Complexity. Urbanization and consequent concentration of population have been proposed as explanations of both high relative regional costs and low unit costs. On the one hand, population concentration is presumed to provide economies of scale that diminish unit investment needs. On the other, it has been asserted that urbanization's effect--in creating transmission difficulties and requiring higher degrees of treatment--is to push unit costs upward.

There is good logic on either side of the argument; but ranking relative costs against relative urbanization suggests that the actual effect is neutral--see Table 21. One might conjecture that the arguments for the effect of urbanization rest in large measure on misapprehension. The simplistic contrast of vast western areas of small population with the mass of persons concentrated along the Atlantic Coast and Great Lakes gives a distorted view of the nature of population concentrations. Constraints on development imposed by land forms and water availability reduce western utilization of land for urban purposes and make the effective rate of population concentration in the western United States much like that of the Northeast and somewhat more pronounced than that of the South and the plains; so that the actual effects of urbanization on waste handling costs are probably quite similar through the Nation.

Engineering studies confirm without explaining the higher relative cost of Northeastern sewage treatment plant construction. Examination of specifications forwarded in connection with applications for Federal grants produces--almost invariably--an unfavorable comparison of estimated plant costs in New England, New York, and Pennsylvania with similar facilities in other parts of the Nation. Sufficient samples were not available over the last three years to provide statistically valid cost correlations for all waste treatment processes on a regional basis, but enough examples of the most common waste treatment method in the Northeast--that is, the activated sludge process--occur to provide comparative construction cost to size statistics. The analysis (cf. Table 22) revealed a sharply adverse cost situation in the area through the range of sizes, with costs becoming progressively less representative as size of plant increased.

TABLE 21

Relative Urbanization Related to
Unit Waste-Handling Investments

Regions, Ranked in Order of Ascending Unit Cost	Urban Population		Rank, Degree of Urbanization	Rural Population	
	Number	Percent		Number	Percent
1 Southwest	3,757,000	72.5	4	1,426,000	27.5
2 Gulf	11,479,000,	67.7	6	5,474,000	32.3
3 Pacific Coast	16,937,000	80.6	2	4,072,000	19.4
4 Southeast	9,440,000	56.4	10	7,284,000	43.6
5 Middle Atlantic	7,318,000	57.1	9	5,504,000	42.9
6 Plains	7,452,000	57.4	8	5,534,000	42.6
7 North Atlantic	27,810,000	81.4	1	6,361,000	18.6
8 Ohio-Tennessee	11,053,000	60.8	7	7,121,000	39.2
9 Great Lakes	21,436,000	71.6	5	8,501,000	28.4
10 New England	8,033,000	76.4	3	2,478,000	23.6

TABLE 22

Relative Construction Costs of an Activated Sludge Plant

Million Gals/Day Capacity	Investment Per Million Gals/Day Capacity ($1957-59) Northeast*	U. S. (Including Northeast)	Northeast as a Percent of U. S.
0.5	$893,000	$516,000	173
1.0	758.000	404,000	188
2.5	611,000	286,000	214
5.0	519,000	229,000	227
10.0	441,000	179,000	246

* Six New England States, Pennsylvania, New York.

Whatever the reasons, the high capital cost of waste handling in the Northeast would seem to be documented adequately enough to be accepted as a fact. And the fact that real costs are significantly higher in the Northeast has serious implications for Federal policy. Quite apart from the obvious questions of equity and efficiency, major allocational problems are inherent in the particular composition of regional cost differences that exist in the nation.

(1) Investment needs are strongly concentrated in the Northeast. The six New England States, New York and Pennsylvania contain just over 20% of the Nation's population but 52% of the sewered population that is not provided with waste treatment services. Moreover, the region's per-capita investment in waste handling facilities has--at least in recent years--been well below that of the rest of the nation.

(2) Although the normalized rate of annual depreciation accruals is lower on a per-capita basis than in other parts of the nation, as a result of the region's deficient capital base, many of the physical facilities found in the Northeast are quite old and command a high effective rate of recapitalization. This, together with a relatively low rate of capital formation in the area, indicates that the Northeast has been borrowing against its real replacement and growth requirements in recent years.

(3) The rate of local investment in waste handling facilities is strongly conditioned by the level of Federal assistance. The allocation formula that has been used has not reflected the particular difficulties of the Northeastern situation; and the failure of appropriated Federal funds to meet promised authorizations has effected a mechanism that has,

perhaps, made matters worse. In Northeastern States, pollution abatement programs have been conducted in keeping with a logic that would have the community needing a work proceed to finance that facility and to construct it in anticipation of future Federal (and sometimes State) assistance payments. The process might have been successful had all other things been equal; but there is a vast difference between the ability of communities and of the nation to command funds in financial markets. As money has become progressively tighter over the past five years, the ability of local government to finance needed projects has become weaker, so that the pace of construction has not kept up with growth of demand. As a result, the Northeast--in spite of a declining share of total population--has sustained a constant share of the national need for waste handling facilities, even without adjustment for the high prices that prevail in the area.

TABLE 23

Investment and Demand, Northeastern States
(Millions of Dollars)

State	"Needs" 1962*	Investment 1962-67	"Needs" 1968*	"Needs" Developed 1962-67
Connecticut	29.9	52.6	53.2	75.9
Maine	77.3	16.2	66.5	5.4
Massachusetts	145.4	61.3	151.6	67.5
New Hampshire	49.1	15.6	44.6	11.1
New York	215.1	211.2	200.0	196.1
Pennsylvania	239.5	144.6	262.5	167.6
Rhode Island	6.0	13.1	16.6	23.7
Vermont	28.9	16.9	29.6	17.6
Northeast Total	791.2	515.9	824.6	549.3
(Percent of National Total)	(26)	(19)	(26)	(19)

*Based on national average unit costs

Although the use of average costs in modelling investment requirements may be an acceptable technique for evaluating most of the nation, dimensions of the Northeastern States' deviation from the mean in the past suggest the need for adjustment. The range of variation elsewhere is relatively slight, and the sample structure on which costs were determined is well distributed. It is entirely conceivable, for example, that use of mean costs overstates South Dakota's or Mississippi's needs, in effect shifting the accounting of investments that take place in Michigan or Tennessee. But the shift involved is not believed to be highly significant and--more important--to be such that offsetting effects produce a reliable national total.

The situation is otherwise for the highest cost States. Not only is the difference in investment that may be involved of potentially radical significance, but the inadequate sample of Northeastern plants going into the calculation of mean costs suggests that total costs may be understated.

Though an entirely reliable set of calculations is not attainable until a complete set of regional cost coefficients is derived, a partial adjustment to reflect the added burden of the Northeastern States is possible. The adjustment presented in Table 24 utilizes the relationship between costs of an activated sludge plant in the Northeastern States and in the United States as its base. Sewered populations of the eight Northeastern States, distributed by community size, were divided by total sewered population to obtain the segment affected by a particular cost relationship. The decimal values obtained were weighted by the indicated cost relationship for the particular size of community, and the product applied to the value of the State's need, as that value had been determined by the evaluation model.

TABLE 24

Adjusted Investment Needs
Eight Northeastern States

State	Millions of 1957-59 Dollars: Unadjusted	Adjusted	Increase
Connecticut	53.2	97.6	44.4
Maine	66.5	97.1	30.6
Massachusetts	151.6	254.9	103.3
New Hampshire	44.6	68.8	24.2
New York	200.0	374.4	174.4
Pennsylvania	262.5	457.9	195.4
Rhode Island	16.6	31.2	14.6
Vermont	29.6	41.8	12.2
Total	824.6	1423.7	599.1

The effect of the adjustment is to increase the scale of indicated national needs by 599 million base year dollars, or 827 million current dollars--twenty-six percent. For the eight State region concerned, it amounts to a 73% escalation of costs. Even that amount falls well short of the dimensions of the cost increase that might be anticipated on the basis of unit investment differences encountered during the 1962-67 period. The adjustment method is consistent with the modelling process, however; so the technique may be considered valid. While a larger incremental investment may actually be necessary in the Northeast, it is possible that the uncalculated amount may be accounted for by the inter-regional displacements known to occur as a consequence of average cost modelling. In any event, no better procedure of adjustment has been suggested. In consequence, the regional investment increment presented here has been used in scheduling analyses that follow.

Alternative Investment Schedules

For the period immediately ahead it is possible to determine with some precision, by application of the evaluation models, the investment that will be required on a national scale to obtain the level of treatment of public wastes that has been determined to match in a general fashion the requirements initially associated with water quality standards. We know the approximate rate at which investment requirements are accumulating, and we know the amount of the current accumulation of needs. The matter, then, resolves to a simple scheduling problem: to find the annual rate of investment that will sustain existing physical capital, meet expansion requirements, offset inflation, and eliminate the accumulation of investment requirements that currently exists.

To simply project past rates of need accumulation would be the simplest method of determining an acceptable rate of investment. It is unlikely, however, that the bulge in rate of development of needs caused by imposition of the secondary waste treatment standard will be repeated. For that reason, the projection process might be expected to overstate the rate of development of investment needs to be anticipated during the early 1970's. *

A more reasonable projection procedure is thought to be one which takes into account both the existing capital base and prevailing rates of demand formation for constituent elements of the investment complex--i.e. growth, recapitalization, and the backlog of accumulated demands--under a series of capital supply assumptions.

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* For those who wish to review the general dimensions of requirements under such a procedure, the elements are:

1) base current needs, in millions of 1957-59 dollars = 3201.1
2) incremental needs associated with higher costs in Northeastern States = 599.1
3) Rate of development of needs, 1962-68 =

$$\frac{\frac{(X + I) - Y}{Y}}{T} = R = 12.1\% \text{ per year}$$

4) projected rate of inflation = 3.5% per year
5) current construction cost index = 138% of 1957-59 (Over a five year period, needs would amount to $11,031.3 current dollars, indicating an annual investment requirement of $2.2 billion.)

To effectuate the procedure, a computer program was developed to apply varying amount of capital against combinations of demand constituents. The program assumed a constant 3.5% rate of inflation, and a constant 3.3% rate of growth. Recapitalization, capital in place, and backlog were derivatives of investment. The program dealt with recapitalization as a prime element that had no effect on other elements of the model. (The condition in which total outlays failed to match recapitalization requirements was not programmed.) Growth needs were calculated to amount in any year to 3.3% of capital in place, and were allotted the second segment of a postulated investment: to the extent that the investment covered growth requirements, the value was transferred to capital in place to serve as an element to calculate the following year's recapitalization requirement, and values exceeding available investment were accumulated as additions to the backlog of unmet needs. The backlog itself was reduced by any amount that available investment exceeded recapitalization and growth elements, or increased as prior demands on a hypothesized investment exceeded the amount of the investment.

Repetitions of the exercise, applying a schedule of investments increasing in $100 million increments from $1 billion to $2 billion a year, indicated that a $2 billion annual outlay is required to reduce accumulated needs within a five year period. (cf. Table 25A). Lesser outlays, of course, increase the time required to attain control conditions that approximate current interpretations of water quality standards requirements. Investments of less than $1.5 billion a year not only postpone attainment, they are insufficient to keep pace with the requirements of recapitalization, growth, and inflation, so that, after an interim period of reduction, the backlog increases rather than declines. (cf. Tables 25B and 25C).

TABLE 25

A-Five Year Backlog Elimination Schedule, Water Quality Standards-Related Public Investments

(Values in Millions of Current Dollars)

Year	"Backlog" at year end	Growth	Recapitalization	Investment
1969	4438.4			
1970	3441.8	437.2	410.9	2,000
1971	2489.5	467.4	459.9	2,000
1972	1584.5	499.7	508.1	2,000
1973	730.0	534.3	555.7	2,000
1974	0	571.2	602.5	1,929.3
1975		610.7	648.4	1,259.1

Total Indicated Investment, 1970-1974:	9929.3*
"Backlog"	4882.3
Growth	2509.8
Recapitalization	2537.1

*Includes an Inflation Component of: 928.8

TABLE 25 Continued

*B-Stretchout Schedule, Water Quality Standards Related Public Investments (Values in Millions of Current Dollars)

Year	"Backlog" at year end	Growth	Recapitalization	Investment
1969	4438.4			
1970	3741.8	437.2	410.9	1700.0
1971	3091.0	467.4	450.8	1700.0
1972	2489.0	499.7	490.1	1700.0
1973	1939.0	534.3	528.6	1700.0
1974	1444.3	571.2	566.2	1700.0
1975	1008.5	610.7	602.9	1700.0
1976	635.3	653.0	638.6	1700.0
1977	328.9	698.1	673.2	1700.0
1978	93.4	746.4	706.6	1700.0
1979	0	798.0	738.8	1630.2

*C-Deficiency Schedule, Water Quality Standards Related Public Investments (Values in Millions of Current Dollars)

Year	"Backlog" at year end	Growth	Recapitalization	Investment
1969	4438.4			
1970	4041.8	437.2	410.9	1400.0
1971	3692.5	467.4	441.8	1400.0
1972	3393.5	499.7	472.0	1400.0
1973	3148.0	534.3	501.4	1400.0
1974	2959.3	571.2	529.9	1400.0
1975	2831.0	610.7	557.4	1400.0
1976	2767.0	653.0	583.9	1400.0
1977	2847.9	698.1	609.2	1400.0

*Note: Due to the inescapable pressures of growth and recapitalization the investment results achieved with $2 billion a year in five years can only be attained in ten years with a reduction in spending to $1.7 billion a year and at that level no decrease in investment pressure is experienced; indeed by 1981, demand again reaches the $1.7 billion a year level and a backlog begins to accumulate by 1982. At a level of $1.5 billion a year or less, the backlog is never eliminated.

Within the terms of the analysis--which approximates reality, in that any failure to maintain physical capital or to meet new demand will inescapably add to the accumulation of unmet requirements--a critical relationship may be found between the current level of investment, $500 to $900 million a year, and the rate of formation of requirements under the pressures of growth and recapitalization.

We are already beginning to borrow heavily against the future when we install new plants today. The immediate effects are probably not too serious, given the age composition of plants in place, most of which were built fairly recently. (cf. Table 26, that lists by periods the approximate date of most recent major improvement or of initial operation of all known municipal waste treatment plants. Of those for which information is available, over seventy-five percent were constructed or reworked within the last ten years, more than eighty-eight percent within the last fifteen years.) But with each passing year, the potential seriousness of the current under-capitalization of public waste handling becomes greater. Twenty percent of the sewered population of the United States is now served by over-loaded plants, and another twenty-six percent of the sewered population is served by plants that need major upgrading.

A point must be made here. There is nothing precise about any of the numbers relating to investment. They are presented to the nearest hundred thousand dollars only to preserve mathematical integrity, not because they are felt to quantify reality with the exactness that such a level of detail might be thought to imply. The evaluations presented in this report are to be viewed only as order of magnitude extrapolations of existing conditions. There are opportunities to reduce the weight of the burden by enlightened planning and administrative policies. Though technological innovations may be expected to have slight, if any, impact on costs over so short a planning horizon as five years, the existing technology does offer capital-saving expedients. If the design and construction industry of the northeast could reduce its costs to national average levels, well over half a billion dollars might be saved within the projection period. If the rate of inflation could be rolled back to that obtaining in the first half of the last decade, another three quarters of a billion dollars might be saved within the period. Use of more dependable sizing techniques, optimal design engineering, and more intensive application of regional concepts might all save hundreds of millions of dollars. Conversely, if inflation accelerates, design standards become more rigid, and local jealousies intensify, the nation can expect an even larger bill to be delivered.

Comparison of the investment schedules indicates the powerful influence of time. Not needs as such, but the rate at which needs develop and are met becomes the prime question in evaluating national progress in providing facilities to control water pollution. The point is as true for each State as for the United States.

TABLE 26

1968 Municipal Waste Inventory
Summary of Waste Treatment Facilities by Year Plant Underwent Major Revision (or Began)

State	Date Unknown	1900 and prior	1901-1910	1911-1920	1921-1930	1931-1940	1941-1950	1951-1957	1958-1962	1963-1968	Totals
Alabama	95	0	0	0	2	5	4	2	33	63	204
Alaska	7	0	0	0	0	0	0	0	0	0	7
Arizona	35	0	0	0	0	0	0	4	8	22	69
Arkansas	28	0	0	0	0	0	0	2	57	116	203
California	541	0	0	0	0	0	0	1	4	0	546
Colorado	30	0	0	1	0	5	5	25	48	90	204
Connecticut	17	0	1	1	3	13	9	10	14	15	83
Delaware	4	0	0	0	0	0	0	0	3	11	18
District of Columbia	0	0	0	0	0	0	0	0	0	1	1
Florida	420	0	0	0	0	1	1	1	31	55	509
Georgia	31	0	0	0	0	21	17	34	36	168	307
Hawaii	2	0	0	0	0	0	0	0	5	14	21
Idaho	25	0	0	0	0	2	1	12	22	31	93
Illinois	79	0	1	0	7	30	35	64	167	246	629
Indiana	75	0	0	1	2	7	10	47	66	94	302
Iowa	37	0	0	19	20	32	27	62	109	193	499
Kansas	23	0	0	1	6	25	38	107	116	119	435
Kentucky	56	0	0	0	1	4	5	21	34	118	239
Louisiana	85	0	0	0	1	0	0	3	35	49	173
Maine	8	0	0	0	0	1	0	1	6	17	33
Maryland	4	0	0	2	0	9	3	6	17	49	90
Massachusetts	68	0	0	0	0	0	1	1	9	15	94
Michigan	79	0	0	1	4	10	5	20	51	98	268
Minnesota	224	0	0	0	0	0	0	0	55	132	411
Mississippi	40	0	0	0	0	0	2	13	61	99	215
Missouri	289	0	0	0	0	1	0	9	96	95	490
Montana	6	0	0	3	1	2	8	25	45	35	125
Nebraska	15	0	0	0	6	26	20	44	93	180	384
Nevada	8	0	0	0	0	2	3	3	2	11	29
New Hampshire	10	0	0	0	0	0	0	0	7	10	27
New Jersey	184	1	0	1	12	5	3	14	24	74	318
New Mexico	27	0	0	0	0	0	0	4	16	33	80
New York	47	0	3	11	21	79	20	55	99	172	507
North Carolina	96	0	0	0	1	9	5	20	58	160	349
North Dakota	5	0	0	4	3	5	16	52	86	40	211
Ohio	92	0	0	1	3	26	13	99	134	169	537
Oklahoma	168	0	0	0	0	0	0	2	86	114	370
Oregon	3	0	0	2	2	5	11	31	47	66	167
Pennsylvania	480	0	0	0	0	0	0	0	1	6	487
Puerto Rico	74	0	0	0	0	0	0	0	6	11	91
Rhode Island	3	0	0	0	0	0	1	4	2	6	16
South Carolina	123	0	0	0	0	0	0	18	31	52	224
South Dakota	14	0	0	1	4	9	16	35	56	55	190
Tennessee	79	0	0	0	0	0	1	12	46	62	200
Texas	628	0	0	0	0	0	0	2	105	176	911
Utah	12	0	0	0	0	1	4	9	12	26	64
Vermont	4	0	0	0	0	0	0	1	12	21	38
Virginia	44	0	0	0	7	7	12	27	65	91	253
Virgin Islands	0	0	0	0	0	0	0	0	0	0	0
Washington	208	0	0	0	0	0	0	0	0	0	208
West Virginia	29	0	0	0	0	7	3	0	25	54	118
Wisconsin	26	0	0	0	0	40	46	95	103	130	440
Wyoming	25	0	0	0	0	0	0	5	30	18	78
U.S. Totals	4,712	1	5	49	106	389	345	1,002	2,274	3,682	12,565

Equally significant is the intention of the potential investor--how does the community rate pollution control in its ranking of all needs for funds? How does the pressure of State programs express itself at the local level? What is the variance of local practice from National average standards? All of these questions will affect the distribution of investment effort. To provide a broad estimate of the magnitude of investment facing individual States if indicated treatment standards are to be met, the scheduling process has been applied. Recognizing that variations in design practice, growth rates, and effective recapitalization rates may be distorted by the application of nationally derived coefficients, decision-makers at the State level may nevertheless find the values useful in formulating financial plans in the field of water pollution control.

Because the reliability of the assessment of investment requirements declines with the size of the element evaluated (a single atypical project will have a more pronounced effect on results for a smaller than for a larger element), five year requirements for States are presented in terms of a range--one standard deviation about the mean--rather than an expected value. The principal variable affecting the breadth of the range is plant size, so it would be unwise to infer that a State's ultimate investment need will be to the low or high side of the range on the basis of the generalized influence of location on cost discussed earlier in this paper. Rather, five year investment requirements would be expected to occupy a mid-point in the range, deviating to one side or the other according to the size of particular projects that must be scheduled within the period.

A similar problem of disaggregation is responsible for use of five year lump sums rather than annual schedules. Where the total system of the nation might be expected to sustain a constant annual rate of investment under any given level of funding, subsystems may be expected to demonstrate a certain lumpiness in allocation, according to scheduling of particular projects. (An exception to the rule might be anticipated in the case of the six to ten most populous States.) The exigencies of scheduling will, of course, affect gross investment over the period, due to the varying effects of inflation, replacement, and growth factors under different sets of time conditions.

These projections of investment levels are considered to be compatible with existing definitions of requirements, current unit costs, a moderating inflationary influence, a five year time period, and a situation in which financial or resource constraints permit achievement. A number of other estimates for the individual States exist, and these may be very different in their details than those presented in this report.

Most of the States have compiled lists of needed works. In particular, the FWPCA requires that such a list be a part of the description of the State program in submission of applications for program grants. Such independent estimates differ from the values assessed here in that they are situation-dependent and time-independent. Nevertheless, they have tremendous value and pertinence, in that they are compiled by men on the scene and represent the influence of both subjective and objective local factors. In particular, such estimates may be considered to provide surveys of intention. They represent an evaluation of State and local planning response to conditions.

Recognizing those values, one must nevertheless approach at least some such estimates with reservations. In some cases they must be interpreted to be saying either 'this is what we should like to do in the absence of any constraints,' or the direct opposite -- 'this is all we think we can do, given existing constraints.' In distinction, the assessment provided in this report says substantially that 'if we are to achieve presently defined national goals in a five year time span, the conditions that exist today indicate that we must invest about $2 billion a year.' Unlike the other evaluations, the one presented here is stringently constrained by time and observed conditions. It is not, however, adjusted for either local practice or local intentions. While it is felt to be the best possible assessment of national circumstances, its local relevance is less defensible. Table 27 presents the model-derived five year investment range applicable to each of the fifty States, the District of Columbia, Guam, Puerto Rico, and the Virgin Islands. Each of the fifty-four values is contrasted with the most recent (to January 29, 1970) estimate by a relevant organ of State or other government of the value of the projects that it anticipates can occur within its jurisdiction over the next five years. While the two sets of estimates are not strictly comparable, in that there are substantial variations at either end of the time frame in the case of a number of State estimates -- some run through 1975, and a few include stages of 1969 projects -- the $10.2 billion summation tends to support very strongly the validity of the $9.9 billion, five year estimate developed in this report.

But while the order of magnitude validity of a $10 billion program would seem well documented on a national scale, there are very troublesome differences on a State by State basis. Only eighteen States -- one third of the total -- fall into the indicated range on the basis of their own assessments of investment requirements. Fully half of the States have provided estimates that fall below the low value in the range. These apparently low estimates are not for the most part considered to be inconsistent with the terms of the national scheduling procedure for four reasons: 1) The modelling procedures are intended to cover statistically probable value of projects that in many cases will not reasonably be foreseen at the time of a particular survey, but that will, in a world that behaves normally, occur within the period. 2) The lumpiness factor in investment may push a major

TABLE 27

Comparison of State Investment Intentions and Derived Value of Needs
(Millions of Dollars)

	State Intentions	Programmed Needs	Intentions Fall Within Range	Intentions Exceed Range	Intentions Below Range
Alabama	35.0	224.3 - 165.5			≥130.5
Alaska	12.0	12.2 - 7.6	X		
Arizona	86.0	46.1 - 35.1		≥ 39.9	
Arkansas	33.0	118.6 - 72.6			≥ 39.6
California	651.8	838.5 - 738.1			≥ 86.3
Colorado	133.0	143.7 - 103.1	X		
Connecticut	280.5	187.7 - 147.1	X (a)		
Delaware	28.0	17.7 - 12.5		≥ 10.3	
District of Columbia	355.0	68.2 - 19.4	X (a)		
Florida	200.0	209.5 - 157.7	X		
Georgia	150.0	250.5 - 198.3			≥ 48.3
Hawaii	14.4	44.0 - 32.4			≥ 18.0
Idaho	0.5	75.5 - 58.1			≥ 57.6
Illinois	437.2	493.7 - 396.9	X		
Indiana	152.6	337.6 - 282.8			≥130.2
Iowa	33.3	160.3 - 122.3			≥ 89.0
Kansas	61.0	250.9 - 118.3			≥ 57.3
Kentucky	62.6	102.6 - 54.4	X		
Louisiana	140.0	206.3 - 104.1	X		
Maine	140.9	206.6 - 114.2	X		
Maryland	236.9	63.7 - 29.5		≥173.2	
Massachusetts	438.0	586.7 - 356.5	X		
Michigan	253.7	311.7 - 249.3	X		
Minnesota	136.3	193.3 - 114.1	X		
Mississippi	40.0	141.0 - 82.2			≥ 42.2
Missouri	390.0	359.1 - 195.3		≥ 30.9	
Montana	13.5	63.7 - 42.1			≥ 28.6
Nebraska	62.0	119.0 - 88.4			≥ 26.4
Nevada	28.6	38.6 - 30.0			≥ 1.4
New Hampshire	138.0	150.4 - 93.6	X		
New Jersey	880.0	343.4 - 262.8		≥536.6	
New Mexico	9.9	50.1 - 38.7			≥ 28.8
New York	1900.1	1323.6 - 788.6		≥576.5	
North Carolina	69.3	254.5 - 199.1			≥129.8
North Dakota	22.0	38.9 - 31.9			≥ 9.9
Ohio	432.5	511.8 - 429.8	X		
Oklahoma	65.3	123.0 - 94.0			≥ 28.7
Oregon	135.0	146.1 - 114.5	X		
Pennsylvania	432.0	1122.8 - 720.8			≥288.8
Rhode Island	51.5	96.7 - 72.9			≥ 21.4
South Carolina	75.0	121.8 - 96.0			≥ 21.0
South Dakota	27.0	48.2 - 39.2			≥ 12.2
Tennessee	105.5	184.9 - 115.7			≥ 10.2
Texas	525.0	502.9 - 441.5		≥ 22.1	
Utah	11.7	82.4 - 68.6			≥ 56.9
Vermont	70.0	117.5 - 83.9			≥ 13.9
Virginia	151.0	152.8 - 117.4	X		
Washington	160.0	198.5 - 146.5	X		
West Virginia	44.3	140.3 - 101.1			≥ 56.8
Wisconsin	243.7	275.0 - 231.4	X		
Wyoming	12.0	38.3 - 19.1			≥ 7.1
Guam	6.2	---		≥ 6.2	
Puerto Rico	28.9	61.3 - 36.1			≥ 7.2
Virgin Islands	15.4	4.4 - 2.6		≥ 11.0	
TOTAL	10217.1	11960.9 - 8473.7			

(a) Programmed needs adjusted for recent accelerated level of starts or state intentions, excluding year 1975, bring two sets of estimates into agreement.

project or projects that are normalized by the statistical method wholly into or out of the five year time frame -- as in the case of the District of Columbia, where 80% of announced spending is scheduled for 1975. 3) The modelling procedure depends on uniform application of high cost methods. The choice of the high cost method was deliberate, intended to account for the observed tendency of real costs to increase as conditions make it progressively more necessary to provide waste treatment efficiencies at the extreme end of the scale for secondary treatment processes. Those States whose intentions to invest fall below the low value in the range tend to be the more economically efficient in their conduct of the waste-handling activity, and to employ lagoons and other low unit cost methods. The propensity of real costs to rise -- and in many cases, the simple fact of inflation -- are not often taken into account. 4) A final reason for variation in estimates of State liability traces to an essential weakness in the estimating model. A uniform rate of loading growth has been applied for every State, but States do not grow at equal rates. Unfortunately, the components of growth are so randomly distributed -- rate of population increase, rate of connection of water using industries, infiltration, and urbanization all bear on the matter -- that it has not proved possible at this time to derive appropriate rates of growth for each State. Unquestionably, however, the effect of the modelling procedure is to create interstate transfers of growth. (Investment staging, or lumpiness, has a bearing in this regard. States with a good deal of newly installed excess capacity will experience growth of service that does not necessarily require an investment within the five year time frame.)

Some of the same factors explain higher than anticipated investment intentions. Lumpiness in investment allocation is a reasonable explanation of the relationship of the two sets of values in the cases of Missouri, Delaware, Guam, Texas and the Virgin Islands; and in the case of Arizona, both lumpiness and rapid growth come into play. In a sense, these jurisdictions expect to begin at an early stage projects whose utility will extend well into the future. These are, then, expectable offsets to some of the States whose intentions fall below the normalized range established by the model.

Nine States, however, do not fall within an explainable range of variability. On the low side, Alabama, Hawaii, Idaho, New Mexico, Pennsylvania, and West Virginia report intentions so far below the statistically probable that the difference between statistical probability and pragmatic observation, the lumpiness factor, the difference between costs derived from regional practice and normal application of the high cost method, or the effects of varying growth patterns provide no explanation. Equally difficult is the high divergence of expressed intentions from the normal range in the cases of New Jersey,

INVESTMENT INTENTIONS COMPARED TO DERIVED NEEDS

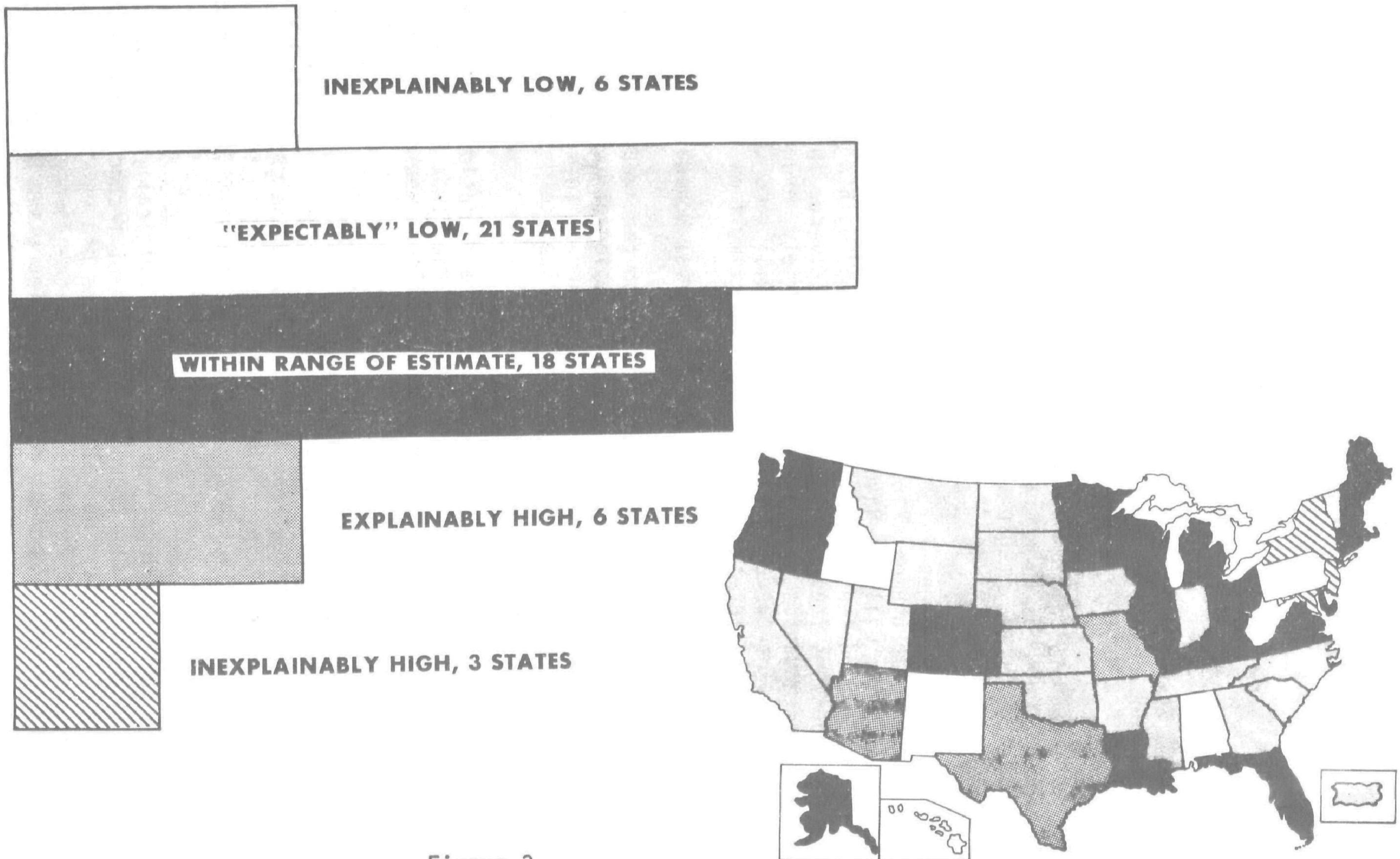


Figure 3

New York, and Maryland. (The latter may to some extent reflect double counting with the District of Columbia for projects in the Washington, D. C. metropolitan area.)

One can only conjecture that reporting discrepancies or specialized influences make some aspects of the States' situations abnormal. At any rate, in comparing the values, the reader may obtain some grasp of the plasticity of the situation, the extraordinary variety of conclusions that may be reached where the rules of the game are largely unspecified.

The rules of the game, as it is ultimately to be played, are all important. There are sizeable dimensions of uncertainty relating to plant scale, regional cost differences and timing of investment. Actual treatment needs to meet water quality standards may vary markedly in many situations from preliminary assumptions because of local conditions. Changes in the rate of industrial connections to municipal plants, improvements in technology, greater use of regional treatment facilities will all have an impact on actual costs, and these can only be accommodated by the analytical method with a set of projection assumptions that may finally prove to diverge in several respects from the eventuation of conditions. Perversely, even Federal policy and legislation based on a level of need will tend to make any estimate self-fulfilling by imposing external stimuli on local decision making.

A Compatible Industrial Schedule

Because the same elements apply to the industrial sector--i.e. investment rates represent the interaction of technological requirements, capitalization, growth, replacement, and price levels over time--the same scheduling techniques may be utilized to determine investment norms for manufacturers.

We have a fairly good grasp of the dimensions of those elements in terms of the definitions presented in the first report of this series. It is recognized that there are significant weaknesses in that assessment, weaknesses that derive principally from data deficiencies. Because no significant new information has come to light in the two years since the issuance of that report (and because such information as industrial sources have provided tends to corroborate the values reported), no attempt has been made to refine the estimates presented. In the absence of information that might alter the earlier estimates in some substantive fashion, they have been fitted into the scheduling equation.

Because the input variables were originally presented as a range (whose bounds may be thought to represent technological possibilities frontiers) a mid-point value is used to present the results of the scheduling effort in Table 28. The elements of the table include 1) the mid-point investment requirement increased by two years' estimated

TABLE 28

Water Quality
Standards-Related Manufacturers' Investment
For Waste Treatment
(Values in Millions of Current Dollars)

Year	"Backlog" at Year End	Growth	Recapitalization	Investment
1969	1513.2			
1970	1129.5	139.4	118.5	650.7
1971	817.3	150.8	138.0	650.7
1972	526.4	163.1	156.9	650.7
1973	258.0	176.4	175.2	650.7
1974	--	190.8	192.8	650.7
1975	--	206.3	209.7	416.0

Total indicated Investment *	= 3253.5
"Backlog"	1651.6
Growth	820.5
Replacement	781.4
* Includes an Inflation Component of	330.0

normal growth and recapitalization requirements and decreased by reported 1968 investment and projected 1969 investment; 2) annual growth assessed at 4.5%; 3) annual recapitalization assessed at 4%; 4) annual inflation assessed at 3.5%. The dynamics of industrial waste treatment are considered to include significantly higher growth and recapitalization functions than is true of municipal waste treatment, so that industrial investment requirements are climbing faster than are municipal. This traces to the fact that the major part of the public investment is for transmission facilities that are replaced at a slower rate than waste treatment plants, and that industrial production is increasing at distinctly more pronounced rates than population.

Given the data set and the assumptions that underlie it, the situation that emerges is one in which manufacturing industries must invest about $650 million a year over the next five years to achieve an equilibrium level of capitalization, one in which investments are required only to meet the exigencies of annual recapitalization and growth. The current level of investment appears to be comfortingly close to the target amount. Unless some significant changes in the rules of the game become necessary, industrial facilities may be expected to come on stream according to the hypothetical schedule that reflects current national policy.

Water Pollution Control Needs at Federal Installations

In order to correct existing water pollution control needs at Federal installations, an estimated $246.5 million dollars will be required. Sources of information from which this cost is derived include Bureau of the Budget Circular A-81 and a recent questionnaire from the Bureau of the Budget to Federal Agencies entitled "Status of Water Pollution Projects at Federal Facilities-FY 1968-1970."

Circular A-81 is a budget process developed in 1967 for the purpose of a phased and orderly plan to correct water pollution problems that exist at Federal installations. Its original intent did not cover estimated treatment facilities for new construction or expected future needs at existing facilities. Each agency submits to the Bureau of the Budget an estimate of cost for each installation where proposed treatment facilities are tentatively scheduled for a given annual budget. Also included in the submission are summaries, programming all projects planned by each agency by fiscal year. FWPCA has assumed that estimates do not include cost escalation factors for projects in fiscal years other than the one reported on. Each year FWPCA is called upon by the Bureau of the Budget for advice and recommendations as to the seriousness of the proposed projects. From the time estimates of cost are prepared by the agency to the time of submission of the annual budget to Congress, cost figures sometime change considerably. The Agency's experience is that revisions are invariably upward. Final cost figures are not usually made available to FWPCA, therefore any representation of these costs made by FWPCA can only be interpreted as a rough approximation.

The status questionnaire asked for information in regard to pollution projects programmed and funded from FY 1968 through FY 1970. In FY 1968 and FY 1969 a total of $108.8 million was programmed of which $76.3 million has been appropriated creating a deficit of $32.5 million. In addition when the questionnaire was compared with Circular A-81 submissions for the same years, it was also discovered that some projects were not included. These omissions further qualify the reliability of the $246.5 million dollars. What is available, then, is no more than a tentative schedule of appropriation requests over a ten year period. The proposed schedule as originally programmed was:

Fiscal Year *	Estimated Expenditure
1968-1969	$ 32,500.0
1970	47,500.0
1971	43,000.0
1972	97,000.0
1973-1978	26,500.0
Totals	$ 246,500.0

* Originally programmed but not yet funded.

FEDERAL COST-SHARING

Nature of Grant Programs and the Reasons for Cost-Sharing

To properly evaluate Federal cost-sharing it is necessary to trace the recent history of how cost-sharing developed, and to define the concept with respect to the Federal Water Pollution Control Act.

Intergovernmental fiscal relations have increased since the 1930's. There are several reasons for this increased activity. Increased urbanization and a faster pace of economic growth have created more demands for services provided by local governments. While the demands have been felt at the local level, the availability of increased revenues has been at the State and particularly at the Federal level. Through fiscal participation an equilibrium of supply and demand for public funds can be obtained often. This amounts to a direct pass-through of Federal funds to strapped local coffers.

Another reason for the growth of payments from Federal to State and local governments has been the desire of groups to influence both the level and nature of public expenditures. The rationale for these intergovernmental expenditures is that the quality of activity of one area will affect outside areas. Furthermore, the higher levels of government will be better able to direct a uniform performance as compared with local governments working toward their own particular ends. Financial participation serves as an incentive to local governments and as a means of adjusting financial inequities that might develop.

Another rationale for intergovernmental financial cooperation is provision of relief to poorer regions and to lower income levels. The justification for this financial aid rests upon the belief that this can best be accomplished by larger rather than by smaller units of government. For if income redistribution were accomplished on a local basis, some communities would have a greater burden per capita than others. The justification for this type of financial aid rests on the given national objective concerning income equilization, and on the many benefits which do not accrue solely to the individuals in these economic conditions but which accrue also to the nation.

In light of these considerations Federal financial architects have designed numerous methods of cost-sharing. Included among the methods are: <u>income equilization</u>--allocating relatively more grants to poor areas than to prosperous ones; optimizing--using functional or categorical grants to increase efficiency in performing specific objectives; and block grants--passing via unconditional grants Federal monies to State and local governments. For each alternative the impact of fiscal Federalism varies. What alternative or combination of alternatives should be chosen depends on the purpose of the grant and the social welfare function, the objectives of the decision maker.

To establish the nature and level of FWPCA cost-sharing programs, the objectives and rationale for the program first must be considered. Is the program a means of redistributing income and/or a means of collecting and distributing tax dollars? Does the program have a specific optimizing function? The basis for distributing the grants, allocation formulas, can be established only after those questions are answered.

The stated purpose of the construction grant program is to prevent untreated or inadequately treated sewage and waste from being discharged into water (Federal Water Pollution Control Act as amended Section 8a). The desirability of the grant is based on the propriety of the Federal aid, the public necessity for the work, the relationship of total system costs to benefits, the benefits received from the work, and the ability to maintain physical capital (Section 8c). Judging from these provisions in the Act, it appears that the grant program is directed to accomplish a specific objective, and may be classified an optimizing grant.

Level of Federal Grant Support

There are a number of persuasive reasons why Federal financial support for State and local pollution abatement efforts may be considered to be appropriate. Ultimately, these devolve upon two considerations, equity and financial necessity.

The equity argument may be set forward very briefly. It holds that pollution control is an expression of a national priority (which may often conflict with local priorities that would put industrial development, lower taxes, or alternative use of public funds well ahead of pollution control); and that the benefits of improved water quality extend in time and place well beyond the point of the action that results in improvement, so that they are most often regional or national in nature. Thus the community should in equity bear the cost of reducing the damages it creates, but there is equal equity in requiring that the beneficiaries of such actions--in essence, the nation at large--bear some costs. Cost-sharing between Federal and local governments, then, represents a rough and ready accommodation to the principles of levying charges against both the occasioners of damage and the recipients of benefits. The same considerations of equity argue strongly for State participation in costs, since State government has a more proximate relation to damages than does Federal government, and more directly represents benefitted population than does local government.

The financial necessity argument extends far beyond the area of pollution control. It is directed to the fact that fiscal demands on State and local governments are increasing faster than the growth of their revenues--at least as these are derived from traditional sources--or faster than gross national product. But while State and local governments face a responsibility to provide an increasing share of the goods and services produced in the national economy, the Federal government holds the most efficient taxing mechanisms in its powers. Further, the disparity between State and local means and requirements is increased in practice by the fact that those services provided by such governments are most needed in precisely the places where financial resources are most limited. Under such conditions, Federal financial assistance becomes a necessary precondition to the conduct of the expanding program requirements of State and local government.

The situation has been too adequately analyzed and documented elsewhere to require further discussion in this place. (cf. especially Revenue Sharing and Its Alternatives: What Future for Fiscal Federalism, Subcommittee on Fiscal Policy of the Joint Economic Committee, 90th Congress, July 1967, and Fiscal Balance in the American Federal System, Advisory Commission on Intergovernmental Relations, Washington, D. C., October 1967). The question is not the necessity of Federal financial assistance, but the amount of such assistance that is required to achieve particular national goals.

Some guidelines as to amount are offered in the form of studies by specialists in governmental fiscal matters. (Detailed citations may be found in sources cited above). Joseph Pechman, Richard Netzer, and Selma Mushkin and Gabrielle Lupo have provided some very generalized assessments of an appropriate overall mix of Federal and local financial efforts, based on the fiscal gap created by the difference between the rate of growth of State and local revenues and their outlays. The estimates agree fairly closely, suggesting the need for a 17 percent to 21 percent Federal financial participation in local government programs by 1970. The developing situation is one in which expansion of local government services can only take place with a substantial increase in the Federal share of the cost of such services. (See Table 29).

Significantly, Joseph Pechman's estimate of the situation assumes that financial constraints will cause a reduction in the rate of increase in production of State and local governmental services. Where the other authorities assume that economic growth, new revenue sources, and increased borrowing can sustain growth of local government services, Pechman projects a revenue supply that has a low

TABLE 29
Estimates of State and Local Governments
Needs for Federal Financial Support
(Billions of Dollars)

	Pechman	Netzer	Mushkin &Lupo
Demands on State & Local Governments, 1965	74	74	74
Local Taxes & Borrowing	63	63	63
Federally Supplied	11	11	11
Demands of State & Local Governments, 1970	103	121	122
Local Taxes & Borrowing	80	100	100
1965 Level of Federal Support	11	11	11
Fiscal Gap	12	10	11
Percent Federal Participation, 1965	15%	15%	15%
Percent if Gap is to be Federally Closed, 1970	21%	17%	18%
Indicated Federal Participation in Incremental Outlays	41%	21%	23%

elasticity, and a slowing in the growth of this sector of the economy even with a relatively larger input to the Federal share of total revenue. In view of the events of the past two years--when markets for State and local bond issues have consistently failed to meet needs, even at constantly increasing price levels, and when taxpayer revolt has stifled new revenue measures at the polls--the Pechman view of the world seems to have been the more accurate one.

At any rate, the sources seem to agree that we are in a situation where continuation and extension of pollution control efforts will require that of every five dollars expended by some level of government, at least one dollar must come from Federal sources. Given the fact that the national priority system probably holds water pollution control somewhat higher in its ordinal ranking than do at least those communities which have failed to provide needed treatment works, a higher level of Federal financial assistance may actually be required to achieve needed controls.

At this time the Federal input to public waste handling activities approximates the relative share projected by the authorities on governmental finance who have been cited. Currently, the combination of grants through the Department of the Interior, Housing and Urban Development, and Agriculture amounts to something over a quarter of a billion dollars a year; while total State and local spending for waste handling is estimated to exceed $1.4 billion annually. (See Table 30). Federal spending in this area has increased tremendously, both in absolute terms and relatively to the outlays of local government. Yet constraints upon local finances have forced many States to provide supplemental assistance to local government in the waste handling area.

The reason is not difficult to determine. Although Federal outlays have increased at a much greater rate than those of local government, the amount of the Federal increase has been well below that which local government has had to meet. Federal outlays for capital investment purposes have been about $170 million greater this year than they were in the first five years of the Federal waste treatment construction grants program. But total capital outlays are almost $400 million a year higher, indicating a $230 million a year incremental burden on local governments. Indeed, annual replacement costs for the systems constructed since initiation of the grant program are estimated to have increased by about $235 million a year, which combined with about $105 million a year increase in operating costs, means that one of the effects of the level and nature of Federal assistance in the pollution control effort has been to directly add a third of a billion dollars a year to the financial burden of American local governments.

The fact, taken in the context of the continuing financial crisis of local government, does much to explain the very slow

TABLE 30

Relation of Federal Assistance to Total Estimated
Public Waste-Handling Expenditures
(Millions of Dollars)

Annual Average Outlay for Period	Investments: Treatment Works	Investments: Collection Works	Operating Charges: Treatment Works	Operating Charges: Collection Works	Total
1956-61, Total	339	317	95	170	921
Federal Share	45	-	-	-	45
1962-66, Total	515	375	135	195	1210
Federal Share	105	-	-	-	105
1967, Total	551	504	170	200	1424
Federal Share	203	50	-	-	253
Percent Federal in Period					
1956-61	13	-	-	-	5
1962-66	20	-	-	-	9
1967	37	10	-	-	18

incremental reduction of pollution abatement needs in recent years. Local government must spend as much today to hold its own in terms of pollution abatement activities as it was spending to increase those capabilities a few years ago. Overhead expenditures for operation, maintenance, and replacement largely cancel the effects of Federal grant assistance. Larger Federal funding is necessary to extend the reach of public waste handling and pollution abatement capabilities.

The appropriate level of funding over the short run depends upon several factors, specifically, the degree of cost-sharing on each project, the method of allocating funds among States and the time period in which all untreated wastes from sewered communities are to be treated and an upgrading and replacement posture is to be reached.

The impact of the degree of Federal participation must be appraised. The rate at which a stable investment posture is to be attained is a function of the residual funds available after existing facilities are expanded, maintained or replaced. The concept expressed here is that failure to adequately sustain existing capital automatically creates an investment need, and adds to the national backlog. Thus, the sooner it is desired to achieve a zero "backlog" level the higher the amount of total and Federal investment shares. But the increase is by no means likely to be greater than the marginal limits of expansion and contraction around the historical level of investment. Accelerating construction too steeply will tend to increase costs more than proportionately through sectoral inflation caused by bottlenecks in design capacity, construction industry capacity and equipment manufacturing capability. In addition, significant changes in investment levels may conceivably drive up interest costs in the already high municipal bond market. Another impact may well be poorer quality works, in terms of both design and construction, resulting from less stringent quality control and the attraction of engineers and contractors with lesser skills in the waste treatment field.

While a program is considered more effective if it results in more pollution control in a shorter time than another, the time shrinking may cause that program to be less efficient. The tradeoff between these two factors is difficult to predict.

A Retrospective View

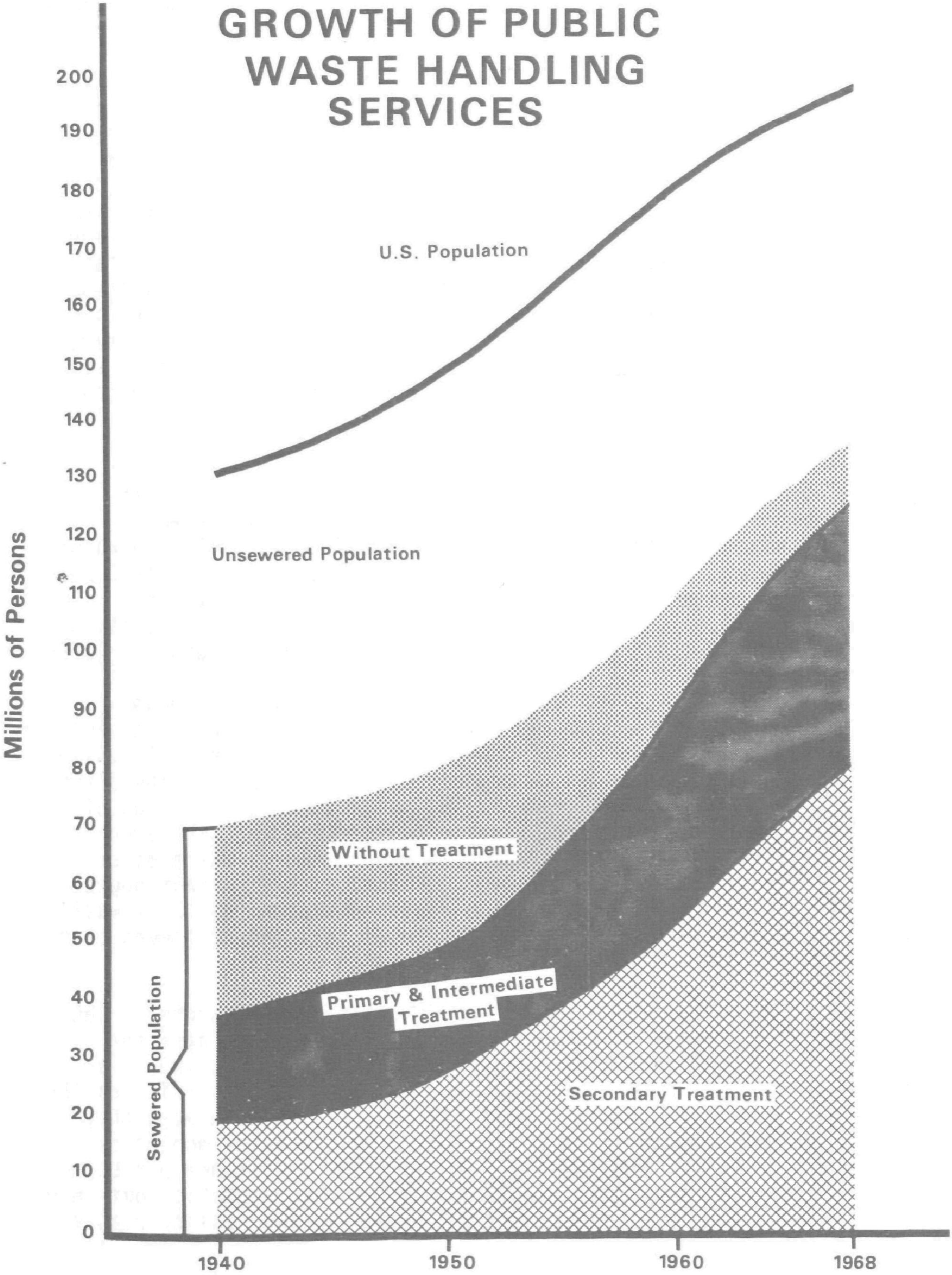
Whether viewed as an urban development program or as an investment in natural resource protection, the wave of treatment systems construction that has taken place since the end of the Korean war--most of it with the assistance of Federal grants--has profoundly changed the conditions and the attitudes that characterize waste handling procedures in American urban areas. And it is those changes, the result of the program's operation, which have made the present alignment of grants unsuitable for today's conditions.

The dimensions of change are illustrated in Figure 4. In 1940 just before the United States entry into World War II, one American in two was served by a sewer system and little better than one in four--or about half of those connected to sewers--was served by a waste treatment facility. A decade later, the relationships had scarcely changed. The exigencies of war, of industrial restructuring, of recovery from the after effects of the Great Depression, had shaped a set of national priorities in which the complexities of waste disposal were relegated to a low position. The proportion of the national population connected to sewers was still 53 percent--just what it had been in 1940. Waste treatment was provided to 60 percent of the sewered population, as compared to 53 percent in 1940; but the gain was due in larger measure to accidents of location than to new construction--cities with waste treatment tended to be in relatively fast growing areas.

But with the end of the Korean War and the eventual saturation of the repressed demand for consumer goods that accumulated during the long years of war and depression, the United States turned its attention toward a number of broad public investments--highways, education, urban renewal, and waste disposal among them--that began to rework the face of the nation. By 1957 when Federal grants for construction of waste treatment works were initiated, 57 percent of the total population was connected to sewers--20 million persons more than in 1950--and more than three quarters of those sewered were supplied with waste treatment, an addition of 28 million persons in seven years. The great increase in public works expenditures involved in that expansion of facilities was probably the principal source of the construction grants mechanism, which was initially viewed as a financial assistance measure. In the twelve years in which such grants have been available, sewered population has increased by 37.5 million persons, and now amounts to almost seventy percent of the population of the United States. Population served by waste treatment has increased by more than 51 million to account for more than 92 percent of those presently served by sewers. In twenty-eight years the population of the United States increased by about 65 million, the sewered population increased slightly more in absolute numbers but far faster in relative terms--a 94 percent increase as opposed to a 48 percent increase--and the population served by waste treatment increased by more than 88 million or almost 240 percent. Of those totals, more than half of the increase in sewering and more than three-fifths of the increase in application of waste treatment have occurred since the inauguration of Federal waste treatment plant construction grants.

The transformation in waste handling procedures has been qualitative as well as quantitative. Considerably more money has

Figure 4


GROWTH OF PUBLIC WASTE HANDLING SERVICES
Millions of Persons
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
U.S. Population
Unsewered Population
Sewered Population
Without Treatment
Primary & Intermediate Treatment
Secondary Treatment
1940
1950
1960
1968

been spent to extend, expand, replace, and upgrade facilities than has been spent for initial installation. As a result we may presume that treatment facilities in operation in 1969 were more efficient than those in operation a decade before.

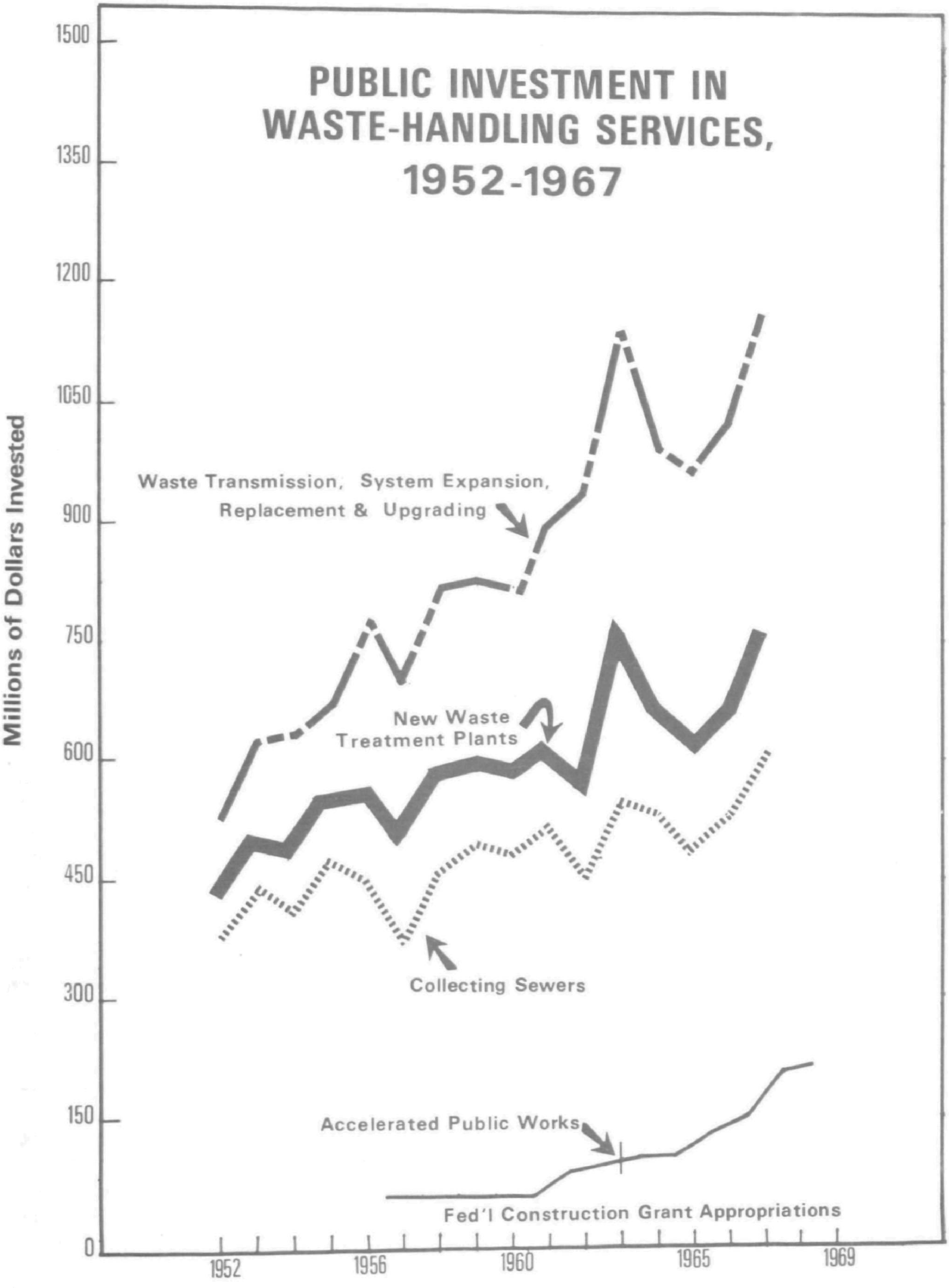
We know that there is a great deal more capacity for expansion in today's plants, so that a good portion of population increase that occurs in the future can be included in currently operating systems for minimal additional investment. Perhaps most significant, expansion of treatment capabilities has induced a great change in treatment procedures. Where plants in place in 1940 and 1950 were intended to treat sanitary wastes, current thinking dictates that in most cases the municipal waste treatment plant treats all of the wastes generated within the municipal jurisdiction, so that public waste handling services are far more comprehensive; and their extension has been a major means of mediating the polluting effects of industrial waste discharges, as these have been progressively incorporated in municipal systems.

Figure 5 which graphs public expenditures since 1952 for liquid waste handling capital demonstrates fairly clearly that each increase in the level of Federal appropriations for waste treatment plant construction grants has moved total public spending to an irregular, new plateau. Particularly sharp peaks in 1963 and 1967 reflect the effects of complementary Federal assistance programs, the Accelerated Public Works Program in 1963 and initiation of Department of Housing and Urban Development sewer grants in 1966-67.

The overall shape of the expenditures line is not, however, as significant in mirroring the impact of Federal financial assistance as is the configuration of its consitituents. Investments in collection sewers, which ascended at roughly the same slope as others types of waste handling capital expenditures prior to the initiation of the grants program, tended to flatten at the time that the grant provision (which does not include collection sewers) was enacted. Availability of Federal assistance, combined with a certain degree of substitutability between collection sewers and other types of waste handling investment, acted to channel funds into the treatment plants and ancillary works that do qualify for FWPCA grants.

Just as the emphasis on treatment-related investments to the relative disadvantage of collection facilities demonstrates the ability of Federal policy to influence local decisions, the relatively minor investments made for new treatment plants indicates the ability of local recipients to utilize Federal funds in ways that relate to local needs. Less than a third of the total monies expended for purposes that qualify for the grant assistance has been used in the construction of new plants. The less dramatic, but very real, need to equip, expand, improve, automate, and replace plants

Figure 5



PUBLIC INVESTMENT IN WASTE-HANDLING SERVICES, 1952-1967
Millions of Dollars Invested
1500
1350
1200
1050
900
750
600
450
300
150
0
Waste Transmission, System Expansion, Replacement & Upgrading
New Waste Treatment Plants
Collecting Sewers
Accelerated Public Works
Fed'l Construction Grant Appropriations
1952
1956
1960
1965
1969

has been the source of the principal portion of local government's demands on the grants program. Each expansion of Federal funding has been translated into an increase in expenditures of the miscellaneous sorts required for system rationalization; and the level of new plant expenditures for previously untreated wastes has scarcely changed over more than a decade of experience.

Federal intention and local need, then, have interacted to shape the instrument, the Federal grant for construction of waste treatment works. Application of that instrument has taken forms that neither level of government might have foreseen.

The Federal Share

It is, of course, difficult to say just how much money the Federal government should provide to achieve "adequate" waste treatment. The amount would be a function of the cost-sharing formula (assuming local ability to provide necessary matching funds) and of time.

Economic theory provides no real insight into some optimum level of Federal funds, leaving the political process to decide upon that level which reflects national interests and values. But economic theory can provide insights into the potential for matching by State and local governments, the time to eliminate non-current unmet needs and the potential success in mustering necessary resources at various dollar levels of Federal program. The potential inflationary impact and incentive effects can also be evaluated for these alternative levels.

Ignoring for the moment inflationary side-effects and the more difficult problem of incentives, let us consider the matter of optimum Federal participation in financing facilities: There is a pressing need to elicit an average annual investment rising from a current value of about a billion dollars a year, plus a need to eliminate a "backlog" of about $4.4 billion worth of required works. There is a definite resistance on the part of some of the local governments who must finance this investment, a resistance due to expression of local priorities and to financial constraints, concomitant with a very strong Federal interest in maintaining and increasing the rate of investment. All components of the investment deficiency are not of equal immediacy: Some facilities needs are quite pressing, in terms of alleviating stresses on the aquatic environment; some are little more than administrative requirements. It must be recognized that each dollar invested creates an immediate charge on local government to expend additional dollars to operate and maintain the function created by the investment. Finally--and a most significant consideration in determining meaningful Federal policies--<u>the need will never be fully met</u>: its nature will change, its geographic distribution will shift, the means of dealing with it will fluctuate; but human activities will always create wastes, and society will always be forced to ameliorate the environmental stresses implicit in waste disposal. The task is a continuing social and technological

TABLE 31
Dollars of Total Investment
Per Dollar of Federal Construction Grants

Year	Total Investment	Sewer Investment	Treatment Plant Investment
1957	11.54	4.94	6.60
1958	13.40	6.20	7.20
1959	13.24	6.72	6.52
1960	13.78	7.18	6.60
1961	9.54	4.75	4.79
1962	8.92	3.55	5.37
1963	10.04	4.05	5.99
1964	8.62	3.96	4.66
1965	6.40	2.74	3.66
1966	6.13	2.66	3.47
1967	5.20	2.49	2.71

imperative, and society can only redistribute financial stress over time, not eliminate the task by any massive, short term investment program.

Of importance in this decision too is the multiplier effect of Federal funds which is shown historically in Table 31. The recent history shows a decrease in the multiplier, which may be partially a result of increased cost sharing ratios beginning with the 1965 legislation and the institution of HUD grants for sewers in 1966.

Whatever the level of Federal participation and the method of allocation their impact will be felt at the State and local level. The effects of an illustrative program have been examined for New England and they are presented in the following case study.

CASE STUDY

Financial Impact of Constructing Water Pollution Control Facilities in New England

Introduction

The purpose of this case study is to investigate and evaluate the financial aspects, arrangements and impact of constructing water pollution control facilities in New England. For illustrative purposes only, it evaluates the financial impact a 50 percent Federal grants program might have on each of the New England States. The major emphases on case study was to show the distribution of costs among the levels of government, and more specifically the burden on the municipal sector. For this purpose a hypothetical level of Federal funds was selected. The case study assumes that adequate Federal funds will be forthcoming to provide a 50% Federal investment in the New England States. The state, local and Federal shares predicated on this assumption are shown in Table 32. Other aspects considered in the study are: (1) past sewerage expenditures relative to needs; (2) expenditures of State and local governments for education, highways, public welfare, etc.; (3) the fiscal capacity and tax effort of State and local governments; and (4) alternative financial arrangements.

The case study first considers the impact at the State level then the impact at the community and homeowner levels. Alternative means of financing the program at the local community level are evaluated in Examples I & II.

Cost of Water Pollution Control Facilities

The cost of providing treatment facilities and interception (exclusive of collection systems) for municipal and some industrial wastes in New England is estimated to be approximately $1.12 billion for the next

TABLE 32
FEDERAL, STATE AND LOCAL SHARE OF FINANCING
THE COST OF WATER POLLUTION CONTROL FACILITIES IN NEW ENGLAND

State	Percent Share	Amt. in $Millions
Connecticut		
Total Cost	100.0	$280.5
Federal	50.0	140.3
State	30.0	84.1
Local*	20.0	56.1
Massachusetts		
Total	100.0	438.0
Federal	50.0	219.0
State	25.0	109.5
Local	25.0	104.5
Rhode Island		
Total Cost	100.0	51.5
Federal	50.0	25.7
State	25,9	12.9
Local	25.0	12.9
Maine		
Total Cost	100.0	140.9
Federal	50.0	70.5
State	30.0	42.2
Local	20.0	28.2
New Hampshire		
Total Cost	100.0	138.0
Federal	50.0	69.0
State	40.0	55.2
Local	10.0	13.8
Vermont		
Total Cost	100.0	70.0
Federal	50.0	35.0
State	30.0	21.0
Local	20.0	14.0
New England		
Total Cost	100.0	1,118.9
Federal	50.0	559.5
State	29.0	324.9
Local	21.0	234.5

*Refers throughout to local government, metropolitan or regional districts

State	Estimated Cost* ($ Million)
Connecticut	$ 280.5
Massachusetts	438.0
Rhode Island	51.5
Maine	140.9
New Hampshire	138.0
Vermont	70.0
New England	$1,118.9

Impact at the State Level

The financial impact that construction of water pollution control facilities will have on the New England area will vary from State to State and from community to community. Individual communities within each State will have varying degrees of financial difficulties depending on such factors as present waste treatment facilities, per capita income of the community, the property tax base, competing claims on community resources, and credit rating.

In general, the financial impact of water pollution control facility costs on the States as a whole will depend largely on: (1) the amounts of Federal aid available to communities within each State for the construction of water pollution control facilities, (2) past sewerage expenditures relative to needs, (3) expenditures of State and local governments for education, highways, public welfare, etc., and (4) the fiscal capacity and tax effort of State and local governments.

Past Sewerage Expenditures: Another important factor that has significant bearing on the financial impact is past expenditures of State and local governments for sewerage systems to meet needs. In other words, has past construction of water pollution control facilities of each New England State kept pace with needs? In general, the States have not constructed the needed facilities in the past. However, some of the New England States have kept pace with their needs more than the other States, as indicated by the per capita expenditures in Table 33.

Table 33 shows the per capita expenditures for capital outlay, operation and maintenance for sewerage services of State and local governments for 1957, 1962, 1966 and 1968. Although the figures include expenditures other than those for treatment and interceptor sewers,

* The costs utilized in this case study are the State investment estimates as presented in Table 27, page 59.

TABLE 33
PER CAPITA
EXPENDITURES OF STATE AND LOCAL GOVERNMENTS
FOR SEWERAGE SERVICES

State	Capital Expenditures 1957	1962	1966	1968	Total Expenditures (Capital, Operation and Maintenance) 1957	1962	1966	1968
Connecticut	$4.39	$8.40	$8.84	$9.97	$6.01	$10.80	$11.35	$13.13
Massachusetts	2.25	3.83	3.61	2.88	3.65	5.38	5.27	4.98
Rhode Island	4.65	2.08	5.92	3.41	6.33	4.72	8.68	6.37
Maine	1.36	2.80	2.76	6.33	2.11	3.76	4.25	7.71
New Hampshire	1.89	1.65	4.08	5.71	2.53	2.65	5.18	7.56
Vermont	0.91	3.72	5.14	11.70	1.59	4.86	6.88	14.08
New England	2.57	3.75	5.06	6.67	3.70	5.36	6.94	8.97

Source: "Census of Governments, 1957 and 1962", Bureau of the Census, Washington, D.C.
"Governmental Finances in 1965-1966", Bureau of the Census, Washington, D.C.
"Governmental Finances in 1967-68", Bureau of the Census, Washington, D.C.

they serve to indicate the approximate and relative level of past spending for water pollution control facilities for each New England State. For example, in 1957 the per capita capital expenditures varied greatly from one State to another with a high of $4.65 for Rhode Island compared to a low of $0.91 for Vermont. The data further indicate that in 1957 the northern States (Maine, New Hampshire and Vermont) spent considerably less than the southern States (Connecticut, Massachusetts and Rhode Island). However, in 1968 the capital investment of the northern States was on the average 50 percent more than the southern States. In 1968, all the New England States, except Rhode Island, spent more on capital outlay than in 1957 with Vermont having spent the most of the six States.

Needed Expenditures: Even more significant than past expenditures for sewerage services are the expenditures needed in the near future to construct water pollution control facilities in each of the six New England States. By way of comparison, the needed investments on a per capita basis for constructing water pollution control facilities for each New England State are:

Connecticut	$95	Maine	$144
Massachusetts	$80	New Hampshire	$197
Rhode Island	$56	Vermont	$166

The above figures are based on the cost estimates presented in Table 32 and 1968 population.

On the average, the per capita costs of needed facilities in the northern States are double those of the southern States. The cost of needed investment in Vermont and New Hampshire are the highest, on a per capita basis, of all New England States.

A further analysis of the needed investments of each New England State is presented in Table 34 to evaluate the impact that financing of water pollution control facilities would have on State and local governments. The annual per capita amounts are based on capital costs estimates amortized for 25 years at 5.0 percent and 1968 population. Also included are the per capita amounts as a percent of total per capita expenditures of State and local governments (1968). (The total per capita expenditures of State and local governments are shown in Table 35.) In addition, an estimate of the annual per capita amounts and percentages for operation and maintenance as well as total annual per capita costs and percentages are given in Table 34 for each New England State.

With Federal aid amounting to 50 percent grants to all projects, all of the New England States will be required to commit (based upon 1968 expenditures rates) 1.6 percent of their total funds

TABLE 34
STATE AND LOCAL GOVERNMENTS' ANNUAL EXPENDITURES
FOR NEEDED PUBLIC WATER POLLUTION CONTROL FACILITIES
(Based on 50 Percent Federal Grants)

State	Annual Equivalent* Capital Outlay		Annual Operation and Maintenance		Total Annual Cost	
	Per Capita Amounts	Percent of 1968 Expend.	Per Capita Amounts	Percent of 1968 Expend.	Per Capita Amounts	Percent of 1968 Expend.
Connecticut	$3.36	0.6	$4.74	0.9	$8.10	1.5
Massachusetts	2.86	0.6	4.03	0.8	6.89	1.4
Rhode Island	2.16	0.4	2.83	0.5	4.99	0.9
Maine	5.10	1.1	7.20	1.5	12.30	2.6
New Hampshire	6.98	1.6	9.83	2.2	16.81	3.8
Vermont	5.88	0.9	8.29	1.3	14.17	2.2

Note: These columns indicate the per capita amounts (based on capital cost estimates amortized for 25 years at 5.0 percent and 1968 populations) and the percent of 1968 expenditures (based on the per capita amounts and the total 1968 per capita expenditures for State and local governments in Table 35).

to such facilities. The annual per capita Capital outlay would range from a low of $2.16 for Rhode Island to a high of $6.98 for New Hampshire. Annual expenditure required for the operation and maintenance of such facilities could amount to 0.5 to 2.2 percent of 1968 expenditures of State and local governments. The total annual per capita cost (capital, operation and maintenance) would range from a low of $4.99 for Rhode Island to a high of $16.81 for New Hampshire.

In summary, Table 34 shows that the burden will be relatively greater for Maine, New Hampshire and Vermont than for the other New England States.

Comparison of Other State and Local Government Expenditures: The financial impact that the construction of water pollution control facilities will have on the States as a whole will depend to a degree on expenditures of each State for other public functions, such as education and highways, relative to the capacity of States to meet these requirements.

A comparison of per capita sewerage expenditures and other State and local government expenditures for fiscal year 1968 is shown in Table 35. Shown are per capita total expenditures, as well as those for education, highways, public welfare, local parks and recreation, sanitation other than sewerage and sewerage for each New England State as well as the United States averages. New England sewerage expenditures for fiscal 1968 amounted to $5-14 per capita, or 1-3 percent of the total expenditures for State and local governments. In contrast, education, highways, and sanitation amounted to $163-206, $58-182, and $1-6 per capita or 32-40, 11-28, and less than 1 percent of the total expenditures, respectively. The United States average expenditures for sewerage amounted to approximately 2 percent of the total, compared to education and highway expenditures at 40 and 14 percent of total expenditures, respectively. In 1968, over 50 percent of all expenditures of State and local governments was for education and highways, while sanitation and sewerage amounted to less than 3 percent.

The past expenditures for sewerage services in relation to the total expenditures of State and local governments have not been appreciable in comparison to those for education and highways. Futhermore, the amount the three southern States may be required to spend annually for the needed facilities (on a per capita basis) is about the same or less than in the past, while the three northern States will need to spend considerably more annually for capital outlay than they did in the past.

Fiscal Capacity of State and Local Governments: A factor that is equally or perhaps more important than those already mentioned is the

TABLE 35
PER CAPITA EXPENDITURES OF STATE AND LOCAL GOVERNMENTS
FISCAL YEAR 1968

State	Total Expendi-tures	Education	Highways	Public Welfare	Local Parks and Recreation	Sanitation Other than Sewage	Sewerage	All Others
Connecticut	$531	$198	$73	$46	$8	$5	$13	$188
Massachusetts	510	163	58	65	5	6	5	208
Rhode Island	555	187	110	70	4	4	6	174
Maine	467	206	89	39	2	2	8	121
New Hampshire	446	178	100	30	4	2	8	124
Vermont	649	260	182	55	2	1	14	135
New England	526	199	102	51	4	3	9	158
United States	512	206	72	49	7	5	9	164

Partial Source: "Governmental Finances in 1967-68"
Bureau of the Census, Washington, D.C.

fiscal capacity of State and local governments. The Advisory Commission on Intergovernmental Relations defines fiscal capacity as follows:

> "... a quantitative measure intended to reflect the resources which taxing jurisdiction can tax to raise revenue for purposes. There are many factors that determine the capacity of a community or State to pay for public services including the population's income, wealth, business activity, etc., the demands made on these resources, and the quantity of governmental services."[1]

The economic indicator of most general applicability is income. Therefore, the economic indicator that will be used here as a measure of fiscal capacity is the per capita personal income of each of the New England States. Since taxes are generally paid out of current income, a community's income is a measure of its capacity to meet both public and private needs. As fiscal capacity is difficult to evaluate in absolute terms, only a relative measure will be considered in comparing one State with another.

The per capita personal income of each of the New England States for 1950, 1960 and 1967, as well as New England and the United States averages are shown in Table 36. In 1967, Connecticut had the second highest per capita personal income of the 50 States and the District of Columbia. In 1967, the States of Connecticut, Massachusetts and Rhode Island ranked above the median income State of the Nation while the other three New England States ranked below. Maine's per capita personal income, which was the lowest of all the New England States in 1967, amounted to only 67 percent of the per capita personal income of Connecticut.

It is evident that the financial impact of constructing waste treatment facilities will be greater in the northern New England States based on the following two factors: (1) the per capita personal income is less and is projected to be less in the future for the three northern States than for the southern States[2], and (2) the estimated per capita cost of needed water pollution control facilities in the northern New England States is considerably greater than in the southern New England States.

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1 "Measures of State and Local Fiscal Capacity and Tax Effort," The Advisory Commission on Intergovernmental Relations, p.c.

2 "Projective Economic Studies of New England," Corp of Engineers, Waltham, Massachusetts, Part II, Appendix G.

TABLE 36

PER CAPITA PERSONAL INCOME

State	1950	1960	1967
Connecticut	1,875	2,807	3,969
Massachusetts	1,633	2,459	3,541
Rhode Island	1,606	2,211	3,328
Maine	1,185	1,844	2,657
New Hampshire	1,323	2,143	3,053
Vermont	1,121	1,841	2,825
New England	1,601	2,425	3,229
United States	1,496	2,215	3,159

Source: Statistical Abstract of the United States, 1967 Bureau of the Census, Washington, D.C., p. 327. "Governmental Finances in 1967-68" Bureau of the Census, Washington, D.C., p. 52

Tax Effort: The extent to which a State makes use of its fiscal or taxable capacity is defined as tax effort. For example, if State X and State Y have the same fiscal capacity, but State X collects more taxes than State Y, then State X is making a greater tax effort than State Y.

A comparison of revenue of State and local governments for each of the six States is used as a relative measure of the tax effort in New England. Table 37 indicates the per capita general revenue, of State and local governments for fiscal 1968, including total general revenue, revenue from the Federal government, all revenue from own sources, and revenue from property taxes.

The per capita total general revenue in fiscal 1968 ranged from a low of $400 for Maine to a high of $579 for Vermont. However, the per capita revenue from the Federal government was $74 for Maine compared to $158 for Vermont. A more realistic economic indicator in evaluating tax effort is the revenue collected from State and local governmental sources. For example, in 1968, Massachusetts collected the highest per capita revenue ($456) of all six States and Maine the lowest ($326). The United States average for the same year was $420. The States of Connecticut, Vermont and Massachusetts were the same or above the United States average while the other three States were below. Per capita revenue collected from property taxes ranged from a high of $204 in Massachusetts to a low of $129 in Maine compared to a United States average of $139.

The relation of State and local governments' revenue per $1,000 of per capita personal income is also included in Table 37. On this basis, Rhode Island and Vermont had the highest tax effort of the six States in fiscal 1968, being greater than the United States average.

Table 38 presents the relationship of State and local governments' annual expenditures for their share of needed water pollution control facilities to total general revenue and property tax capabilities. Also shown in Table 38 are the per capita amounts as percent of total general revenue and property tax revenue of State and local governments for 1968.

With Federal aid amounting to 50 percent of construction cost, all of the New England States will be required to commit (based upon 1968 revenue rates) 1.7 percent or less of their total general revenue to such facilities. The annual capital expenditures for needed water pollution control facilities as a percent of property tax revenue would amount to 1.8 percent or less for the southern States compared to 4.2 percent for the northern States. The additional percentages for annual operation and maintenance for the needed facilities range from 0.6 to 2.4 percent of total general revenue compared to 1.9 to 6.0 percent of property tax revenue.

TABLE 37
GENERAL REVENUE OF STATE AND LOCAL GOVERNMENTS
FISCAL YEAR 1968
(Per Capita)

	Total General Revenue	From Federal Gov't.	All Revenue From Own Sources Including Property Taxes	Relation of State & Local Gov't. Revenue Per $1,000 of Personal Income
Connecticut	$502	$81	$421 186*	$126
Massachusetts	534	78	456 204*	151
Rhode Island	492	103	389 146*	164
Maine	400	74	326 129*	151
New Hampshire	412	79	333 165*	135
Vermont	579	158	421 138*	205
United States	506	86	420 139*	160

Partial Source: "Governmental Finances in 1967-68," Bureau of the Census, Washington, D.C., p. 31-33

*Figures represent revenue from property taxes

TABLE 38
RELATIONSHIP OF STATE AND LOCAL GOVERNMENTS' ANNUAL EXPENDITURES FOR NEEDED WATER POLLUTION CONTROL FACILITIES TO TOTAL GENERAL REVENUE AND PROPERTY TAX CAPABILITIES
(Based on 50 Percent Federal Grants)

State	Annual Equivalent* Capital Outlay			Annual Operation and Maintenance			Total Annual Cost		
	Per Capita Amounts	Percent of 1968 Total General Revenue	Percent of 1968 Revenue from Property Taxes	Per Capita Amounts	Percent of 1968 Total General Revenue	Percent of 1968 Revenue from Property Taxes	Per Capita Amounts	Percent of 1968 Total General Revenue	Percent of 1968 Revenue from Property Taxes
Connecticut	$3.36	0.7	1.8	$4.74	0.9	2.5	$8.10	1.6	4.3
Massachusetts	2.86	0.5	1.4	4.03	0.8	2.0	6.89	1.3	3.4
Rhode Island	2.16	0.4	1.5	2.83	0.6	1.9	4.99	1.0	3.4
Maine	5.10	1.3	4.0	7.20	1.8	5.6	12.30	3.1	9.6
New Hampshire	6.98	1.7	4.2	9.83	2.4	6.0	16.81	4.1	10.2
Vermont	5.88	1.0	4.2	8.29	1.4	6.0	14.17	2.4	10.2

Note: *These columns indicate per capita amounts (based on capital costs amortized for 25 years at 5.0 percent and 1968 populations) and percentages (based on the per capita amounts and total general revenue and property tax revenue of State and local governments for 1968, Table 37).

In summary, the financial impact of constructing water pollution control facilities certainly will be relatively greater for the States of Maine, New Hampshire and Vermont, than for Connecticut, Massachusetts and Rhode Island, based on per capita construction costs of waste treatment facilities, per capita personal income, and State and local governmental expenditures and revenues.

Impact at the Community and Homeowner Levels

Quite apart from any assumptions with respect to the availability of Federal and State aid, local communities in New England will face varying degrees of difficulties in financing their share of the total cost of waste treatment and collection facilities. Once they know what their share of the cost is and proceed with bond issues to finance it, they face alternative means of recapturing these costs, i.e., repayment of bond issues. These problems may be intensified by the fact that, in many New England communities, an industry dominates the local econ4my, thus raising the very important question of whether repayment should be in the form of a sewer service charge or by means of general taxation, or a combination of both.

In general, the financial impact of water pollution control facilities at the community level will depend largely on the existence of present water pollution control facilities, per capita income of the community, property tax base, competing claims on community resources and credit ratings.

The percentage of the local share that will be shouldered directly by homeowners will depend on the alternative means of repayment of bond issues used by a community, i.e., whether repayment is in the form of a sewer service charge or by means of general property taxation. It is important to realize that, in the final analysis, the cost of sewerage facilities is paid for directly and indirectly by all taxpayers, but the impact on property owners will vary with the method of financing.

In order to evaluate the financial impact at the community and homeowner levels, a number of alternative financial arrangements will be considered.

Alternative Financial Arrangements:

The Funding Problem: Although Federal and State grants are available to local communities for water pollution control facilities, the communities must finance their share of the cost. In general, most of the cities and towns in New England will depend on municipal bond issues to finance the local share, but they will have varying degrees of difficulties in financing, due to municipal credit ratings, legal bonded debt limits and market conditions.

Bond Issues and Municipal Credit Rating: The two types of bonds most widely used to finance water pollution control facilities are general obligation and revenue bonds. In the case of general obli-bonds, the town or city pledges its full credit for repayment of the debt from the general tax fund or service charges. Such bonds in effect constitute a tax lien on all assessable property in the community. In contrast, a revenue bond is an obligation issued to finance a revenue producing enterprises, payable exclusively from earnings of the enterprise, in this case service charges. Since the repayment of revenue bonds is dependent on the earnings of the enterprise, these bonds usually carry an interest rate that is 1/2 to 1 percent higher than general obligation bonds.

An important factor in determining the interest rate a community must pay for municipal bonds is the credit rating of the community. Credit ratings are determined by such national firms as Moody's Investors Service, Inc. and Standard & Poor's Corporation and indicate the community's ability and willingness to repay the bonds. Investors charge communities interest rates that are commensurate with their credit ratings.

Moody's rates the bonds of communities that have $600,000 or more of debt. Their credit ratings are as follows:

Aaa - Best Quality
Aa - High Quality (generally known as high grade bonds)
A-1 - Upper Medium Grade
A - Upper Medium Grade (elements exist that suggest susceptibility to impairment)
Baa-1 - Lower Medium Grade
Baa - Lower Medium Grade (Neither highly protected nor poorly secured)
Ba - Some Speculative Elements
B - Speculative
Caa - Poor Standing
Ca - Very poor Prospects of Payment
C - Lowest Rated Class

Many characteristics of a community are evaluated to arrive at a credit rating. The most important elements used by Moody's in determining a rating for a community are, (1) management (the policies of the community in regard to fiscal matters), (2) the economy of the community (the presence of industry and commercial establishments within the municipality as well as its capital program), and (3)the bonded debt. Several other tangibles and intangibles influence a rating.

Moody's rating for the New England States and a number of selected communities are given in Table 39. The State of Rhode Island has an A-1 rating, Massachusetts, an Aa rating and the other four States, Aaa

TABLE 39

MOODY'S RATINGS

OF

NEW ENGLAND STATES AND SELECTED COMMUNITIES

(December 1969)

State and Community	Rating
Connecticut	Aaa
Groton	A-1
Hartford	Aaa
Plainfield	A
Maine	Aaa
Bangor	Aa
Caribou	Baa-1
Massachusetts	Aa
Amesbury	A
New Bedford	A
New Hampshire	Aaa
Concord	Aaa
Hudson	A
Rhode Island	A-1
Barrington	Aa
Warwick	Baa-1
Woonsocket	Baa
Vermont	Aaa
Brattleboro	Aa
Montpelier	Aaa

ratings. In general, the communities in New England have a lower rating than their respective States.

In November 1969, the interest rates for Aaa, Aa, A and Baa ratings were 6.05, 6.34, 6.65 and 6.83 percent, respectively. In general, a difference of 0.1 percent in the interest rate on a $1 million bond issue (20 year maturity) would cost taxpayers or users $20,000 more. For instance, the State's share of the cost of waste treatment facilities for Massachusetts is estimated to be $110 million. Based on the present trend in interest rates and 20 year maturity, it would cost taxpayers or users approximately $6 million less to repay the State's share if the State of Massachusetts had a credit rating of Aaa instead of Aa.

Legal Bonded Debt: Another factor that may create a funding problem for local communities in financing water pollution control facilities is their legal bonded debt limit. All communities have a legal debt limit for public works construction, but in all New England States, except Maine, water pollution control facilities and school construction are not included under the debt limit specified by law.

Although water pollution control facilities may be exempt from the legal debt limit there is a question as to what extent a community should exceed its legal debt limit. As a general guide, the International City Manager's Association suggests that (1) the ratio of indebtedness to full taxable value should not exceed 10 percent, and (2) debt retirement should be so scheduled that at least 25 percent of the principal is always due for amortization within a five year period. Moody's Investors Service, Inc. suggests that a total debt service requirement (interest and retirement of principal) which is more than 15 percent of the community's normal annual budget may be considered high, but also points out that no strict rule of thumb can be applied since in communities with financial difficulties, even 10 percent may be too high.

In summary, the funding problem will vary from community to community as reflected by the type of bond issues, credit ratings and legal bonded debt limits of each community.

The Repayment Problem:

General Property Taxation: Many communities in New England are repaying municipal bonds, including those issued for water pollution control facilities out of revenue collected from property taxes. To evaluate the impact of financing waste systems on the local community, the increase in property taxes on a $20,000 home (market value) under various conditions of aid availability will be considered for several communities in each of the New England States. Each community was selected to represent various magnitudes of investment.

It was assumed that the method of financing would be general obligation bonds (25 year maturity). An interest rate of 5.0 percent was used for all communities although the actual interest rate each community will pay depends upon its credit rating and market conditions. The capital costs used are preliminary estimates and may not reflect the actual costs to each community.

Table 40 indicates the effect on property taxes for a $20,000 home (market value) for each of the selected municipalities under conditions of (1) 50 percent Federal aid and 25-40 percent State aid, (2) no Federal aid and 25-40 percent State aid, and (3) no Federal and State aid. The annual tax increase is attributable to the cost of water pollution control facilities, i.e., annual amortized capital cost plus the estimated annual cost of operation and maintenance. The three chosen to evaluate the financial impact on the selected municipalities under extreme conditions (full aid and no aid) and under an intermediate condition (State aid only). Even though the second and third assumptions may not be realistic, they serve to measure the financial impact.

The total 1968 property taxes on a $20,000 home for the selected communities ranged between $360 and $1061. The new annual property taxes ranged between $413 and $1095 under conditions of maximum aid available; $440 and $1146, State aid only; and $453 and $1168, no aid. These figures include the annual capital, operation and maintenance costs of waste treatment facilities and are based on 1968 assessed valuations, assessment ratios and tax rates.

The annual increase in property taxes needed to finance the facilities ranged between $11 and $75 under maxmum aid; $20 and $126, State aid only; and $28 and $160, no aid. Of the 16 selected communities, all had an annual tax increase of $75 or less under conditions of maximum aid compared to 11 communities with State aid only, and 9 communities without Federal or State aid.

It is important to emphasize that these figures do not include the cost of a collection system, and, to estimate more accurately the impact on a homeowner not served by a sewer system, an annual cost for a collection system must be added to the above figures. An average annual cost of $50-$75 per household for a collection system would result in a total annual cost of $61 to $150 under maximum aid for a $20,000 home for the collection and treatment of sewage. The total annual cost of collection and treatment per $20,000 home would range between $70 and $201 under State aid only, and between $78 and $235 under conditions of no aid for the selected communities.

Service Charges: A number of New England communities use a sewer service charge, also called a rental charge, use charge or sewer use tax as a source of revenue to repay general obligation, or revenue bonds used to finance waste treatment facilities and/or to pay

TABLE 40
EFFECT ON PROPERTY TAX ON A $20,000 HOME IN FINANCING WASTE TREATMENT FACILITIES
(MARKET VALUE)

State and Community	1968 Taxes	Increase in Annual Taxes			New Annual Taxes		
		Max. Aid	State Aid Only	No Aid	Max. Aid	State Aid Only	No Aid
Connecticut							
Groton	$570	$25	$48	$ 60	$595	$618	$630
Canton	564	20	40	49	584	604	613
Plainfield	360	53	96	120	413	456	480
Maine							
Bangor	668	36	60	76	704	728	744
Caribou	609	49	81	101	658	690	710
Farmingdale	388	49	80	100	437	468	488
Massachusetts							
Amesbury	1020	75	126	148	1095	1146	1168
New Bedford	1061	16	34	39	1077	1095	1100
Rockport	455	16	30	36	471	485	491
New Hampshire							
Concord	877	54	94	128	931	971	1005
Conway	440	21	30	37	461	470	477
Dover	691	11	20	28	702	711	719
Hudson	620	68	120	160	688	740	780
Rhode Island							
Jamestown	380	34	60	73	414	440	453
Woonsocket	737	21	38	45	758	775	782
Vermont							
Brattleboro	747	26	46	58	773	793	805
Windsor	721	33	59	76	754	780	797

for the cost of operation and maintenance of the system. Other communities use a combination of service charges, general taxes and betterments. For example, in Brockton, Massachusetts, 50 percent of sewerage revenue is from service charges, 25 percent from betterments and 25 percent from general taxation.

The sewer service charges can be based on one or a combination of factors such as the following: metered volume of water used, flat rates, sewage flow and/or strength, property frontage or area, value of property or number of rooms.

Basing the service charge on the metered volume of water use is one of the most frequently selected methods, since 85 percent of the water distributed in the Nation is metered. With this method, the charge can be based on a uniform metered volume of water used, sliding scale of metered water used, block ratio of water used, percentage of water bill or by the size of the water meter.

Flat rates, which are used in areas where metered water service is not available, can be based on the number of equivalent dwelling units, number of persons residing or working on the premises, number of plumbing fixtures, and/or the number of sewer connections. The disadvantage of the flat rate basis is the users are not charged in terms of quantity or quality discharged into the system.

The metered sewage charge is usually limited to industry and commercial establishments and some inter-municipal arrangements because of the cost and technical difficulty in metering the quantity and quality if it were feasible to meter on a widespread basis.

Example I which is presented later compares a service charge with general taxation for a large industry within a small community.

The Problem of Joint or Separate Facilities

Explanation of Distinction: For the purpose of this report, a separate facility is defined as one where the wastes are from municipal sources which include domestic, commercial, and a small amount of industrial wastes while a joint facility is one that receives domestic, commercial, and a large amount of industrial wastes. However, in both cases, the facilities are constructed as well as owned and operated by the municipalities. The first example to follow was selected to compare the impact of a service charge with that of general taxation in the case of a joint treatment system.

In a number of the smaller towns in Northern New England, one major industry produces exceptionally large pollution loads compared to the total load discharged. In such town, the waste load from the community may have a biochemical oxygen demand (BOD)* load of 500 - 1,000 lbs/day while the industry's load may be 60,000 to 100,000 lbs/day.

* Biochemical Oxygen Demand - The amount of oxygen required by living micro-organisms in the decomposition of organic matter in water.

By law, the industry is required to treat its waste, but it may do this by (1) building its own treatment facility, or (2) having the community build a treatment facility which the industry and the community can use jointly. However, the latter alternative has prompted some to question whether the amount of Federal and State assistance to a community constructing a joint facility serving a dominant industry should be reduced. ABT Associates in their report to the FWPCA, subsequently transmitted to the Congress, on incentives to industry recommended:

> "...it does not seem desirable to continue to give grants to municipalities to construct industrial treatment facilities. Instead, the current practice should be changed so that grants are only given for the percentage of capacity which is actually used to treat domestic wastes. Towns should be required to allocate costs between industrial and other wastes according to standarized procedures."1

The report further mentions that:

> "The present value to the firm of the tax savings for pollution control spending under the current tax law is 30% to 45% of the cost of the capital investment and 50% of any operating costs. The very substantial size of this aid should be kept in mind when considering the argument often made for additional tax assistance, namely, that the community as a whole ought to assume part of the costs for abating pollution. Whether it should or not, the community is already in fact assuming much of the burden to industrial pollution control." 2

Example I illustrates the costs to both the industry and the town if a joint facility is constructed compared to separate facilities.

Example I

A small community with a large paper company located in the town is used for this example. It is estimated that the cost of required water pollution control facilities, including collection and treatment, for the town alone is $500,000 while a system that could accommodate both the industry and the town is estimated to cost $6 million. For the purpose of this analysis, the following assumptions were made:

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1 ABT Associates Inc., "Incentives to Industry for Water Pollution Control: Policy Consideration," December 1967, p. 54.

2 Ibid., p. 41

Federal aid 50 percent and State aid 30 percent of construction costs, 25 year amortization period, 5.0 percent interest rate on general obligation bonds, and annual costs of operation and maintenance as 5 percent of capital costs. Total costs eligible for State and Federal assistance are approximately $5.9 million for the joint facility.

The waste characteristics for the town and the industry are as follows:

Waste Characteristics	Town	Industry
Flow-mgd.	0.25	10.7
Biochemical Oxygen Demand (BOD) - lbs/day	500	63,100
Suspended Solids - lbs/day	500	292,4000

This means that the industry's average daily flow is approximately 43 times that of the town, 5 day BOD is 126 times, suspended solids is 585 times and the cost approximately 11 times. What financial arrangement would be most equitable for the industry and the town? Should the town pay 1/43, or 1/126, or 1/585 of the annual cost of the joint facility and the industry the remainder? The following analysis will consider the cost to the town and to the industry based on general property taxes, cost distribution, flow, BOD and suspended solids. It is not the intent of this example to develop a scheme for equitably distributing costs of a joint facility between the town and industry, but to present a number of possible alternatives that can be used in determining an equitable cost-sharing arrangement. The financial arrangement is shown as follows:

Joint Facility

Total Cost of Joint Facility	$ 6,000,000
Eligible Costs	5,900,000
Federal Share - 50%	2,950,000
State Share - 30%	1,770,000
Local Share - 20%	1,180,000

Total Local Share (includes $100,000 ineligible costs for collection system) -	$ 1,280,000
Annual Capital Cost (amortized 25 yrs. @5.0%)	90,800
Annual Operation and Maintenance Costs -	300,000
Total Annual Cost -	$ 390,800

Cost Sharing

General Property Taxes

If the annual cost of $390,800 were to be financed from property tax revenue, then an increase in the tax rate would necessary:

Total assessed value of all property (1969)	$18,943,060	
Total assessed taxes (1969)	1,006,733	
Tax rate (per $1,000 valuation)	53	
New Taxes ($1,006,733 + 390,800)	1,397,533	
New Tax rate (per $1,000 valuation)	74	
Increase in Tax Rate	21	
Industry's Share of Joint Facility (1969 industry's assessed evaluation, $12,185,400)	$251,700	64.4%
Town's Annual Share of Joint Facility (1969 assessed valuation, commercial and residential $6,757,660)	139,100	35.6%

Service Charge

1. If the cost-sharing were to be based on flow, then:

Town's Annual Share -	$ 9,000	2.3%
Industry's Annual Share -	$ 381,800	97.7%

2. If the cost-sharing were to be based on 5 day BOD, then:

Town's Annual Share -	$ 3,100	0.8%

Industry's Annual Share - $ 387,700 99.2%

3. If the cost-sharing were to be based on suspended solids, then:

Town's Annual Share - $ 800 0.2%

Industry's Annual Share - $ 390,000 99.8%

The cost to the town will vary greatly depending on whether or not general taxation or a service charge based on flow, BOD or suspended solids is used to repay the general obligation bonds for a joint facility. A summary of the total annual costs (capital, operation and maintenance) to the community and the industry is tabluated below:

Joint Facility

(Total Annual Costs)

	General Taxes		Service Charge Based On					
			Flow		Bod		Suspended Solids	
	Cost in $1,000	Percent	Cost in $1,000	Percent	Cost in $1,000	Percent	Cost in $1,000	Percent
Town	$139.1	35.6	$ 9.0	2.3	3.1	0.8	0.80	0.2
Industry	$251.7	64.4	$381.8	97.7	387.7	99.2	$390.0	99.8

It is evident with a joint facility that the town would pay a higher percentage of the total annual cost if general taxation were used to raise revenue than if a service charge were used based on flow, BOD or suspended solids. However, a more reasonable financial arrangement would be one in which the total annual cost to the industry and the town is determined by construction and operation costs that are attributable directly to each. A detailed analysis of these costs would then be required to arrive at a more accurate and equitable service charge for each.

Separate Facility: A further comparison is considered in this example to evaluate the total annual costs to the town if a separate facility were constructed instead of a joint system.

Separate Facility

Total Cost of Town Facility $ 500,000

Eligible Costs 400,000

Federal Share 50%	200,000
State Share 30%	120,000
Local Share 20%	80,000
Total Local Share	180,000
Annual Capital Cost (25 yr. @ 5.0%)	12,800
Annual Operation and Maintenance Cost	20,000
Total Annual Cost	32,800

The total annual cost for the town would amount to $32,800 if the town constructed and maintained a separate facility. On the other hand, if the industry constructed and maintained its own facility, then its total annual cost would be $642,800 based on no Federal or State financial assistance. This would result in our annual reduction of profits of approximately 4.6¢ per share before taxes (1968 proce range per share, $44 - 29 1/2) based on the number of common shares outstanding as of December 31, 1968. The company earned $2.48 per share in 1968 while dividends amounted to $1.40 per share.

With a joint facility, the town's annual share would range from $800 to $139,100 or from 0.2 to 35.6 percent respectively depending on the method of financing. In contrast, the industry's annual reduction of profits for a joint facility would range from 1.8 to 2.8¢ per share before taxes depending on the method of financing and based on full Federal and State financial assistance.

If general taxation were used to raise revenue to finance the annual cost of a joint facility, then the town would pay more than if the town had its own separate facility. However, if a service charge were used, based on flow, BOD, suspended solids or a combination of these for a joint facility, the town would pay less annually than having its own facility. The reduction in profits to stockholders would not be that significant if the industry were to construct and maintain its own facility. However, the amount of Federal and State aid for a joint facility would amount to approximately $4.7 million compared to $320,000 for a separate municipal plant.

<u>Example II</u>

In the final analysis, part of the cost of financing water pollution control facilities is borne directly by homeowners and otherr users and the remainder, namely the Federal and State share, is borne indirectly by all taxpayers. The impact on the homeowner can be evaluated, but the impact on the taxpayers in general cannot. To illustrate the impact on the average homeowner, the following example is presented.

A particular community in New Hampshire was selected because there is virtually no industry in the town, and the cost of water pollution control facilities will be borne directly by homeowners. Although the 1960 population of the town was 3,650, it has nearly tripled in the past nine years to a present estimated population of 10,000. The building boom will not continue, however, because of the town's new zoning regulations. Presently, only a small percentage of the population is sewered, and there are no treatment facilities. The estimated cost of interceptors and water pollution control facilities is $1.8 million and the cost of lateral sewers is $1.48 million. The Federal and State aid programs can provide 90 percent of the cost of treatment facilities and interceptors, leaving approximately $0.18 million plus $1.48 million or a total of $1.66 million to be financed by the community.

In the analysis to follow, the estimated cost of water pollution control facilities for the average homeowner in this town will be compared to the average cost of other utilities such as water, electricity and telephones.

The cost of water pollution control facilities to the average homeowner will vary depending on the funds available and method of financing used, i.e., general taxes or service charge. Based on 50 percent Federal aid and 40 percent State aid, the cost to the average homeowner ($20,000 market value) would amount to approximately $25 per year compared to $50 per year if only State aid were available. If a service charge were used, based on a percentage of the water bill, then the cost for waste treatment facilities for a family of 4 would amount to approximately $50 per year with full aid and $100 per year with State aid and no Federal aid.

In addition, homes that are not presently sewered will have an additional betterment charge that may amount to $50-75 per year for 20 years. For these homeowners, the annual cost of a collection and treatment system may range from $75 to $175 depending on available funds and the method of financing.

By way of comparison, the monthly average utility charges for a family of four are electricity, $10; water, $7; and telephone, $8 (with toll charges $11.50). These compare to $7 to $15 for waste treatment and collection, depending on the availability of funds.

PRIORITY SYSTEMS

The Federal Water Pollution Control Act stipulates that no grant shall be approved for any project unless the project (1) conforms with the State's water pollution control plan, and (2) has been certified by the appropriate State agency as entitled to priority over other projects on the basis of financial as well as water pollution control needs.

From a national point of view, it may be assumed that the FWPCA's primary objective is pollution abatement and control. Secondary objectives include providing financial assistance to local communities and preserving the State role in pollution control. With these objectives and a frame of reference that assumes sufficient monies are not available to assure that all projects will be funded, the need for a priority system overrides all arguments against one. The discussion of priority systems here is within the context of the only alternative that makes such systems meaningful--scarcity of funds. Priority systems assume their greatest significance when the abatement program must be stretched out over time because of a scarcity of funds whether local or federal. With sufficient funds available to assure a massive clean-up over a relatively short time frame (e.g., New York State Pure Waters Program) the significance of priority systems would diminish.

In general, development of a priority system is a means by which critical needs or problems can be identified. In most cases this is accomplished by applying several criteria to a group of projects which permits them to be ranked in order of desirability. The Act only requires that each project financially assisted be entitled to priority over the other projects on a financial need as well as a pollution control basis. (This could be interpreted that, between two eligible projects, only the project with the greater financial need would receive assistance; and the other project could proceed without Federal assistance.)

In Table 41 the various criteria the States use have been identified. They generally fall in three broad categories, (a) water pollution control needs, (b) financial needs, and (c) state of planning and readiness. In some instances, criteria within a category have been aggregated. These should be interpreted as identifying in a general sense what types of criteria are used. For example, under the heading abatement needs, an X indicates the criteria employed was either a court order or project to eliminate the discharge of inadequately treated wastes, or eliminate a nuisance, etc.

TABLE 41
PRIORITY SYSTEM CRITERIA

	POLLUTION ABATEMENT								FINANCIAL							PLANNING/READINESS							Priorities Assessed Independent of Grant Applications		
	Comp. Plan	Health Hazard	WQS	Trtmt. Reqd.	Abatmt. Needs	Water Uses	Vol. Waste	Inter/ Intra	Finan. Status	Inc-ome	Const. Cost	Ass. Val.	Bond. Debt	Pop.	Other	Site Acqd.	Engr. Rept.	Plans Apprvd.	Finacng. Arrangd.	Contract Awarded	Implmntn. Plans	Grant Appl.for	Yes	No	Unk.
Alabama						X					X					X		X	X					X	
Alaska				X	X					X	X	X		X							X		X		
Arizona		X	X	X	X				X	X	X	X	X											X	
Arkansas		X			X	X	X	X																X	
California		X		X	X	X	X					X	X		X				X						X
Colorado			X		X							X	X												X
Connecticut					X	X	X			X	X		X				X	X	X				X		
Delaware	X		X			X				X			X		X									X	
District of Columbia(a)																									
Florida		X	X	X	X	X					X							X	X	X					X
Georgia	X	X			X						X							X	X					X	
Hawaii			X									X				X		X	X					X	
Idaho				X	X					X	X	X									X			X	
Illinois				X	X	X					X	X		X				X	X					X	
Indiana		X		X	X	X				X								X						X	
Iowa		X				X				X	X						X	X					X		
Kansas		X			X	X					X				X										X
Kentucky		X				X	X	X							X		X	X	X			X		X	
Louisiana		X		X	X	X				X					X									X	
Maine		X	X	X	X	X					X				X			X	X			X	X		
Maryland				X	X						X	X	X		X			X	X					X	
Massachusetts		X				X					X				X									X	
Michigan		X			X	X					X		X		X				X					X	
Minnesota					X	X				X	X							X	X	X				X	
Mississippi		X			X	X				X	X					X	X	X	X						X
Missouri			X	X	X	X					X				X			X	X						X
Montana				X	X						X	X									X		X		
Nebraska		X		X	X	X		X			X			X	X			X	X						X
Nevada		X		X	X	X									X				X					X	
New Hampshire		X	X			X				X	X				X			X					X		
New Jersey	X				X	X	X								X										X
New Mexico				X						X	X												X		
New York			X	X	X					X			X											X	
North Carolina					X						X	X	X			X		X	X					X	
North Dakota						X					X						X		X					X	
Ohio				X	X	X				X	X													X	
Oklahoma			X	X	X						X	X						X	X			X	X		
Oregon	X			X	X	X					X	X						X	X					X	
Pennsylvania					X	X					X	X						X						X	
Rhode Island					X	X					X						X	X	X	X					X
South Carolina				X	X	X					X		X				X	X	X					X	
South Dakota						X		X									X	X	X				X		
Tennessee		X		X	X	X					X		X			X		X	X					X	
Texas				X	X	X	X								X	X		X	X					X	
Utah		X						X		X	X	X	X				X	X	X					X	
Vermont		X	X			X					X				X		X	X	X				X		
Virginia			X	X	X	X			X					X										X	
Washington			X		X	X					X	X	X				X	X							X
West Virginia			X		X	X				X	X												X		
Wisconsin				X	X	X				X	X		X											X	
Wyoming		X			X	X		X					X							X				X	
Puerto Rico		X			X	X				X				X	X										X

(a) Priority system not applicable

TABLE 42

Numerical Rank of Criteria by General Categories

	Need		Status of Plans
	Pollution	Financial	
Alabama	1	2	3
Alaska	3	1	1
Arizona	1	2	
Arkansas	1	2	
California	1	3	1
Colorado	1	2	
Connecticut	1	2	2
Delaware	1	2	
District of Columbia			
Florida	1	2	3
Georgia	1	3	2
Hawaii	1	3	2
Idaho	3	1	1
Illinois	1	2	2
Indiana	1		2
Iowa	1		2
Kansas	1	2	
Kentucky	1	2	3
Louisiana	1	2	3
Maine	1	2	2
Maryland	1	1	3
Massachusetts	1	2	
Michigan	1	2	3
Minnesota	1	2	3
Mississippi	1	2	3
Missouri (a)			
Montana	1	2	2
Nebraska	1	3	2
Nevada	1	2	
New Hampshire	1	2	3
New Jersey	1	2	
New Mexico (b)			
New York	1	2	
North Carolina	1	2	2
North Dakota	1	2	
Ohio	1	1	
Oklahoma	1	3	2
Oregon	2	2	1
Pennsylvania	1	1	
Rhode Island	1	3	2
South Carolina	1	2	3
South Dakota	1	2	3
Tennessee	1	3	2
Texas	1	3	2
Utah	2	3	1
Vermont	1	2	3
Virginia	1	2	2
Washington	1	1	3
West Virginia	2	1	2
Wisconsin	1	2	
Wyoming	1	1	1
Puerto Rico	1	2	

(a) Not Numerical (b) Single Formula

With the exception of the State of Missouri, each State's criteria system adopts a numerical formula with the project receiving the highest point total assuming the highest priority. By grouping criteria into three categories, and considering the numerical values of each category, it is possible to assess which group of needs assumes the most importance in a State. (See Table 42). From this, it can be seen that the patterns are not uniform. Some States place more weight on water pollution needs, others give greater weight to financial needs. In a few instances, readiness to proceed produces the highest numerical point score.

On paper, the criteria which the States apply appear to be effective with respect to the agency's prime objective--water pollution control and abatement. For most States, pollution control needs are assigned the highest numerical values and thereby receive the most weight. In a few instances, they share equal weight with a financial need or the planning and readiness category. However, as far as the construction grant application is concerned, there is no assurance that the particular project for which assistance is requested is the project with the most critical pollution need in that interdependence with other pollution sources is seldom, if ever, explicitly considered. In most States, and perhaps in all, the criteria are actually applied only to those projects on which applications are filed. This results in ranking the applications in the priority they stand in relation to each other, rather than to some absolute standard of pollution abatement effectiveness. Even if priorities are assigned to all projects that can be identified, only grant applications are considered as the effective priority list.

A review of grants approved through January 31, 1969 where construction is complete or under way reveals the following distribution among communities by population size:

TABLE 43
Distribution of FWPCA Grants by Size of Community
as of January 31, 1969

Population Size	$ Million	% of Grants
Less than 2,500	173.1	15.3
2,500 - 5,000	128.1	11.3
5,001 - 10,000	155.9	13.7
10,001 25,000	215.7	19.0
25,001 50,000	150.6	13.3
50,001 125,000	143.9	12.7
125,001 250,000	62.5	5.5
250,001 500,000	36.2	3.2
500,001 and over	68.8	6.1
TOTAL	$1134.8	100.0

It would appear that the existing State criteria systems tend to favor small communities rather than large ones. This was certainly true in the State of Ohio which only in recent years has amended its procedures so that the city of Cleveland is now eligible to receive Federal assistance from the construction grant program. However, the State priority systems are not entirely the cause for this prohibition. Earlier versions of the Act carried a stipulation against Federal funding for communities whose population exceeded 125,000, but this restriction no longer has an effective application.

TABLE 44

Metropolitan & Non-Metropolitan Distribution
of FWPCA Construction Grants,
1956-1968

	Grants Offered $Millions	Percent
Communities within SMSA's	659.4	59.7
Communities outside SMSA's		
Less than 2,500	111.2	10.1
2,500 - 4,999	74.0	6.7
5,000 - 9,999	78.5	7.1
10,000 - 24,999	103.0	9.3
25,000 - 49,999	77.9	7.1
TOTAL	1103.9	100.0

Though not analyzed here it could also be argued that smaller communities are easier to convince in proceeding to overcome their waste treatment deficiencies. Or perhaps they are more financially stable than the large metropolitan central city. In any event it cannot be said that Federal assistance has not served the metropolitan areas of the nation. Since the beginning of the construction grants assistance program through December 31, 1968, 59.7% of the total grant dollars has been applied in metropolitan areas. By comparing Tables 43 and 44 it can also be shown that small communities (within metropolitan areas) i.e., those under 50,000 population, received 32% of the total grant dollars approved.

The fact that most criteria systems are applied only to grant applications, and that some States impose an additional requirement which stipulates that construction begin within a specified time (usually the fiscal year of the application), nullifies the effectiveness of criteria systems. They become ineffective, because they do nothing to assure that critical pollution needs are served. It is, in fact, the accident of readiness that causes such critical needs to be fulfilled, nothing in the application of priority systems contributes to that end.

The efficiency of State criteria systems appears difficult to assess. Not one State applies a specific test to measure the efficiency of investments in terms of water pollution control. But a pragmatic view of the operation of the systems, one that questions whether a particular investment results in greater pollution abatement benefits than a similar investment elsewhere, will give the answer that chance, not formal priorities, is responsible for any efficiencies resulting from the use of construction grants. All investments may reduce the discharge of untreated wastes, but there is no assurance that the critical problem affecting the quality of a waterbody is attacked. (For example, if two communities discharge their wastes into the same stream, State grant entitlement criteria would be applied independently to the application received from either. If only the downstream community applied because it was "ready to proceed," in all probability the application would be certified without considering the impact of the other's waste.)

The existing system discourages any State agency from refusing to certify a particular application. Each year certain monies are allocated to each State, and to deny applications is to lose Federal assistance. Applications tend to be routinely certified where the benefit from the investment may not be fully realized until additional problems are brought under control. While this approach may in time improve the quality of the stream, it is far less efficient than allocating scarce resources to where they are most needed.

Equity by definition requires that costs be borne by those who receive the satisfactions derived from such costs (at a minimum in the case of water pollution abatement, the residents of a watershed or all the residents of a State) or by those responsible for the cost-imposing damage.

The priority systems as they are applied must be considered to be a source of aggravated inequity. (This may be tacitly recognized in the formal criteria of the States: none includes an explicit recognition of an equity principle.) The failure to assure a measure of equity is attributed to the ultimate reduction of priority to the matter of willingness to proceed. If ineffective, the system must be inequitable, since it both denies the intended recipients the assurance of the benefits of the most necessary works, and it denies those damagers who do construct or intend to construct treatment works the assurance of the preconditions for attainment of physical benefits from those works.

The State criteria systems provide a technique by which projects can be evaluated. From an administrative point of view, they eliminate most of the work which otherwise would be required to approve the particular applications. Once a project is approved by the State as eligible for Federal assistance and entitled to priority over other projects little else needs to be considered.

From the standpoint of the grant applications the priority system assures minimum delays in the processing of projects that are ready to proceed. In theory at least, the most important aspect of utilizing criteria as a basis for establishing priorities is the fact that it tends to guide State agencies to those projects where the greatest need occurs or exists. This would be particularly valuable if the States employed their criteria and established priorities independent of applications being made for assistance, but in most cases the criteria systems indicate that priorities are assessed only on grant applications. (In some States the "one-year list" identifies more projects than can be funded. This may be done to assure that no matter when the application is made during the fiscal year, it will be accepted, since the project has previously been identified, assigned a priority and the "one-year list" does not have to be amended.)

Though not specified by every State, the readiness to proceed concept controls. Almost all approved grants are under construction at least by the second year following the grant. (See Tables 45 and 46).

Table 45 shows that of the WPC grants approved, which were completed or under construction as of January 30, 1969, 90 percent of them were under way within 24 months. The remaining projects which took anywhere from 27 to over 72 months of elapsed time to begin construction, tied up about $40 million in grant funds. While this represents a small percentage of the total grant funds involved there is no logic in tying up the funds, particularly in view of the scarcity of available resources. This same logic prevails in defense of the practice of grants only to communities ready to proceed.

Table 46 shows the age of grants approved but still pending and not yet under construction as of December 31, 1968. Here again the evidence is strong that most projects begin construction within two years. For those projects whose grants have been approved beyond two years, approximately $38 million in funds are tied up.

For the grants approved and still pending after two years and those which took more than two years to begin construction, the priority rating is meaningless. Since most States certify each application and identify its priority, it would be reasonable to assume that the projects would be under construction soon after they are approved. Given that this condition is possible under the existing system and does in fact exist, the practical aspects of the criteria system are suspect. Projects are delayed for a variety of reasons, but the undesirability of freezing funds and the strict application of the "readiness to proceed" principle should result in a reassessment if not reallocation.

TABLE 45

National Summary--Elapsed Time (Mos.) Between Grant Offer and Construction Start

	Months																
Size of Place	0	6	9	12	15	18	21	24	27	30	36	42	48	54	60	72	>72
Under 2500	36.9	47.5	49.4	50.0	51.5	51.1	48.8	55.3	63.0	45.0	55.4	52.1	28.6	59.1	50.0	41.7	60.3
2,501- 5,000	14.1	13.4	16.3	15.9	16.2	14.7	15.3	12.3	21.2	23.3	12.5	25.0	25.7	4.5	10.0	33.4	12.6
5,000- 10,000	14.0	12.7	12.3	11.5	13.9	10.4	13.5	14.0	4.9	10.0	8.9	9.4	21.4	13.6	10.0	16.7	10.1
10,001- 25,000	13.8	11.6	10.9	12.4	8.4	11.4	11.8	8.8	6.2	10.0	7.2	6.2	7.1	4.5	20.0	8.3	9.4
25,001- 50,000	6.8	6.2	4.6	5.7	5.3	4.3	5.3	3.5	1.2	0.2	8.9	6.2	-	4.5	10.0	-	3.2
50,001-125,000	5.2	4.1	2.6	2.4	3.3	3.9	1.8	2.6	2.5	0.3	1.8	-	-	4.5	-	-	3.4
125,001-250,000	2.2	1.8	2.3	0.8	1.0	1.8	2.9	0.9	-	0.3	5.4	-	-	4.5	-		-
250,001-500,000	1.6	1.3	0.7	0.5	-	1.1	0.6	2.6	-	-	-	-	7.1	-	-	-	0.2
500,001 and over	5.5	1.5	0.7	0.8	0.5	1.4	-	-	-	0.2	-	-	-	-	-	-	0.9
% Grants in each time period	9.4	47.0	14.8	7.7	4.8	3.4	2.1	1.4	1.0	0.7	0.7	0.4	0.2	0.3	0.1	0.1	5.7

Source: FWPCA Project Register, January 31, 1969

115

TABLE 46
NATIONAL SUMMARY OF FWPCA GRANTS APPROVED AND STILL PENDING AS OF 12/31/68
(in millions of dollars)

	TOTAL		1968		1967		1966		1965		1964		1963		1962		1961		1960		1959	
	#	$	#	$	#	$	#	$	#	$	#	$	#	$	#	$	#	$	#	$	#	$
ALABAMA	29	13.1	18	10.2	7	0.5	4	2.4														
ALASKA	1	2.7					1	2.7														
ARIZONA	8	2.7	7	2.7					1	(a)												
ARKANSAS	20	4.1	12	3.6	5	0.2	2	0.1	1	0.2												
CALIFORNIA	16	6.8	15	6.4	1	0.4																
COLORADO	15	1.8	14	1.4			1	0.4														
CONNECTICUT	11	1.4	11	1.4																		
DELAWARE	5	1.9	1	(a)	1	1.3	2	0.3	1	0.3												
DISTRICT OF COLUMBIA	3	3.6	1	2.3					2	1.3												
FLORIDA	18	3.8	15	3.0	3	0.8																
GEORGIA	23	7.8	20	6.3	1	0.8	1	0.3	1	0.4												
GUAM	1	0.8	1	0.8																		
HAWAII	1	0.7	1	0.7																		
IDAHO	15	1.5	4	0.2	3	0.5	5	0.2	1	(a)	1	0.2	1	0.3								
ILLINOIS	18	5.9	15	4.6	2	0.1			1	1.2												
INDIANA	19	6.2	16	5.3	1	0.2			2	0.7												
IOWA	7	2.3	7	2.3																		
KANSAS	31	1.5	30	1.5	1	(a)																
KENTUCKY	43	4.9	24	3.4	13	1.1	3	0.2	2	0.2					1	(a)						
LOUISIANA	20	3.1	14	1.6	4	0.2	1	0.6			1	0.7										
MAINE	10	2.4	4	1.2	4	0.1	1	0.5			1	0.6										
MARYLAND	40	2.2	32	1.2	4	0.5	1	(a)	1	0.2	1	0.1							1	0.2		
MASSACHUSETTS	10	1.9	10	1.9																		
MICHIGAN	5	1.7	2	0.4	1	0.1	2	1.3														
MINNESOTA	23	4.5	20	4.4			2	0.1					1	(a)								
MISSISSIPPI	60	7.3	28	3.8	21	1.2	7	2.0	1	0.2	2	0.1	1	(a)								
MISSOURI	21	2.0	15	1.3	4	0.1	1	0.5	1	0.1												
MONTANA	13	0.8	9	0.7	3	(a)	1	0.1														
NEBRASKA	26	2.5	14	1.0	8	1.4	3	0.1							1	(a)						
NEVADA	4	0.4	4	0.4																		
NEW HAMPSHIRE	9	1.8	6	1.1			1	0.3	1	0.1			1	0.3								
NEW JERSEY	1	0.2					1	0.2														
NEW MEXICO	9	0.6	7	0.4	2	0.2																
NEW YORK	61	6.6	45	3.4	9	2.0	3	0.3	2	0.3	1	0.1									1	0.5
NORTH CAROLINA	17	5.5	17	5.5																		
NORTH DAKOTA	17	0.3	8	0.2	6	0.1	3	(a)														
OHIO	41	11.1	25	8.5	12	2.0	2	0.3	2	0.3												
OKLAHOMA	50	3.8	26	2.7	10	0.5	14	0.6														
OREGON	5	1.8	4	1.7					1	0.1												
PENNSYLVANIA	58	8.9	55	8.5	1	(a)	2	0.4														
PUERTO RICO	17	5.2	5	1.5	7	2.4	1	0.2			4	1.1										
RHODE ISLAND	5	4.1	3	1.1			1	2.3	1	0.7												
SOUTH CAROLINA	34	4.8	19	2.6	5	0.3	1	(a)	5	1.1	1	0.1	2	0.1	1	0.6						
SOUTH DAKOYA	15	0.4	10	0.2	3	0.2	2	(a)														
TENNESSEE	25	5.0	17	4.0	6	0.3	1	0.2							1	0.5						
TEXAS	40	6.2	28	3.9	5	1.9	6	0.4			1	(a)										
UTAH	11	0.9	4	0.1	2	(a)	5	0.8														
VERMONT	7	1.8	4	0.4	1	0.3	1	0.7			1	0.4										
VIRGINIA	13	3.0	7	2.6	2	0.2	1	0.1	1	(a)			2	0.1								
VIRGIN ISLANDS	1	1.8	1	1.8																		
WASHINGTON	18	1.8	15	1.5	1	0.2	2	0.1														
WEST VIRGINIA	26	7.4	8	1.2	5	2.1	7	2.2	3	1.6	2	0.2					1	0.1				
WISCONSIN	10	4.6	6	2.3	3	1.1			1	1.2												
WYOMING	4	0.2			3	0.1	1	0.1														
TOTALS	1009	190.1	684	129.2	170	23.4	93	21.0	32	10.2	15	3.6	8	0.8	4	1.1	1	0.1	1	0.2	1	0.5

(a) less than $50,000.

Source: FWPCA Project Register 12/31/68

Looking at the criteria in another manner, they are very comprehensive because they address themselves to a variety of categories. Therefore, if many communities in a State were competing for Federal assistance, the priority system would screen them very effectively. However, communities do not generally compete to construct this type of public investment. To the contrary, the State of Maryland perhaps expresses the attitudes of communities in this respect. The following excerpt was taken from the FY 1968 Maryland State Program Plan:

> "...Almost without exception, every sewerage project in Maryland has been undertaken at the suggestion, urging, insistence, formal orders, and, when administrative procedures are exhausted, by court action initiated by the Health Department and the Board of Health and Mental Hygiene.
>
> "...Because the application for a grant is made only after the community agrees to proceed with the construction of the project, a hard and fast listing of the priority in which applications will be considered is ill-advised if not unworkable...In Maryland's situation it would be the height of folly to tell some community, after a long and bitter struggle to get them to act, that they would have to wait for financing not because the money wasn't available, but because someone higher on the predetermined priority list has not yet caved in.
>
> "In Maryland, we have not reached the point where applicants are eager and competing for grants to build sewage treatment works. There are too many other competing needs....making demands on their limited capacities to borrow and spend to do anything that is not necessary. They build only what they are forced to build and only then if there are Federal and State grants immediately available...."

The above quote perhaps covers most State/community relations in this regard. It indicates that it may be illogical to require State priorities on each application. In this instance the State treats applications on a first come first served basis. One might assume from the statement that the State devoted its efforts to those pollution problems deemed most critical and that they treat them on some priority basis in the first place, so that their success might likely follow the priorities originally determined. A more realistic interpretation, however, would take the view that bargaining power would prevail in such a situation. All other things being equal, the larger unit has more bargaining clout and is the greater polluter. Thus, action flows from the least important to the most important element--a reversal of logical priority operation.

However, since State political leverage on a community may be presumed to be inversely related to cost effectiveness of investment, it is not difficult to see why the small community often builds its plant first. Then, because of inadequate improvement in stream quality, its weight is added to pressures for action by the larger community or industry. However obvious the situation the way to implementation of the most cost effective investments first has not been so obvious.

Perhaps this insures--assuming the pattern is the same in every State--that the majority of the applications received will come from those communities which are ready to proceed. They represent the communities who have been worked over, so to speak, and who have "caved in." If this is the real world, the need for a priority system with an elaborate set of criteria does not exist. What is needed is simply more direct and immediate attention paid to the benefits derived from the project, i.e., improved water quality, or stream standards satisfied. Furthermore, unless these conditions or benefits are present, no grant should be approved.

It would appear, as in Maryland, communities are not competing for grants to build sewage treatment works. Table 47 shows that year by year there are unused allotments of the construction grant funds. Yet, the total grant applications and funds requested are always greater than the monies available for grants.

Although the total amounts may be small when compared to entire allocations for each year, it is interesting to note that several of the States have large deficiencies as far as waste treatment is concerned. There may be many reasons for the monies remaining unused, but an obvious one is that in those States, communities are not competing for funds made available to them.

In practical terms, the criteria used to develop priorities among projects obviously has worked and has allocated funds; however, it must be concluded that the systems as currently constituted cannot be made workable with respect to establishing priorities on the basis of abatement need because of the inherent bias toward readiness to proceed as a dominant criterion.

Although desirable, the State priority systems as a basis for establishing priorities among construction projects for receiving Federal assistance do not satisfy any of the four tests used to evaluate them. They are neither effective, efficient, equitable, nor practical as far as the agency's water pollution control objective is concerned.

TABLE 47

Federal Water Pollution Control Administration
Division of Construction Grants
Analysis Branch

Unused Allotments by Fiscal Year
(in millions of dollars)

States	1957-58	1959	1960	1961	1962	1963	1964	1965	1966	1967
Alaska	$0.85	$0.18	$0.30	$0.42	$ (a)*	$0.39	$0.68	$0.75	$	$
Delaware									0.25	
Hawaii	0.26								0.90	
Idaho				0.08	0.01	0.13	0.89	0.95	0.85	0.64
Maine	0.77	0.13	0.37	0.37						
Mississippi		0.43		0.11		0.20	0.11	1.26		
Montana						0.27	0.88	0.99	0.48	0.98
Nevada		0.17	0.09							
New Hampshire				0.18						
New Mexico								0.10		
North Dakota				0.42	0.58	0.80	1.28	0.80	0.77	0.91
Rhode Island	0.20	0.11	0.22	0.02			0.14			
South Carolina		0.07	0.51	0.23						
South Dakota	0.22	0.60	0.43	0.31	0.12	0.10	1.21	0.85	0.90	0.69
Utah						0.54	0.49	0.46		
Vermont				0.11			0.41		0.89	
Wyoming	(a)	0.23	0.06	0.44	0.56	0.45	0.88	0.93	0.79	0.79
Guam	(Not eligible under program until FY 1963)					1.38	1.52	1.51	1.50	1.49
Puerto Rico	0.39	0.47	1.10	0.83	0.64	0.04	0.54	1.71	1.90	
Virgin Islands	1.65	0.81	0.82	0.82	1.25	1.38	1.35	1.51	1.48	1.47

*(a) Less than $10,000

The overriding force which causes this failing is the "readiness to proceed" concept. It must be concluded that in most instances Federal construction grants have been awarded on a "readiness/willingness to proceed" basis, and apparently no systematic effort has been made to maximize benefits from assisting in the construction of municipal waste treatment facilities.

On the other hand, it is equally true construction grant funds should not be approved and set aside for a community to use whenever it decided it was ready to proceed. From the agency's point of view, the optimum condition requires that the monies be put to use as quickly as possible to assist in solving or bringing under control particularly critical pollution problems not necessarily within one State but perhaps over a wider area.

PUBLIC TREATMENT OF INDUSTRIAL WASTE

The Situation

There is increasing evidence that a very substantial--if not a major--portion of the recent pressure on public waste treatment capital originates in the form of demand for capacity to handle wastes of industrial origin.

The dimensions of that demand can not be measured precisely. The Municipal Waste Inventory contains an incomplete description of hydraulic loading of the nation's public waste treatment plants; it does not include an assessment of the contributions of wastewater by source of discharge. There is no inventory of industrial wastes. The nearest thing to such an accounting is the very generalized set of estimates for factories using 20 million gallons or more of water a year that is published at five year intervals by the Census Bureau under the title Water Use in Manufacturing.

There are inescapable weaknesses involved in any assessment of the extent of industrial waste treatment that may be made through use of public systems on the basis of the Bureau of Census data. The most recently published information concerns the year 1964. It is, then, over five years old; and the five years involved are those in which it is felt that industrial use of public waste treatment facilities experienced its most marked increase. Moreover, Census information involves only about 10,600 establishments of the more than 300,000 water-using factories in the United States. While the surveyed plants account for more than 97% of estimated water use by manufacturers, it is suspected that the small plants that are excluded have been the ones which historically have been most apt to use municipal facilities. The estimated 434 billion gallons of water used by such small plants in 1964 must, in large part, have been discharged to public sewers and may be thought to account for an indeterminate portion of the 100 gallons per-capita per day that is often assumed to be the normal municipal loading rate to waste treatment plants.

A hazy assessment of the over-all impact of industrial loadings on municipal systems is, however, possible. We can establish--imperfectly, and lacking detail--that factories and people make approximately equal demands on public facilities for transmitting and treating liquid wastes.

Water Use in Manufacturing, with its aggregate estimates of water use by the largest industrial users, is the source of Table 48 that presents the regional distribution of major water-using manufacturers' discharges to public sewers, as they are accounted for in that document for 1964. (The regions are the blocks of States used in discussion of locational influences on cost: See Figure 2.)

The table indicates that twenty percent or more of the water that passed through public sewers in 1964 was the discharge of major manufacturing plants. One of the problems in comparing aggregate domestic and industrial discharges is the basic uncertainty that exists with regard to per-capita domestic waste discharges. While one hundred gallons per-capita per day is a common rule of thumb, the number is conceded to include some sort of "normal" industrial-commercial component. Measurements of loadings to individual septic tanks, houseboat discharges, and largely residential communities suggest that per-capita domestic loadings tend to be well below the accepted 100 gallons, falling in a range of roughly 45 to 65 gallons. To accommodate both traditional sizing standards and more recent measurements, the comparison of municipal and major manufacturers' discharges to public sewers was calculated on the basis of a municipal loading of both 100 and 65 gallons per capita per day.

The table does not, however, sufficiently describe the impact of industrial wastes on municipal treatment requirements. Annual volume of wastewater discharged to sewers fails to reflect significant aspects of waste treatment, notably timing and concentrations.

Domestic waste loadings tend to vary on an hourly basis, with morning and early evening peaks. There is also a weekly bias--that is lessening over time--imparted by the tradition of Monday washdays. But, over the course of a year, loadings are homogenous for most communities. Some industrial discharges, on the other hand, have pronounced cyclical patterns. Seasonal operations occur in many industrial sectors and the five day work week is still the standard for industry. Significant in this regard is the fact that food processing, which accounted for a quarter of estimated industrial discharges to public sewers in 1964, is highly seasonal in at least some of its forms.

Because waste treatment plant design is scaled of necessity to daily peak loading rates rather than average annual loadings, the effect of industrial operating fluctuations is to place a multiplier upon capacity requirements.

The higher average materials concentrations of industrial wastes also serves to move municipal costs away from the level indicated by average annual hydraulic volume. Industrial waste concentrations tend to vary widely. A study by FWPCA of seventy-seven municipal waste treatment plants that recorded industrial waste data revealed influent concentrations that ranged from 9400 milligrams of standard biochemical oxygen demand (BOD_5) per liter of water down to 20 mg/l. The mean value

Table 48
Pattern of Waste Discharges
To Public Sewers By Manufacturing
Plants Using 20 Million Gallons Or More In 1964

Region	Discharges Billion Gallons Total	Discharges Billion Gallons To Public Sewers	Percent To Public Sewers	For Comparison Domestic Wastes Billion Gallons @65G/Capita	For Comparison Domestic Wastes Billion Gallons @100G/Capita	Manufacturer's Discharges as a Percent of Total
New England	488	49	10.1	157	242	24-17
Northeast	2439	204	8.4	653	1004	24-17
Ohio-Tenn.	2129	172	8.1	243	374	41-32
Great Lakes	2483	297	12.0	514	790	37-27
Middle Atlantic	986	39	4.0	158	243	20-14
Southeast	851	32	3.8	181	279	15-10
Gulf	2350	28	1.2	260	400	10-7
Plains	291	64	22.0	185	285	26-18
Southwest	96	22	22.9	89	137	20-14
Pacific Coast	1452	151	10.4	356	547	30-22
Total	13,560[1]	1058[1]	7.8	2796	4301	27-20

[1] Exceeds reported U. S. total, apparently due to effects of rounding in the Census Bureau's reporting of State figures.

(weighted for volume) of the industrial influents to the seventy-seven treatment plants was 535 mg/l--more than two and a half times that of domestic wastes; and the median value was 350 mg/l. Cost modifying effects of the diffuse concentration pattern is by no means uniform. Higher concentrations, to the extent that the nutrient balance of the influent is proper, accelerate biological productivity of the life forms that accomplish the treatment effect. In such cases, a given level of efficiency is obtained with a reduction in time of detention, and a consequent easing of costs. Higher or lower concentrations may require longer detention, recirculation or dilution, thus jacking capital requirements upward.

It is, of course, impossible to accurately assess the impact of these conditions on physical capital, but the total estimated industrial discharge to public sewers in 1964 can be weighted by appropriate adjustment factors to give a generalized view of the relative demands on facilities posed by domestic and industrial wastes, both in terms of hydraulic loading and of biochemical oxygen demand. Such adjustment suggests that, on the basis of an indicated 11 billion gallons a day of actively utilized waste treatment capacity, almost 40% was taken up by industrial wastes. 1/ When the focus shifts from volume of water to gross volume of oxygen demanding materials, industrial wastes treated in municipal plants accounted for 53% to 63% of the total. 2/

1/ The statement assumes 1) a 260 day average operating year for factories 2) 65 gallons per capita per day of municipal waste loadings, 3) availibility of treatment capacity to sewered industrial wastes in the same proportion as to sewered domestic wastes, 4) half of the wastes of minor manufacturing plants discharged to public sewers. Percentage industrial utilization was computed:

$$I = \frac{C+D}{C+D+ABE}$$

Where
- A = sewered population of United States (118.5 million)
- B = daily per-capita waste discharge (65 gallons)
- C = annual sewered wasteflow of major manufacturing plants (1058 billion gallons)
- D = annual sewered wasteflow of minor manufacturing plants (50% of 434 billion gallons)
- E = average number of manufacturing days per year (260 days).

2/ The statement rests on a comparison of "normal" domestic waste strength of 1/6 pound of BOD_5 per person per day and normal water discharge of 65 gallons per person per day with industrial concentrations of 350 mg/l of BOD_5 (median for the seventy-seven communities measuring industrial waste strength) to 535 mg/l of BOD_5 (average for the 77 communities.

TABLE 49

Distribution of Industrial Loadings to a Sample Group of Municipal Sewage Treatment Plants

BOD_5 Concentration of Industrial Influent, mg/l	No. of Plants	Hydraulic Total Volume in Million Gals./Day	Percent of Total Volume	Total Pounds BOD_5 of Industrial Influents	Percent of Total BOD_5 to Plant
100 or less	7	6.70	8.1	2,770	0.7
101-200	13	28.36	34.3	39,190	10.5
201-300	8	6.05	7.3	12,700	3.4
301-400	9	4.61	5.6	13,590	3.6
401-500	7	9.37	11.3	33,510	9.0
601-700	6	1.88	2.3	10,530	2.8
701-800	4	6.27	7.6	38,340	10.3
801-900	4	2.76	3.3	19,550	5.2
901-1300	6	10.27	12.4	91,310	24.4
1501-1900	4	4.40	5.3	63,830	17.1
2100-3000	7	2.04	2.5	41,460	11.1
4000	1	.01	0.1	670	0.2
9000	1	.01	0.1	1,560	0.4
TOTAL	77	82.73		374,010	

Even in 1964, then, industrial waste discharges appear to have been a significant, if not a preponderant, source of demand for municipal waste treatment capacity. The 1968 municipal waste inventory provides enough information on plant size and hydraulic loadings to lead to the inference that the volume of industrial loadings has increased substantially. Total hydraulic loadings of the municipal waste treatment system may be calculated to have increased to something over 15 billion gallons a day, on the basis of average daily flows. Of that total, 37% to 59% (the spread is due to the 65 to 100 gallons per/capita day standards used to assess domestic loadings) may be estimated, on the basis of connected populations, to be due to industrial influents.

The details of the information on which that assessment is based are presented graphically in Figure 6. The figure contrasts the median size of municipal waste treatment plants according to community population with the median hydraulic loading in each population size group.

On the basis of the observed relationships, it seems clear that per-capita volume of sewage rises with size of community population. The _a priori_ assumption made here is that the reason for the condition is industrial wastes, and the rising availability of factories to discharge their wastes in larger communities. The assumption fits industrial location probabilities, and such limited specific information as we possess with respect to occurrence of industrial use of municipal systems.

Policy Aspects

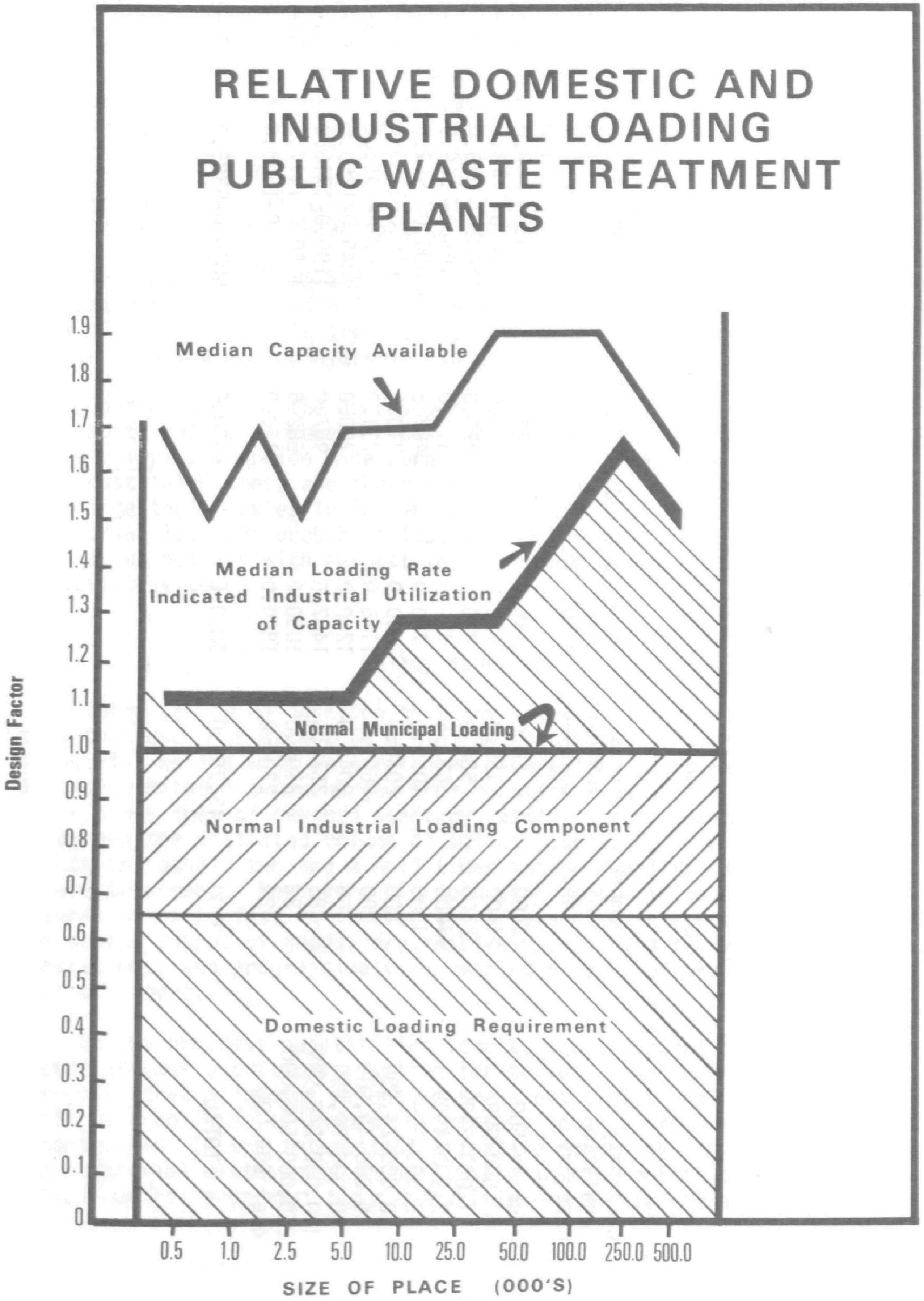
There can be no question that any effort at water pollution control that does not accept as a minimum condition the treatment of industrial wastes will be a failure. The estimated volume of oxygen demanding materials discharged from manufacturing plants amounts to three times that of sewered sanitary wastes--before treatment in each case; and the estimated volume of solids discharged from manufacturing plants is roughly two and a half times that of sanitary sewage, again before treatment. Moreover, the volume of industrial waste is growing several times as fast as that of sanitary sewage as a result of growing per capita output of goods, progressively declining raw materials concentrations, and progressively increasing degrees of processing per unit of product.

On the broadest quantitative levels, then, control of industrial wastes assumes a critical position for pollution control programs. A community that maintains effective treatment of its sanitary sewage can still be a polluter if industrial waste discharges from its borders are uncontrolled. In the interest of effective community action, both sewage and industrial wastes must be dealt with in the conduct of local pollution control programs. Many communities--probably not a majority,

TABLE 50
Relative Domestic and Industrial
Loading of Municipal Waste Treatment Plants in 1968

Community Population Category	Number of Plants	Million Gallons Per Day: Gross Indicated Loading	Domestic Component @ 100 G/C/D	Domestic Component @ 65 G/C/D	Industrial Remainder	Percent Industrial
under-500	1400	64.0	49.0	32.0	5.0- 2.0	23-50
500-999	1600	156.0	120.0	78.0	36.0- 78.0	23-50
1,000-2499	2400	588.0	420.0	273.0	168.0- 315.0	29-54
2,500-4999	1300	682.5	487.5	317.0	195.0- 366.0	29-54
5,000-9999	1000	1050.0	750.0	487.5	300.0- 562.5	29-54
10,000-24,999	800	2010.0	1400.0	910.0	610.0-1100.0	30-55
25,000-49,999	300	1687.5	1125.0	731.0	562.5- 956.2	33-57
50,000-99,999	160	2040.0	1200.0	780.0	840.0-1260.0	41-62
100,000-249,999	85	2677.5	1487.5	967.0	1190.0-1710.0	44-64
250,000-500,000	28	2100.0	1050.0	682.5	1050.0-1417.5	50-68
over 500,000	24	2700.0	1800.0	1170.0	900.0-1530.0	33-57
TOTAL	9100	15,756.0	9890.0	6430.0	5870.0-9325.0	37-59

Figure 6


RELATIVE DOMESTIC AND INDUSTRIAL LOADING PUBLIC WASTE TREATMENT PLANTS
Median Capacity Available
Median Loading Rate Indicated Industrial Utilization of Capacity
Normal Municipal Loading
Normal Industrial Loading Component
Domestic Loading Requirement
Design Factor
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.5
1.0
2.5
5.0
10.0
25.0
50.0
100.0
250.0
500.0
SIZE OF PLACE (000'S)

for the simple reason that factories tend to be concentrated--have accepted the simple technique of treating all, or most, of the wastes occurring within their jurisdiction, without regard to its source.

That practice, taken for granted for many years in the case of inner city fabricating plants and applauded as a progressive innovation when extension to major peripheral or waterside factories was initiated on a large scale, has recently come under attack on grounds of equity or propriety. Antagonists have questioned the suitability of applying public resources and public funds to the solution of the problems of profit making industries. In particular, the General Accounting Office, in a preliminary report to the Congress on the administration of Federal waste treatment plant construction grants, cast doubt on the validity of the practice of extending Federal assistance on the basis of total construction cost rather than restricting the scope of Federal assistance to capacity intended to serve domestic users only. (It is, perhaps, significant that the GAO's final report to the Congress contained almost no mention of the subject, and had no recommendations with regard to the matter. Established usage, economy and efficiency may have been such persuasive arguments for current Federal assistance practice in this regard as to change the reviewers' first reactions--or they may simply have despaired of developing procedures for resolving the enormous problems of definition involved in determining what is in fact a "municipal" waste source and what is properly industrial.)

The estimates of investment need presented earlier in this study presume---through application of sizing standards and projections of rate of increase in loadings--continuation of current tendencies toward broader public responsibility for industrial waste treatment. As has been noted, industrial sources presently sustain a rough parity with domestic and commercial sources in demand on public waste handling sources, and maintenance of trends in full force today will soon give factory wastes a predominant position. Industrial needs, then, must be considered to be a central matter in determining investment policy. The remaining portion of this section of our study attempts to qualify the economic impacts of public treatment of industrial wastes in terms of effectiveness (or contributions to water pollution control), efficiency (approach to maximum output derived from anticipated resource inputs), equity, in its economic sense of assessing costs on the basis of benefits received and/or damages incurred, and of technical and institutional practicability.

Effectiveness

Public treatment of industrial wastes is effective in insuring the utility of the treatment of sanitary wastes, since it guarantees that the results of treatment for the domestic population will not be nullified by the effects of untreated industrial wastes. It is effective, too, in that it locates responsibility for the operation and maintenance of the local waste handling activity within a single authority with a clearly defined responsibility for the operation and maintenance of the local waste handling activity that is assigned to a group of professional operators. In substance, it puts the municipal or other public agency into a public utility status with respect to an industry segment or group of factories--a posture not at all unlike one that it normally accepts on behalf of a group of residential and commercial customers, and often for other public jurisdictions or agencies as well.

An element that enters strongly into consideration of the effectiveness of that relationship, but one which is difficult to quantify, is the weakness of industry's incentives to treat wastes adequately. Waste treatment is a collateral and profitless activity from the standpoint of the firm. Subjective though it may be, the general opinion of professionals in the field of water pollution control is that factory management often views waste treatment as an imposed responsibility that may most conveniently be discharged for form's sake by constructing a facility--which may then be operated very indifferently. This opinion assumes a critical importance, in view of the industrial tendency to reject capital intensive waste treatment methods, even where a considerable increase in operating costs is incurred thereby. (The low capital, high operating cost formula is rational from the standpoint of the firm, both because it frees capital for alternative and profitable applications, and because of the quite separate effects of corporate tax provision for operating expenses and capital depreciation.) Given that set of conditions, there is relative assurance of effective waste treatment where industrial wastes are channeled through a public system. Responsibility is passed to an instrumentality with a strongly developed set of incentives to operate and maintain the system in an acceptable fashion. Even where the cost to industry is equal on an annual basis, it has an incentive to adopt the use of public facilities, both because operational problems are removed from its purview and because the full amount of any sewer charge becomes a tax deductible expense in the year incurred, without the interposition of deferred depreciation requirements.

Efficiency

That is efficient in an economic sense which increases the output of products from a given input of resources. Efficiency, then, is a relative and not an absolute test. But if the task of the public administrator is to maximize the satisfactions available from the resources available to him, efficiency must always be a prime goal.

There is no question that in a majority of cases public treatment of industrial wastes is more efficient than separate treatment of municipal and industrial wastes, in that it commonly costs less per gallon of water processed or per unit of pollutant removed to treat waste from several sources at a single point.

There are two reasons for the cost advantage. On the one hand, economies of scale are attained by construction and utilization of larger plants that are required when a number of independent waste sources are collected at one point for treatment: on the other, staging capabilities and complementary characteristics of sewage and industrial wastes often permit operational economies.

The order of magnitude in which economies of scale occur is indicated in Table 51 which lists cost to size relationships for the principal waste treatment processes. Though the cost of the incremental unit placed into operation varies according to the treatment process employed, the savings that accrue through consolidation and use of larger plants are substantial in every case.

Perhaps the principle may best be presented through use of an example. Consider the situation of a community that develops 10 million gallons a day of liquid wastes in some combination of sewage and industrial discharges and--for the sake of illustration--assume that it is physically convenient to provide treatment 1) through construction of ten equally sized plants, five operated by municipality for the use of residential and service industry users, five operated by individual factories, 2) through use of two equally sized plants, one operated by the community and the other by the factories in consortium, 3) through use of a single large plant serving the needs of all waste producers in the community. Assuming a twenty-five year useful life of plant, a five percent rate of interest and serial amortization in each case, and equal transmission costs, the alternative solutions would entail differential costs on the order of those presented in Figure 7.

Over the life of the system, average annual costs would amount to about $584,000 in the case of the ten plant solution, $451,000 in the case of the two plants, and $332,000 for the single plant solution. Obviously, it is to the benefit of the community and its residents to utilize the single plant solution--if the consequent cost savings can be shared equitably among the various categories of waste producers.

Not so obvious, but equally true, is the fact that it is to the benefit of the national economy to seek the single plant kind of solution whenever it is possible. By doing so, the Nation frees for other purposes resources that might otherwise be utilized for waste treatment.

In practice, scale economies may in many--perhaps a majority--of cases be supplemented by operational economies derived from the characteristics of wastes from disparate sources. Complementary daily flow cycles of manufacturing and of domestic activities can be utilized to reduce demands for peaking capacity. Many industrial wastes are deficient in nitrogen and/or phosphorus that are required to sustain effective bacterial action in the treatment process. Such wastes must be fertilized by the addition of those nutrients. Sewage, on the other hand, characteristically contains both nitrogen and phosphorus in excess of bacterial needs. By combining sewage and industrial wastes, the nutrient deficiency characteristic of the latter may be supplied, with an absolute reduction and often elimination of need for chemical additives. And because nitrogen and phosphorus residuals of sewage

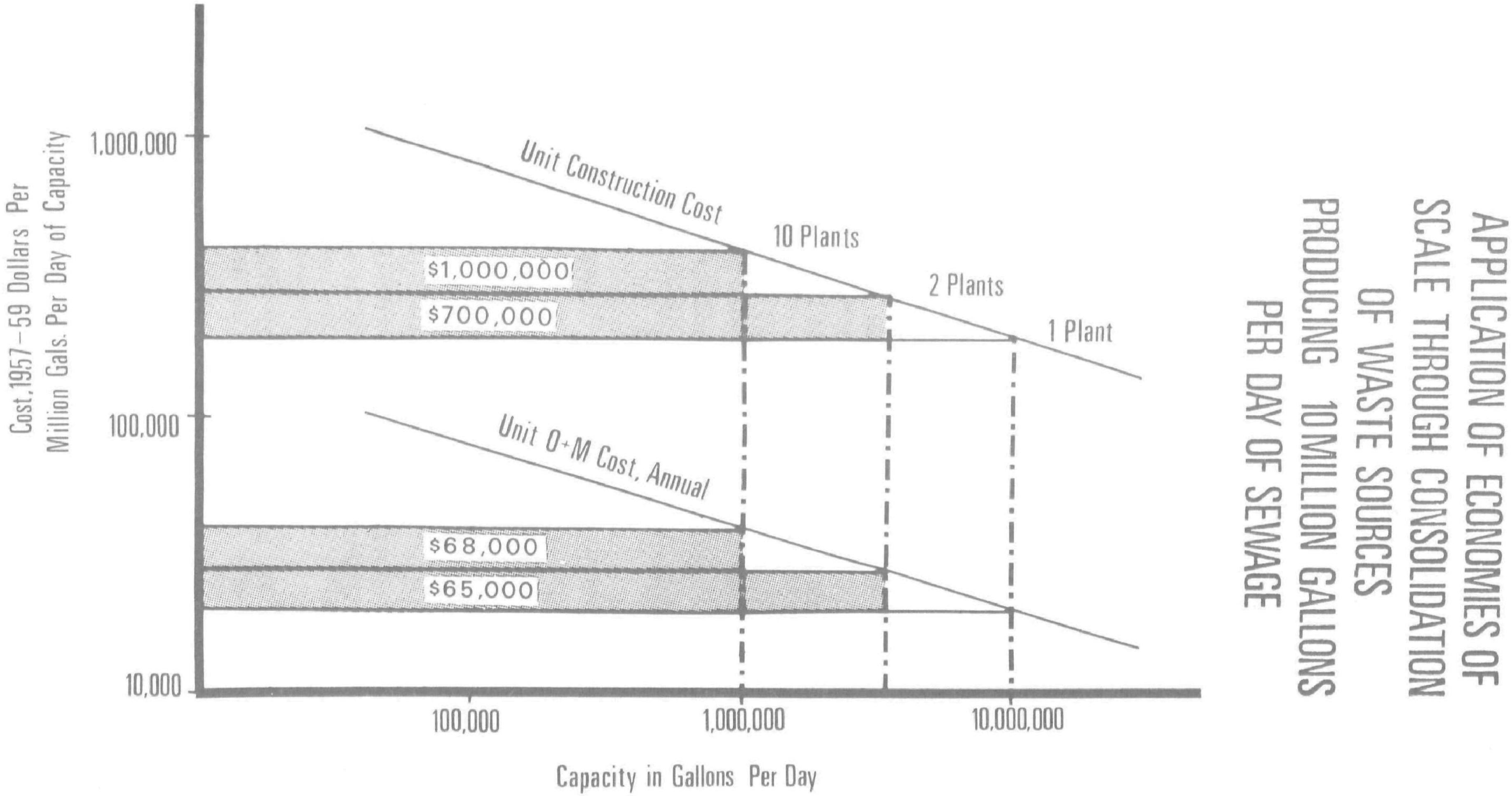
TABLE 51

Generalized Cost To Size Relationships of Basic Waste Treatment Processes

PROCESS	Million Gallons Per Day Capacity				
	.01	.10	1.0	10.0	100.0
		Construction Cost, $1000's*			
Primary		58.7	308.6	1,247.7	6,559.0
Primary, Separate Sludge Digestion		85.2	305.1	1,092.2	3,084.0
Activated Sludge	11.7	70.8	417.3	2,458.9	14,487.6
Trickling Filter		101.8	288.9	1,374.4	5,045.2
Lagoons	6.2	23.4	88.0	330.3	1,080.0
	Annual Operating & Maintenance Charges, $1000's**				
Primary		4.5	19.7		
Primary, Separate, Sludge Digestion		5.5	20.6		
Activated Sludge		6.3	31.3	172.3	
Trickling Filter		5.1	18.3	83.3	
Lagoons	0.1	0.6	3.0		

*Source: Modern Sewage Treatment Plants, How Much Do They Cost and Sewage Treatment Plant Cost Index for June 1969

**Source: R. L. Michels, et al "Operation and Maintenance of Municipal Waste Treatment Plants," Journal of the Water Pollution Control Federation, March 1969. 1962-64 dollars raised to 1968-69 conditions by use of BLS Craftsmen's median earning, 1968 ÷ craftsmen's median earnings, 1963 X table value



	Construction Cost	Interest Charges	25 Years Operation	Lifetime Costs
10 plants	$4,200,000	$2,600,000	$7,800,000	$14,600,000
2 plants	$3,200,000	$2,000,000	$6,000,000	$11,300,000
1 plants	$2,500,000	$1,500,000	$4,300,000	$ 8,300,000

Figure 7

treatment are in themselves a serious source of pollution, the incremental reduction of those nutrients in the ultimate discharge that occurs when they are incorporated in sludges derived from the industrial wastes means that the waste treatment may often be more complete and effective than conventional secondary sewage treatment. A final source of potential economy and enhanced effectiveness should be noted. The temperature of industrial wastes is often higher than the sewage. In those cases where the volume and temperature of wastes from industrial sources is sufficient to increase meaningfully the temperature of the total volume of wastes being treated, the effect is to accelerate the life processes of the bacteria that effect the decomposition processes. That metabolic acceleration produces an efficiency increment, in that a given degree of waste stabilization can be attained with a reduction in detention time--and thus a reduction in capacity requirements--or a higher degree of reduction is achieved where there is no change in the period of detention.

It should be noted that the indicated operational efficiencies are quite apart from, and additional to, those derived from scale economies. Because the practical effect of the two biochemical mechanisms--higher average temperature effects and takeup of sewage nutrients by industrial sludges--is more complete waste treatment, absolute pollution abatement benefits as well as relative cost reductions are apt to flow from municipal-industrial joint waste treatment arrangements.

Technical & Institutional Practicability

It is probable, as indicated earlier, that industrial wastes are currently the major source of loadings discharged into public waste treatment plants. (The statement presumes application of a correct definition of "industry," but it may well be true even if the idiomatic substitution of "industry" for "factory" is made). The textbook standard that dates back to the 1920's specifies that per-capita waste production is 100 gallons per day; but even traditional sizing standards reflect some assumption of the existence of a "normal" industrial requirement above the capacity that must be installed to handle production of domestic sewage. In fact, however, 100 gallons per capita per day fails completely to measure the inflow to modern sewage treatment plants. Hydraulic demand rises consistently with community size; and in even the smallest size class, the median loading level is 110 gallons per capita per day.

Some authorities have attempted to explain a higher than normal level of loadings on the basis of increased per capita use of water that is presumed to have accompanied rising living standards. There is probably validity in the observation; but it cannot be used to upset the conclusion that public treatment of industrial wastes accounts for more than half of capacity utilization in present day waste treatment plants. Both the fact that relatively recent studies are responsible for the assessment of residential sewage production of 40-65 gallons per capita per day and the fact that one in four sewage treatment plants presently handles 75 gallons per capita per day or less--with no appreciable increase in incidence of reported overloading among such plants--tends to support the statement that industry and not rising individual use of water is responsible for most of the incremental need for public waste treatment plants.

Thus, there is nothing either novel or exciting about the practice of accepting industrial wastes in municipal treatment plants. It is simply a continuation of established practice. As cities have installed sewers, they have customarily attached commercial and service establishments to the sewer network, and in many cases manufacturing establishments were connected as well. When, under the pressure of events, the sewered waste streams came to be collected and passed through a waste treatment plant, all recipients of the sewer service became customers of the treatment service. In point of fact, there is little option for many firms. Location may constrain any establishment located within a city to utilize public sewers to carry away its liquid wastes.

What is significant is the fact that a definite change in the composition of industries using public facilities has occurred. Until fairly recently factories that made heavy use of water in their processing tended to take advantage of waterside locations to discharge wastes directly, rather than through the intermediary of public sewers. Where the small plant located within the built-up area of the city customarily used the sewer, the large plant located on the periphery discharged independently. But the situation has been changing radically with the imposition of more stringent and more broadly applied pollution abatement requirements. With increasing prevalence, large water-using, peripherally located factories have attempted to satisfy publicly imposed operating demands through the use of public facilities.

Most of the wastes of the group of food processing industries that receive treatment get it in public waste treatment plants. It is becoming more and more common for paper mills, and even pulp mills, to discharge wastes into public sewers. Chemical, pharmaceutical, plastics, textile, and rubber plants wastes have been successfully incorporated into public treatment systems. In six of eleven major manufacturing sectors, the prevalence of treatment through public systems in 1964 equalled or exceeded prevalence of treatment in industry-operated plants. In spite of the fact that the three manufacturing sectors that make most abundant use of process water (primary metals, chemicals and allied products, and paper and allied products) are often precluded from use of public treatment facilities by reason of discharge volume or waste characteristics, a fourth of the gross volume of factory waste that was treated passed through public facilities in that year.

(See Table 52.) The proportion is probably greater today. And it is safe to assume that in almost all cases, waste treatment provided to commercial and service industries depends upon use of public facilities.

TABLE 52

Relative Prevalence of Industry-Provided and Publicly-Provided Waste Treatment by Major Manufacturing Sector, 1964

	PERCENT OF WASTE TREATED	
	BY INDUSTRY	BY PUBLIC SOURCES
Food & Kindred Pdts.	34.9	65.1
Textile Mill Pdts.	38.4	61.6
Paper & Allied Pdts.	91.4	8.6
Chemical & Allied Pdts.	88.0	12.0
Petroleum & Coal	90.9	9.1
Rubber & Plastics	50.0	50.0
Primary Metals	95.8	4.2
Machinery	20.6	79.4
Electrical Machinery	16.5	83.5
Transportation Eqpt.	34.0	66.0
Other Mfg.	58.9	41.1
All Mfg.	75.2	24.8

Generally speaking, there are no technological impediments to common use of treatment facilities by manufacturers and by households. The treatment processes are basic and simple, applicable to most kinds of waste. There are some wastes that require processing other than, or additional to, the screening, sedimentation, flotation and the biochemical stabilization employed in conventional municipal waste treatment systems. In such cases, industry must either provide pretreatment measures or supply its own treatment facilities.

A variety of institutional and procedural practices have been developed to extend treatment to factory wastes. The nature of the arrangement between public agency and factory tends to be decided on a local level, though some regionally consistent trends may be noted with respect to financing treatment.

With respect to physical facilities, the common method is to treat both sewage and industrial wastes in a single plant in order to attain the economies of scale and complementarities available from the practice. On many occasions, the pressure on capacity imposed by such an arrangement has created a need for major plant expansion or even plant replacement; and there can be little doubt that the availability of Federal construction grants has made such arrangements far more attractive to industry. It is unusual, but the practice of providing separate facilities for the use of industrial customers, or even a single customer, is not unknown. Though owned and operated by a public agency, such a facility must be regarded as an extension of the factory in point of fact. Such arrangements have been viewed as a subterfuge to obtain public funds for the use of a private interest. The generalization is, perhaps, too sweeping. Each situation should properly be reviewed in the context of its financing and its place in the total public system. But there can be no question that the few arrangements of this sort--no more than half a dozen were uncovered in a superficial review of Federal grant awards--are responsible for much of the opposition that has been raised to providing Federal grants for construction of the portion of a treatment facility that will be used to treat industrial wastes.

Financial mechanisms that have been applied to fund the capacity requirements associated with wider public treatment of industrial wastes probably have a large effect on the favor or disfavor with which the practice is generally evaluated. An increasingly favored method of obtaining revenues is the use of the sewer service charge. Its prevalence has grown with expansion of public treatment of factory wastes; and the existence of some very complex charge formulae based on volume, strength, and characteristics of wastes argues strongly that industrial wastes, rather than domestic sewage with its homogenous character, is a factor contributing to the extension of sewer charge systems. User charges are not, however, universal. In some cases, particularly in the Northeastern States, there is a tendency to continue to rely on general taxation to finance treatment works. It is often the case that where user charges exist they tend to be scaled to provide for plant and sewer operation and maintenance, with general taxes often covering capital costs--the typically higher coupon rate of local revenue bonds may account in part for this. Where capital and debt servicing charges are built into the scale of user fees, the practice is to establish them at rates that cover only local participation in the investment. (Cases may exist where the amount of Federal assistance is also charged back to users, but we are unaware of them.)

User charges, general taxes, Federal and State grants are the usual means to finance and service the elements of industrial waste treatment that use public facilities, but specialized kinds of financial relationships have also been developed on the local level. There have been instances where the firms that propose to share in the use of a municipal treatment system have advanced a proportion of the funds required for construction, have contributed land for the purpose, or have purchased the bonds issued to finance construction. Nor is factory construction of a plant in which capacity is provided for an adjoining community unknown, though the few such situations that come to mind antedate availability of Federal assistance for plant construction.

Operational procedures would seem, on the basis of the information that is available, to have involved no undue problems. Contrary to the generally held engineering opinion of a decade ago, when communities were cautioned against the operating problems that industrial wastes would impose, treatment seems generally to take place with little or no more difficulties as the proportion of industrial wastes in the influent has increased. It would seem that discharge conditions are usually stipulated with some precision in order to forestall malfunctions, and that factories generally install the equipment and procedures necessary to meet those requirements.

Operational failures are not unknown, however; and when they occur, they may be spectacular; as in the case of the Michigan plant where bacterial action was short-circuited by a change in the characteristics of a paper mill's discharge, so that sludge drying beds emitted powerful odors of putrefaction; or the case of the Ohio waste treatment plant that literally burned down, presumably as the result of ignition of an accidentally discharged and volatile industrial waste.

Review of the literature provides few serious examples of operational failures. More common is the sort of damage that results from inadequate design applications or loss of an industrial waste source. Where a treatment plant is designed in substantial part to accommodate the wastes of a factory, and that factory stops its operation, a significant loss of sunk capital is inescapable. Similarly, the application of sewer service charges that embody incentives to reduce waste discharges through in-plant modifications has on occasion proved too successful. Factories have succeeded in reducing the volume or strength of their discharges to the point that a significant portion of the capacity of the treatment plant is not utilized, with the result that system users find themselves in the unfortunate position of paying for a good deal of unnecessary capacity.

Equity

It would seem that the central difficulty that exists with respect to the practice of treating industrial wastes in public systems is the ethical problem of the propriety of supplying out of public facilities and public funds a service to assist a private interest. The problem becomes particularly pointed when Federal construction grants are involved, for the simple reason that the Congress has evinced a disinclination to provide general subsidies for industrial waste treatment purposes.

Yet there is something specious about the ethical question and the terms in which it is phrased. The distinction between a municipal waste and an industrial waste is an artificial one, wholly dependent on definition. The prevailing pattern of opinion has been to accept all commercial and service industries as legitimate contributors to the municipal waste streams, and even to accept small factories or "dry process" industries as the "normal industrial component" of "municipal" wastes. Where, then, does one draw the line? Commercial laundries and restaurants may logically be considered to be only extensions of domestic activities, as may hotels and motels. But what of the grocery store and the department store? Do warehouses and marshalling yards generate municipal wastes or industrial wastes? What about the airport, the shopping center, the industrial park?

These questions may be valid, but they must be admitted to be somewhat beside the point. The real distinction involved is not one of source, but of relative magnitude. Certain manufacturing industries characterized by very large plants and marked use of water per unit of output are generally accepted to be the exclusive source of "industrial" waste. Not the fact that the waste comes from a factory, but that the amount of waste approaches or exceeds the amount generated by the population dependent on that factory causes its discharge to be so distinguished. It is in the case where incremental costs imposed by the necessity to treat the industrial wastes are significant that the equity question is posed.

The distinction on the basis of relative magnitude may well be a valid one. The damages occasioned by the major water-using industries are generally recognized to exceed those of all other waste-discharging sources. Similarly, the incremental abatement costs posed by factories in such industries are so much greater than the incremental cost of providing for the retail establishment or the dry process industry, that it would appear that the general public's interest is affected in a significantly different manner when it is asked to bear that cost. Conversely, the benefits--in terms of potential water quality enhancement--are also disproportionately great when such a factory's wastes receive treatment. Moreover, the water quality benefit is received by the public at large. There would seem, then, to be considerable logic in support of Federal or State grants in such a situation.

Nor is the equity question a simple matter of the apparent injustice of using public funds to remove the burden of waste treatment from a private interest to whom that burden will represent a significant incremental cost. If Federal grants were to be withheld or reduced to certain communities that treat a significant amount of industrial wastes, then the community that takes a broad view of its environmental protection responsibilities--seeking in an enlightened fashion to ensure their effectiveness and efficiency over time--will be penalized, and the community that takes the narrow view of its responsibilities will achieve a relative advantage. Cities generally would be penalized by such a policy, since a large portion of a city's waste come from industrial sources that have no other place of discharge than the public sewers, while suburban settlements would receive an advantage. Given prevailing income distribution in metropolitan areas, the policy would tend to favor the relatively affluent and hurt the poor. Moreover, the substantially arbitrary distinction between municipal and industrial wastes would tend to produce inter-sectoral inequities. Some industrial sectors would receive the benefit of Federal assistance, others would be cut off from it. 1/

Finally, it should be considered that there are elements of regional discrimination implicit in a policy of limiting grant assistance for public treatment of industrial wastes. Not all industries, but the heavy water-using, first-stage processors are, as has been noted, presumed to be the source of industrial wastes. To exclude such waste sources from Federal assistance would be to inflict a distinct penalty on the far West and on the Southeast where a disproportionate share of industrial activity is based on such processing, and where the propensity to provide public treatment of industrial wastes is historically well established--in the far West, at least, the policy antedates the Federal assistance program by at least a decade.

Potential inequities inhere, then, in any public posture that may be assumed with regard to broad public treatment of industrial wastes. The efficiency and practicability of the practice are established beyond question. It contributes to effectiveness of pollution abatement efforts by establishing public control of wastes from all sources; and in heavily industrialized urban areas it is the most practical way to achieve effective water pollution abatement. Yet in the case of certain heavy industries, its effect is to shift from industry to the public sector an economic burden of very sizeable dimensions.

The essential question of equity arises out of the opportunities for cost avoidance that the practice provides manufacturing industries; and objections to Federal assistance have been magnified by the existence of certain cases where a local government's application for a grant amounts to a thinly masked effort to obtain public assistance for what is essentially an industrial facility. Moreover, the inequities

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1/ This report has been produced in a building that is part of a recently constructed complex of office, retail, and residential units, populated during the day by persons brought in from more than a fifty mile radius, and with a probable waste discharge equal to about one sixth of that of the city on whose outskirts it lies. There is no objection to public treatment of the wastes of this paperwork factory or to Federal construction grants to provide the plant expansion and the transmission facilities needed to accomplish it. Yet the effect of those grants is to benefit the real estate, construction, retail, and financial sectors just as surely as the capacity to handle a New England town's tannery wastes benefits the factory owners.

that are relatively slight in the context of the Federal program become enormous on the local level, in the case where general tax revenues are utilized to construct and operate such a treatment system.

The equity questions assume a legal coloration when viewed from the standpoint of Section 8(a) of the Federal Water Pollution Control Act, which provides that:

> The Secretary [of the Interior] is authorized to make grants to any State, municipality, or intermunicipal or interstate agency for the construction of necessary treatment works to prevent the discharge of untreated or inadequately treated sewage or other waste into any waters. . .

The section is specific in limiting the availability of Federal construction grants to governmental units; and the legislative history suggests very clearly that there was no Congressional intent to extend such grants to industrial treatment of wastes; yet the Act provides that the grants extend to plants whose purpose is to treat not only sewage but "other wastes," so long as it is a governmental agency that intends to construct--and presumably to operate--the works in question. Nor does the Water Pollution Control Act's exposition of the discretionary powers and the responsibilities of the Secretary of the Interior, as they apply to the award of Federal Construction Grants, suggest that a policy of excluding communities for treating industrial wastes should be observed.

There is, then, ambiguity with respect to the degree to which administrative procedures should interpret the intent of the Congress with regard to municipal treatment of industrial wastes in awarding construction grants. There is also an obvious disparity between the way in which municipalities approach their waste treatment responsibilities and the way in which the Congress viewed those responsibilities when the act was formulated over a decade ago.

Given the conflicting demands of the situation, it would appear that the Federal policy should continue to be one that supports effectiveness and efficiency inherent in the strengthening of local and regional waste handling programs that are comprehensive in their reach. From the national point of view, the fact that availability of Federal assistance has led to an indirect use of grants by public agencies to finance industrial waste treatment works by inducing manufacturing plants to connect to enlarged municipal system is not in the least bad. It is entirely consistent with the purposes of the Water Pollution Control Act, since it increases the degree of treatment of untreated or inadequately treated wastes, and adheres to the subsidiary objective of contributing to planned regional or metropolitan pollution control systems.

Because cost-sharing would seem to lie at the root of the difficulty, remedies might be applied most efficaciously by locally established requirements to ensure that projects be financed in a fashion that provides an equitable correspondence between costs occasioned and payments made. The simplest and most prevalent procedure to make the occasion of cost compatible with financial burden is the use of a sewer service charge scaled to the volume and/or strength of the wastes derived from each user (or class of users). Ideally, such a requirement would be placed by applicants for Federal waste treatment construction grants, since its overall effect would be to place a price upon waste treatment that fully reflected the costs of the service. (Use of general tax revenues is thought to subsidize inefficiencies by masking costs, and reducing users' ability to control his costs by limiting his production of pollutants). But if the only concern is to guard against industrial exploitation of public resources, charge requirements might be placed only by systems handling more than 100 gallons per capita per day--or some other acceptable figure to characterize presumption of a greater than "normal" industrial loading.

Admittedly, the imposition of such a requirement would only reduce the cost-sharing contradictions at the local level. Federal contributions to some heavy industry sectors would continue to be greater, relative to taxes collected, than to others which are less categorized by liquid waste production. But to exclude heavy waste producers from participation in Federal programs would only reverse, not eliminate, the fact of disadvantaged industrial sectors. The main burden of Federal relations with industry throughout the nation's history has been a steady struggle to evolve a pragmatic balance between the public interest and the characteristic external damages imposed by a given industry. There seems to be no reason to depart from that policy in the case of industries whose characteristic problems include a high measure of production of water-borne pollutants. The public interest would seem best served by including such industries in the enforcement provisions relating to water pollution, and by providing the States and municipalities in which they are located a full measure of the assistance provided to all municipalities for the purpose of pollution abatement.

REGIONAL WASTE HANDLING SYSTEMS

The Water Pollution Control Act was framed to favor and support establishment of regional waste handling systems. The ostensible values of regional cooperation and regionally directed programs underlie a number of provisions of the Federal Water Pollution Control Act including ones that 1) directed comprehensive river basin studies, 2) required that Federal grants for construction of waste treatment works adhere to the conclusions of comprehensive programs developed under the Act, 3) provided a ten percent incremental grant award for construction that is certified to be included in a metropolitan or regional plan, and 4) encouraged interstate compacts.

It is probably significant that the same law that requires that a community be included in a comprehensive plan augments the amount of grants to communities that are certified to be included in some kind of plan. The fact that the incentive postdates the requirement suggests either that the rate of plan development has not matched expectations, or that there has been some meaningful gap between the planning process and its practical results. To a certain extent, both explanations are true descriptions of events. Planning has been a painfully slow process. More relevant to this discussion, however, is the fact that river basin planning has failed almost entirely to produce pollution control programs founded on basin systems.

The argument for the river basin based regional system is well founded. A regional system provides a means to adjust administrative institutions, capital investment, and abatement practices to the overriding physical imperatives of streamflow, temperature, and water chemistry--and to do so in a manner that effectuates economies of scale and allows selective application of effort. To obtain these practical benefits, it shifts the focus of attention from the series of specific sources of pollution, with their unequal and interlocking impacts, to the river basin and to the physical conditions and chemical reactions that take place in the stream. In concept, it is the most effective and the least costly means to insure water of given desired quality.

But the river basin pollution control system can not be found in the United States; and it shows no evidence of coming into full scale existence in the near future. There are, however, variants that flourish with more or less vigor and public acceptance.

The problems of implementing regional pollution abatement systems, then, seem to fall under the heading of practicability. Their potential effectiveness, efficiency and equity are unquestioned; but there seems to be something in the idea that conflicts with American views of the way that things should be done. Political realities and institutionalized procedures collide powerfully with the concept at a number of places; and where a regional solution to a problem has been adopted after a collision has taken place, regionalism has been subtly adapted to the needs of pre-existing institutions. The emphasis of this discussion, then, will be not upon the theoretical benefits of regional systems, but upon the difficulties of implementing them, and on the modifications that theory has experienced as it has been translated into fact. If basin systems with all their presumed virtues are inconsistent with other values that Americans prefer, it may be worthwhile to consider the evolutions of the concept that have been considered to be acceptable, and to devise incentives to organize in forms that preserve something of the efficiency and effectiveness of basin planning, but that adhere to politically acceptable modes of action.

To undertake that kind of comparison, it is necessary to distinguish between three characteristic forms of regional organization.

The river basin system is the purest form of the regional pollution control system. It places all sources of pollutants under a common regulatory authority with an independent financial base. The authority may undertake remedial measures on the basis of need and natural requirements imposed by stream conditions. The field of regulatory action is considerably broadened to include measures other than waste treatment--streamflow augmentation, waste storage, waste transmission, in-stream settling, artificial reaeration, zoning, assessment of penalties--and the intensity of treatment requirements can be varied to take advantage of natural conditions.

The closest approach to this idealized system is to be found in Germany, where the Ruhr and Emser Gennosenschaften have for almost a century administered a program of environmental controls that includes area-wide regulation geared to natural conditions, autonomous financing derived from user and effluent charges, stream classification, and application of in-stream as well as sewerage engineering. Several approaches to a basin system have been made in the U.S.; but these efforts have been of the nature of voluntary federations that include an administrative superstructure substantially without enforcement powers (other than those of the separate constituencies entering into the agreement) or the resources to engage in investment programs.

Note that this discussion is framed in the context of the short run future. Historical developments portend a more distant future in which the basin-wide authority will have the powers needed not only for water quality management but total water resource management. The Delaware Commission and others constructed in its pattern give insights into what may evolve; but this cannot be expected as a viable mechanism in most cases in the period of interest. How such authorities evolve will depend upon Federal policy, among other factors, and most significantly on Federal policy in the water resource field as a whole rather than in the field of water quality management. The Water Resources Council has given attention to this matter, as will the recently constituted National Water Commission.

The Metropolitan Sanitary District is a form of the regional pollution control system where the operational base is not the water body, but the social and economic focus provided by the urban area. Where the river basin system has been neglected, the metropolitan system is by now the generally accepted approach to waste handling in and around major American cities. Almost without exception, large cities serve as the nodes of vast collection systems that reach well beyond the city's legal boundaries to bring wastes into one or more waste treatment plants. It speaks, perhaps, to the profoundly urban orientation of Americans that they have rejected organizations based on the natural elements of the watershed, but have almost instinctively created sets of local systems based upon core cities. The character of such arrangements varies to include informal associations in which the central city accepts and treats the waste of its satellites for a fee (Portland, Oregon), the county-wide or multi-county sanitary district composed of a group of contributing communities (Allegheny County, Pennsylvania), several separately organized and funded collection systems lying within or cutting across legal boundaries to conform to physical configurations of a metropolitan area (Los Angeles County, California), and highly concentrated unit systems with independent funding and a high degree of regulatory and operational autonomy (Chicago, Illinois). The form of the arrangement may be dictated by local preferences, but the function of the city as the foundation of metropolitan waste handling is generally accepted.

The State-wide system is a recent development that is founded upon several evolving influences--some provisions of the Clean Water Restoration Act that provide strong Federal incentives to State planning and financial assistance, rivalry between State and local governments, the entry of States into financial assistance programs for local waste handling, the growing bureaucratic strength of the technicians who administer State pollution control programs, and an advanced level of pollution abatement capabilities that in most States has created a need for disciplined and orderly system maintenance postures in the conduct of environmental control policies. As with metropolitan systems, the emerging State-wide systems appear to be taking on separate configurations that reflect the political institutions and traditions of States, as well as the regulatory philosophy of the individuals or groups designing the system. Maryland, New York, and Ohio have all proposed to enter with great vigor into the conduct of local waste handling programs, obtaining their sanction and effectiveness from the use of State funds for investment purposes and at least modest operating assistance to communities. Less formal or less fully formed systems would appear to be developing in an almost organic fashion in New Jersey, Rhode Island, and Delaware, where the limited geographic reach of the State and highly developed pollution control capabilities create a situation requiring staged, coordinated extensions of pollution control activities.

Effectiveness

Existence of an organized regional waste handling system provides no assurance of effective pollution control, but effectiveness of the systematic processes is their chief theoretical merit. The core of the concept is recognition of the fact that not all discharges are equally polluting: relative magnitude of discharge, characteristics of receiving waters, and nature of discharge all play a part in determining the polluting potential of an effluent. The regional strategy for pollution abatement depends upon a simple process of reasonable allocation. Resources gathered from all elements of the system are applied in the fashion that reflects the ordinal significance of the elements of a given set of conditions. The most pollutional influences are controlled first in point in time, the more critical situations are more closely controlled.

Minimum conditions for effectiveness, then, are comprehensive application of controls to sources of pollution, and discriminating application of those controls. Unless the functional powers of the system managers include the ability to draw resources from all constituents and to apply them selectively, the potential to effect desired water quality goals is dissipated. Effectiveness, in the final analysis, depends upon an abrogation of sovereignty by contributors to the system. They must forego local choice as to whether and to what degree they will treat their wastes, and they must supply revenues that may be made available to other elements of the system.

The effectiveness of regionalism can not be divorced from political considerations. To operate as a system, regionalism requires that technical decisions over-ride local political distinctions. Either voluntarily or through statutory coercion, all significant sources of pollutants must adhere to and share the costs of systematic conditions if the organization is to be of more than ceremonial consequence.

Both metropolitan system and proposed State systems diverge from the effectiveness requirement in that each accepts somewhat more limited goals. The intent of the metropolitan system is in most cases to provide a means to most conveniently dispose of the liquid wastes of an urban area. The prime purpose of the State system is to extend State control over community actions in the sphere of waste handling, and to insure the responsible use of State funds advanced to remedy local financial deficiencies. Pollution control is almost a collateral goal; and area or regional cooperation is no more than organizational technique utilized to facilitate accomplishment of another purpose. The voluntary nature of the typical metropolitan system testifies to the fact that the prime concern is satisfying an imposed--from whatever direction--requirement for waste treatment. Given a voluntary situation, pollution may continue through failure of a significant waste source to join the system, which then does no more than satisfy the formal regulatory requirement imposed upon participants. Similarly, the fact that State systems largely exclude major sources of industrial waste, except as these are brought into the system through the instrumentality of a community, suggests that the prime purpose is to amplify the extent of State control over local government in the area of waste handling. These expedients may be extremely effective in terms of their own limited goals, but they are by no means to be considered directly effective in reducing water pollution.

But if State and metropolitan arrangements provide no direct promise of an increase in capital effectiveness, due to their lack of comprehensive authority and inability to impose abatement priorities related to streamflow and other natural conditions, both hold the promise of incremental operating effectiveness. By imposing operating standards and by supplying financial support, the State or the metropolitan system should invariably result in an overall increase in the effectiveness with which waste treatment plants are operated. Moreover, such systems become large enough to employ specialized skills and to satisfy internally their need for trained operators through normal processes of apprenticeship and promotion, something that no small-scale waste treatment organization can do.

The potential effectiveness of regional systems will become an increasingly critical matter as the pollution control effort matures; and there is good reason to predict that over the long run, attainment of water quality standards will not be possible in many places in the absence of basin-wide or State-wide regulatory and planning institutions.

Authority for the conclusion may be found in those watersheds whose water quality has been intensely studied--the Willamette, the

Snake, the San Joaquin, the Colorado, the Arkansas, the Ohio, the Potomac, Lake Erie, and Lake Michigan. Without exception, investigators have found that sewage treatment is only a part of a body of pollution abatement requirements. Industrial waste treatment is another, slightly larger, piece. A host of land management and water management practices contribute to the presence of pollution; and these must be adjusted and monitored if pollution abatement is to be accomplished. Comprehensive reach, technical virtuosity, and flexible resource allocations will become increasingly necessary as water pollution control efforts extend in time and intensity. Where attention begins and ends at the sewage outfall--as is likely with local responsibility for pollution abatement and even with the use of metropolitan waste treatment systems--pollution will probably be only slightly and locally diminished.

In terms of effectiveness of national programs over the near future period, it is apparent that such programs must be related to existing, viable political organizations, not framed in terms of a conceptual apparatus which can be arranged only with considerable time and expense if at all. A key to a large proportion of the pollution problems rests in the large urban area. Programs directed to this unit of government might well prove to be the most effective.

Efficiency

Sizeable efficiencies have been attributed to regional pollution control systems; but these have rested on the assumption of flexible, watershed-based applications. Failure to translate the theoretical organizational pattern into practice has largely short-circuited attainment of the particular efficiencies that are thought to be peculiar to regional systems.

Efficiency considerations, however, must be thought to underlie the most vigorous form of regional pollution control organization to be found in the United States. Development of metropolitan waste handling procedures has stemmed largely from the economies of scale that the practice affords. Larger plants involve lower unit costs. A high ratio of transmission facilities to treatment facilities provides a longer average life for the body of physical capital employed. System size permits greater labor specialization, more complete worker utilization, and continuity of staffing. A broader financial base reduces lumpiness in capital allocation and tends to ameliorate impacts of money market and other financial constraints. All of these scale advantages adhere in theory to any broad-based regional system; but they are most closely associated with metropolitan areas because of the geographic and administrative coherence of such a region.

Economies of scale are not, however, the kind of savings that are distinctive to regional systems. The unrealized economies of flexibility and pertinence are the ones that proponents of such systems systems had hoped would develop from application of regional principles.

Such economies had been expected to flow from attention to underlying physical imperatives and from application of least cost solutions. The formulation techniques are straightforward and relatively undemanding. Development of computer technology has enhanced their breadth and flexibility enormously, though the technical concepts were applied on a limited basis well before the general availability of computer techniques.

Unfortunately, all such solutions have two things in common. They require some waste sources to treat to a much higher degree than others--and usually such waste sources are factories. And they include some in-stream measures for which no community can be assessed responsibility under existing regulatory procedures. Unequal imposition of controls, with no direct increase in benefits obtained by those whose costs are increased thereby, would create such obvious problems of administration that it is not at all difficult to see why optimizing systems have not been utilized. In the absence of a method for sharing the savings among all components of the system, the promised efficiencies of river basin pollution control programs are unlikely to be obtained.

Equity

Equity considerations are, in theory, served more completely by a full-fleshed river basin system of pollution control that includes proportional user charges than by any other approach that has been devised. The broadening of the financial base to include all inhabitants of a watershed is consistent with the unassignable nature of benefits conferred and with the inter-related nature of damages occasioned. (In large measure, the same judgement applies to State-wide systems, and for the same reasons.) By assigning costs on the basis of least cost solutions, the basin system comes as close as is humanly possible to establishing an equitable cost of pollution control. By distributing locational and scale advantages as well as by reducing the charges (50-75% of the total, judging by FWPCA model studies) atributable to institutional and organizational resistance, the basin system is intended to balance actual pollution control costs with remedial charges, and so to reduce the inequities occasioned by uneconomic behavior of those interests seeking to avert or shift costs, as well as by the diseconomies incurred by the self-interested behavior of pollution control groups seeking to increase their portion of national income.

Practicability

We are presented with the anomalous situation of a means to organize for pollution control that is apparently superior to any existing procedure in terms of equity, efficiency, and effectiveness, and yet one that is used only on a very limited scale and with modifications that seem to detract from, rather than add to its virtues.

There are no technological constraints. Limitations on application that trace to deficient knowledge of physical conditions in waterbodies can be remedied. The method is wholly consistent with Federal policies, as contained in the Federal Water Pollution Control Act.

Yet Americans have shown no inclination to pursue the policies required to develop river basin pollution control systems. To the contrary, the main thrust of State policy, and of Federal policy as outlined in the guidelines for adoption of interstate water quality standards, has been to go down the line of uniform waste treatment requirements, local rather than regional responsibility, State regulation, and adversary enforcement proceedings rather than cooperation and acceptance of technically induced courses of action.

The operative element in determining public acceptance of river basin pollution control systems would seem to be the fact that such systems relate to few, if any, of the existing procedures of American governments. They represent a foreign accretion, a perhaps functional but isolated additional layer in the structure of intergovernmental relations. And when it is considered that independent financial status is one of the prime essentials for effective operation of such systems, it becomes clear that their implementation would take pollution control out of reach of normal local government decisions, and set it apart from discussion of the hierarchy of total public needs for resources.

American State and local government is generally strong, attuned to public demand, and sanctioned by tradition. Quite reasonably--since they have a working, well understood, and reasonably efficient method of doing things--citizens and established powers tend to resent the interposition of independant authorities that reduce citizen participation in public processes, and that receive funds that local preference might wish to consign to schools or hospitals or roads or police powers. In the nation's value system, citizen participation and citizen control would appear to offer satisfactions well worth the price of some minor technological diseconomies.

Similar political and cultural value mechanisms impede industrial participation in regional systems. It has been demonstrated again and again in water quality studies that industrial waste discharges are of pivotal importance, so that the effectiveness of any pollution control scheme must hinge upon industrial participation. Indeed, the success of the Ruhrverbaende may be ascribed entirely to industrialists, who devised and initiated the system in the nineteenth century and have adhered to its requirements ever since. The behavioral mode was--and is--quite consistent with the cooperative, cartelized organization of German industrial activity, just as German municipal adherence to the system conforms to a pattern of routine acceptance of centralized, technical administration.

American industrial behavior, on the other hand, is conducted with a considerable degree of competitive activity--and its ritual code of values places a premium on competition that is even greater than the degree of real competition would suggest. Rather than cooperating to reduce the impact of external diseconomies, the American business manager will attempt to evade the consequences of such actions on his costs or failing that, to insure that his competitors will bear at least an equal cost. Regulation, negotiation, the competitive interposition of public interest and private interest that marks the American system of countervailing powers--these prevail in the conduct of water pollution control activities. They are not conducive to establishment of rationalized regional systems; but it would be rash to contend that the total and long run productivity that results from the opposition of countervailing powers is not well worth the intermediate diseconomies that the system generates.

Perhaps it is an indication of the innate flexibility generated by our political and industrial practices that the regional systems concept has been adapted--or is in the process of adaptation--to fit American conditions. The central function of the city and the established pattern of local public utility services have accepted the general outline of regionalism in developing the metropolitan sanitary district. State control and the interpenetration of State and local government activities are apparent in the development of State-wide systems, as in Maryland or New York, where cost-sharing, planning, and efficiency standards are evolving from processes that a decade ago were directed exclusively to the obvious and limited ends of control of contagion and adoption of "good practice".

It would seem that regionalism and systems engineering based on watershed conditions are not practicable in the United States at this time. The institutional mechanisms to implement them generally do not exist, and may even be inimical to some very strong social preferences. On the other hand, existing institutions are evolving to incorporate many of the desirable features of watershed systems. The major forms of regionalism that are emerging are, at this time, perhaps less efficient than the river basin system. But they are not only more comfortable in terms of compatability with existing institutions, they exhibit a rich variety that tends to conform to local conditions. Over the long pull, the flexibility of interrelated State-wide and metropolitan systems may prove to have an effectiveness of a high order.

Economies of Scale

One of the principal inducements to regional waste-handling systems--particularly when viewed in the context of the metropolitan system rather than the broader terms of the river basin or State-wide system--is their presumed ability to activate substantial economies of scale.

Analysis of recorded investments since 1962 raises the possibility that the particular advantage is not a constant virtue. There appear to be significant discontinuities in application of economies of scale, at least as these relate to investment. The dimensions and findings of that analysis are presented here, but it must be emphasized that it would be premature to base policy decisions upon those findings. They are incomplete, in that they deal only with initial construction costs and are not time-phased. Interpretation of the interplay of investment and operating costs, the long run implications of the difference in effective life of treatment and transmission components of a system, and consideration of the effects of interest rates may indicate that the inferred discontinuities of scale economies in initial investment may be reduced, eliminated, or reinforced by more comprehensive consideration of cost factors.

In theory, the unit costs of waste handling should decline as size of the system increases. A generally accepted economic concept holds that each incremental unit of product spreads fixed costs over a larger base, so that unit costs invariably decline with size; and--also in theory--there is no point at which increasing size should result in an upward shift in unit costs: at the point at which returns to size become negative, the rational manager will begin to replicate a system rather than expand it. (The logic of the latter argument is somewhat debatable. If there is some physical or other limit to effective optimum size that dictates replication rather than expansion, the second and succeeding units may be viewed as subsystems of a multi-unit system; in which case, unit costs might properly be calculated on the basis of costs and output of the aggregated components.)

The theory rests on physical as well as financial and organizational aspects of cost. The general terms of the physical relationship are expressed by the engineering rule of thumb called the six-tenths-power rule, a convention that holds that in the design of a system the cost of an incremental unit of capacity is equal to approximately sixty percent of the cost of an anterior unit of the same dimensions. (More precisely: if X capacity costs Y dollars, then 3X will cost $3Y^{0.6}$): Both the economist's and the engineer's expression of the concept of economies to scale imply a continuous assertion of those economies. The economist will usually have at the back of his mind a general view of marginally diminishing returns to size, while the six-tenths-power rule suggests a constant rate of continuous accretion of such returns; but the principle is a fixed feature of either practitioner's view of the world.

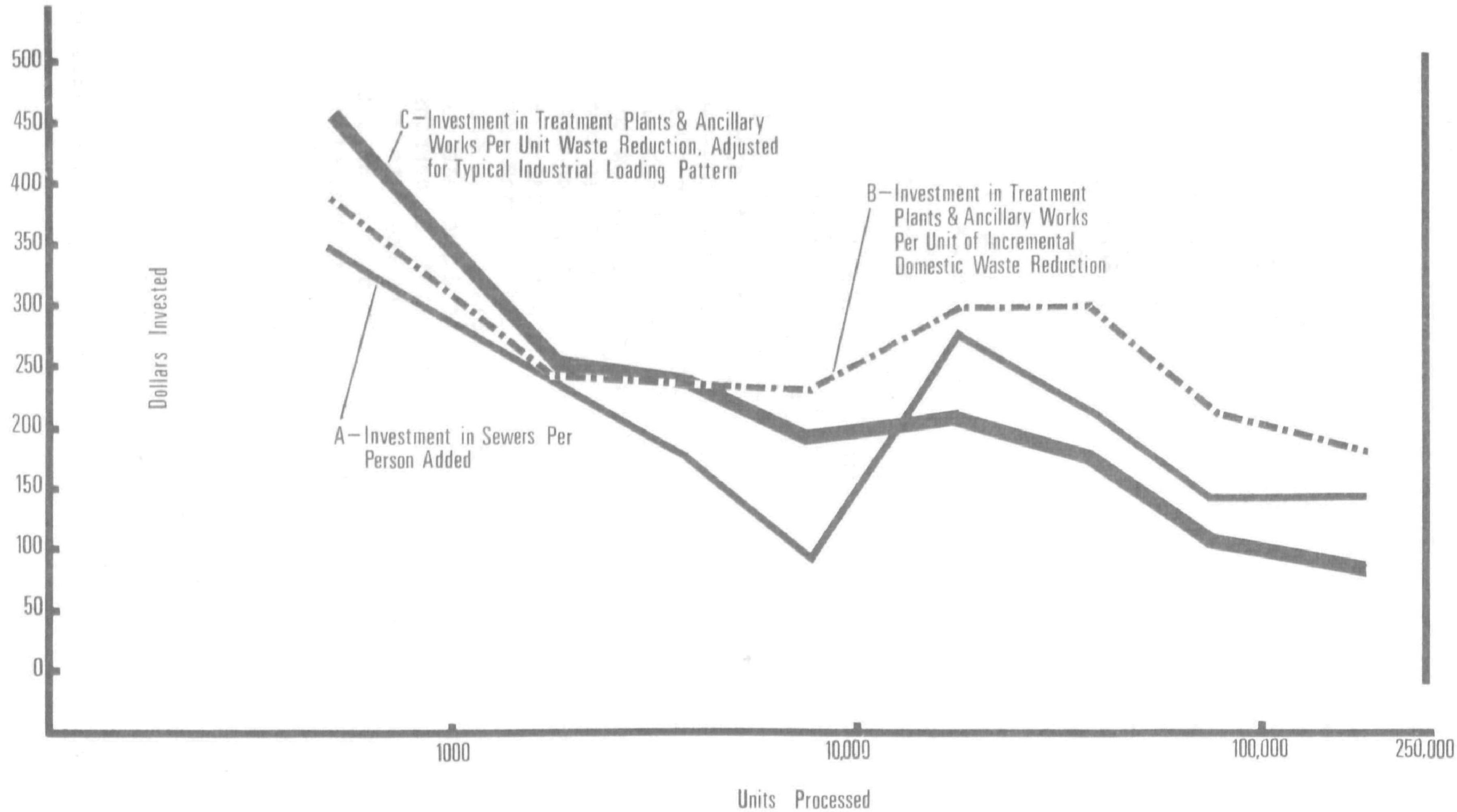
Investigation of the cost of incremental waste handling services provided through investments made between 1962 and 1968 suggests very strongly, however, that there is a significant discontinuity in the expression of waste handling economies to scale. Figure 8, presents the results of the analysis, which related unit investment to size of place.

The procedure followed in developing the relationship was an exercise in aggregation. Total expenditures that were made for sewers by communities of a given size class were divided by additional population reported to be connected to sewers in communities of the same size class (line A). Total expenditures for waste handling investments in all categories other than sewers were divided by a factor equal to 80% of all persons added to secondary waste treatment systems plus 30% of all persons added to primary waste treatment systems in each size class during the period (line B). (The factor is intended to provide a measurement of incremental waste reduction based on a rough measure of waste strength--one person equal to one population equivalent of biochemical oxygen demand--and a broad estimate of the average efficiency of the basic waste treatment processes.) Finally, the mean contribution to municipal waste discharges imposed by industrial effluents in towns of each size class was taken into account by multiplying increased population served by a loading factor proper to the size of the community and then by the appropriate treatment factors and dividing investments other than those for sewers in each size class by the products (line C). (The multipliers, which even and extend the observed pattern of the relationship of waste concentrations to persons served in places of a given size were: 0.85 for towns equal to or less than 1000, 0.95 for towns of 1000 to 2500, 1.15 for towns of 5000 to 10,000, 1.40 for towns of 10,000 to 25,000, 1.67 for towns of 25,000 to 50,000, 1.9 for towns of 50,000 to 100,000, and 2.05 for towns of 100,000-250,000. These were determined by an analysis of operating records for treatment plants built with the aid of Federal grants. c.f. R. Michel et al "Plant Operation and Maintenance," Journal of the Water Pollution Control Federation, March 1969.)

Subject to the reliability of the data and the uncertainties of cost and population distributions within population size classes--the lines connect the juncture of population class midpoints with

Figure 8

UNIT INVESTMENT BY SIZE OF PLACE, FOR INCREMENTAL WASTE-HANDLING CAPABILITIES 1962-68



unit investments--the Figure may be thought to provide a fairly good estimate of what it has cost to connect one more person to a sewer system (line A), to treat the wastes of one more person to the average level provided by a community of the size in which he lives (line B), and the cost to provide that same average degree of treatment to an additional population equivalent of wastes from either domestic or industrial sources (line C). There may be significant divergences between actual unit costs and the indicated costs at any point along the curves, but their general shape must be considered to be accurate if the data is accurate.

The graphed lines indicate clearly, if somewhat imprecisely, that unit investment requirements drop off initially as size of place increases; but as population reaches about 10,000, a rather sharp increase in unit waste handling costs may be anticipated.

Although the pattern of discontinuous application of economies of scale may seem to conflict with theory, there is no reason to doubt that the phenomenon exists. With respect to waste treatment, there are well defined explanations for the increase in unit costs for larger towns and for cities. (These are discussed below.) For sewers, however, we can only conjecture about the influences that press costs upward for towns of a given size.

Possible explanations for rising incremental sewer costs in larger places include higher excavation costs and other disruption charges in built up areas, greater likelihood of the interposition of terrain problems as area expands with population, more complex systems in larger areas, lower population density in outlying areas that may be served by larger towns, and need to include within the system substantial areas that are locations for commercial or industrial development and so provide limited additions to the body of users relative to the area of additional service. Should such factors, indeed, be responsible for the increase in unit sewer investments for towns of ten to twenty-five thousand, it is not unreasonable to infer a second discontinuity in expression of economies of scale that may occur in very large cities, where the same complexities of size exist in an enlarged fashion as compared to cities in the upper size classes considered in the analysis. (While the additional discontinuities may be inferred, it has proved impossible to document them. Reporting procedures are such that it is not possible to distinguish between investments made by cities and those made by large consolidated sanitary districts--the basic reason that unit investment calculations were not made for places of more than 250,000 population.)

Reasons for the apparent intermediate diseconomies of scale are far easier to assign with some authority in the case of waste treatment. One very significant factor--the relative rise of industrial wasteloads with increasing size of place--has been considered in the analysis by assigning multipliers to account for the indicated prevalence of industrial wastes at each population size class. The effect of the adjustment is to sharply reduce dimensions of indicated diseconomies. It is obvious that to assign costs entirely on a per-capita basis is to exaggerate unit costs when a significant portion of capacity is utilized for industrial wastes. Because the proportion of industrial wastes handled by a system typically increases with population, the exaggeration becomes increasingly operative as population increases.

Also significant to the pattern of unit costs is distribution of treatment processes by size of place. As hydraulic loading increases, a shift in the factors of production occurs from land-intensive treatment processes to capital-intensive methods. Because construction costs alone enter into the calculation, the interaction of land and construction costs is not reflected in the curves of Figure 8 . (Land costs are highly variable, but tend to rise with population concentration; so it is unlikely that consideration of land costs would make any significant change in the shape of the cost to size curves. If land prices did not characteristically increase at multiples greater than demand for land for waste treatment needs, then the shift to facilities-intensive treatment methods would be unlikely to occur.)

The manner in which increased demand for waste treatment capacity influences preferences among treatment methods is indicated very clearly in Table 53, which lists the relative prevalence of treatment processes in 1968 by size of plant. In some cases, the "normal" construction cost for a 1 million gallon per day plant as presented in Modern Sewage Treatment Plants, How Much Do They Cost? is indicated in the table. In other cases, statistical analyses of the correlation of plant size and construction costs are not available. The general ranking of costs, however, is known to follow the pattern presented in Figure 9.

Figure 9 is not calibrated for relative unit costs and removals except in the most elementary sense. The position of a process simply indicates that under normal conditions it costs more per unit of capacity than processes that appear below it in the figure and less than processes that appear above it. Degree of waste removal, too, is presented only in a "more than" or "less than" sense. It should be understood, too, that the indicated relationships are by no means invariable. The less costly "post-secondary" processes may sometimes conveniently be substituted for secondary treatment by small towns, in which case they might be little, if any, more costly than biological filters. The basic principle that capital replaces land as size of place increases definitely limits the application of septic tanks, lagoons, and land disposal, to relatively small communities.

The relationships embodied in Figure 9 help to explain the discontinuities that have been found to exist in application of economies to scale in waste treatment. Table 53 indicates that the

TABLE 53
Distribution of Waste Treatment
Processes by Size of Plant

Percent of Plants of Size Class by Type of Treatment

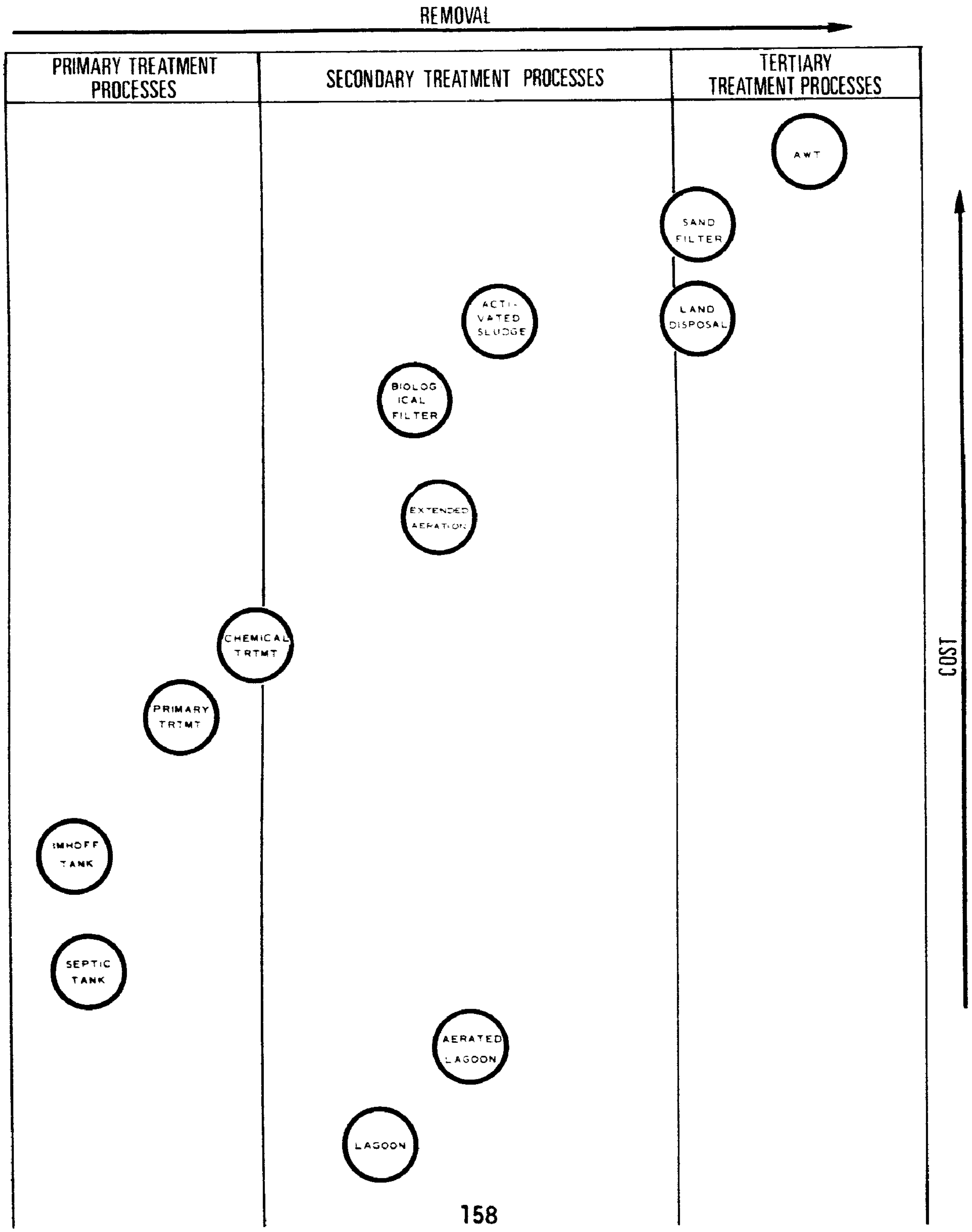
Design Flow, Million Gallons Per Day

Type of Treatment	.25	.25-.499	.50-.999	1.0-4.999	5.0-9.999	10.0-29.999	30.0-49.999	50.0-99.999	100.0-199.999	200.000	Percent of All Plants	Expectable Cost Per MGD of Capacity 1/
Imhoff & Septic Tanks	13.3	7.2	4.8	2.1	0.7		4.3		4.0		9.3	$237,000
Primary Treatment	4.3	10.1	14.8	20.3	28.6	34.7	30.4	34.5	28.0	33.3	9.9	235,000
Chemical Treatment	0.1	0.3	0.6	1.7	1.7	4.2	2.2	13.8			0.6	235,000
Biological Filters	22.0	41.5	43.1	45.7	35.0	23.5	17.4	6.9	12.0		30.6	288,000
Activated Sludge	6.2	11.9	13.3	17.5	25.5	31.5	32.6	41.4	36.0	50.0	10.6	321,000
Lagoons	39.5	20.4	15.4	8.0	4.1	1.4	2.2				27.9	68,000
Extended Aeration	8.8	5.6	4.5	1.8	1.7	0.9	2.2	3.4	4.0		6.6	NA
Other Secondary	1.2	1.5	2.1	1.6	1.7	2.3	6.5		16.0	16.6	1.5	NA
Land Disposal	1.4	0.4	0.6	0.4	1.0	0.5					1.0	NA
Intmt. Sand Filters	3.0	1.0	0.7	0.4		0.5					2.0	NA
Tertiary Treatment	(a)	(a)	(a)	0.4		0.5	2.2				0.1	NA
Number of Plants	6973	1677	1279	1832	294	213	46	29	25	6	12374	
Percent of Total	56.3	13.6	10.3	14.8	2.4	1.7	0.4	0.2	0.2	0.1	100.0	

(a) = Less than 0.1%
NA = Not available
1/ 1957-59 Dollars

Figure 9

GENERALIZED RANKING OF UNIT COST AND REMOVAL EFFICIENCIES OF CONVENTIONAL WASTE TREATMENT PROCESSES



likelihood that a high construction cost treatment method will be applied increases directly with size of plant.

Time, as well as land availability and required treatment effectiveness, plays a part in the mix of treatment methods. Imhoff tanks and community septic tanks represent hangovers of an obsolescent technology; it is seldom that a community would install either of them today. Similarly, it is extremely unlikely that any small community west of the Mississippi or south of the Mason-Dixon line would install a primary treatment plant of any description. The much higher removal efficiencies and much lower costs available with the use of lagoons have made them standard technology for small communities in most of the nation during the last ten years. Indeed, the point at which the investment cost to size function for treatment plants and ancillary works turns upward in Figure 8 corresponds very closely with what has generally served as the effective limit of application of lagoons--that is, a town of about ten thousand persons, or an hydraulic capacity of a million gallons per day.

APPENDIX

THE FACILITIES EVALUATION MODEL

The mathematical modeling technique employed as part of the cost analysis for municipal waste treatment plants was devised to calculate the following, based on the 1962 and 1968 Municipal Waste Inventory data supplied by the States and municipalities:

1. current replacement value of facilities in place

2. value of recognized improvements needed in treatment or operation of waste treatment systems as stated in the 1962 and 1968 Municipal Waste Inventory

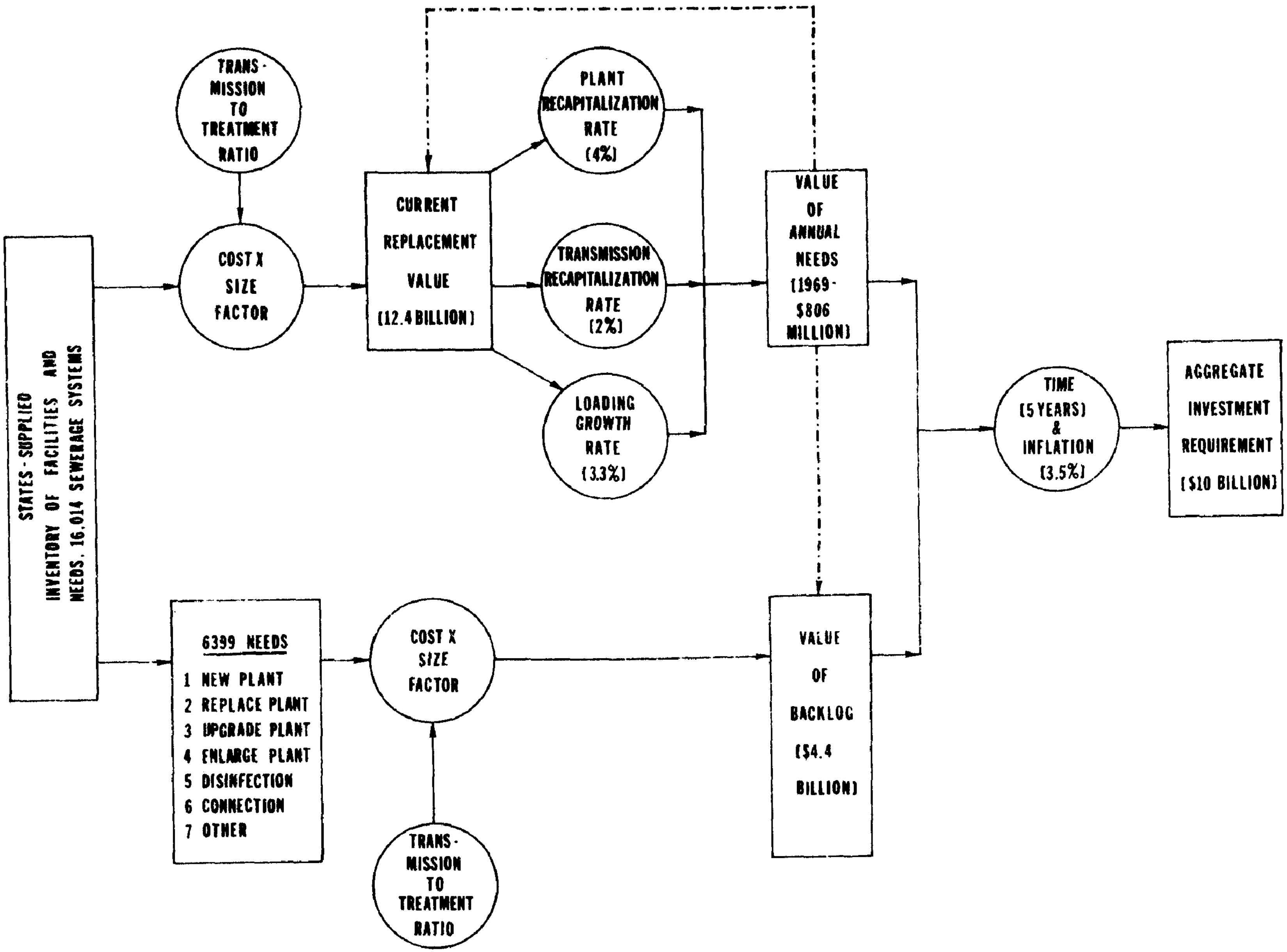
The scope of answers attainable using this technique has answered questions as to how much money would have to be spent to replace treatment plants that are still in existence; what the current inventory (backlog) of needs is, and what it was in 1962. The technique can also evaluate the additional treatment costs needed in future timeframes, based on current facilities.

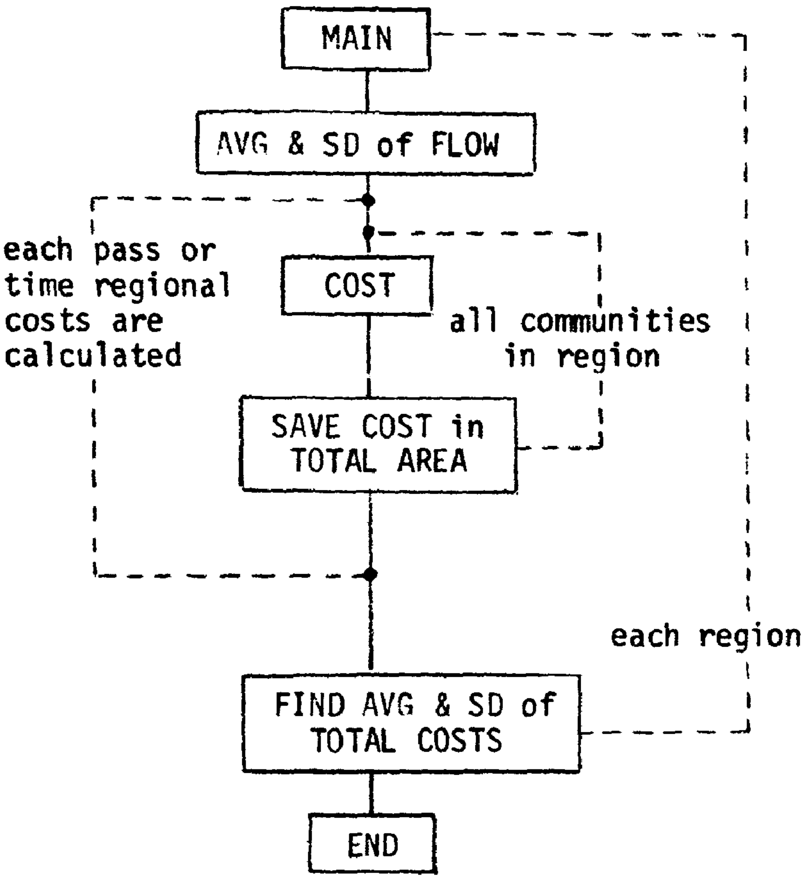
The current replacement value of facilities in place was calculated on the basis of costs experienced in building facilities with similar design flow and removal efficiencies. This analysis included a measure of variability in the cost per unit treated. The costs associated with the stated needs in the 1962 and 1968 inventories included both variability in projected design flow and in cost per unit treated. This modeling approach, in addition to incorporating variability as indicated, provides a mechanism to handle a large amount of data with the ability to vary conditions parametrically to determine the effect of the change of one variable on the stability of the outcome.

The results of these analyses are presented in the body of this report.

A diagram of the calculation scheme follows.

FACILITIES EVALUATION MODELS
GENERALIZED LOGIC





The solid blocks indicate the basic work units to be explained after the diagram. The dashed lines indicate the program flow with the number of times each box is entered listed with the dashed lines.

1. MAIN:

Main reads and selects the data to be manipulated and totalled in succeeding portions of the program.

2. AVG & SD of FLOW:

This routine calculated the average and standard deviation of actual per capita flows observed at the existing waste treatment facilities by size of place (1-10). These values are used later in the program in the cost calculations. Let us refer to these flows as AQ and SDQ for average and standard deviation of flow.

3. COST:

This portion of the program calculates treatment plant costs (on an individual basis but aggregated by type of need and region studied). These costs were calculated basically as follows for each plant:

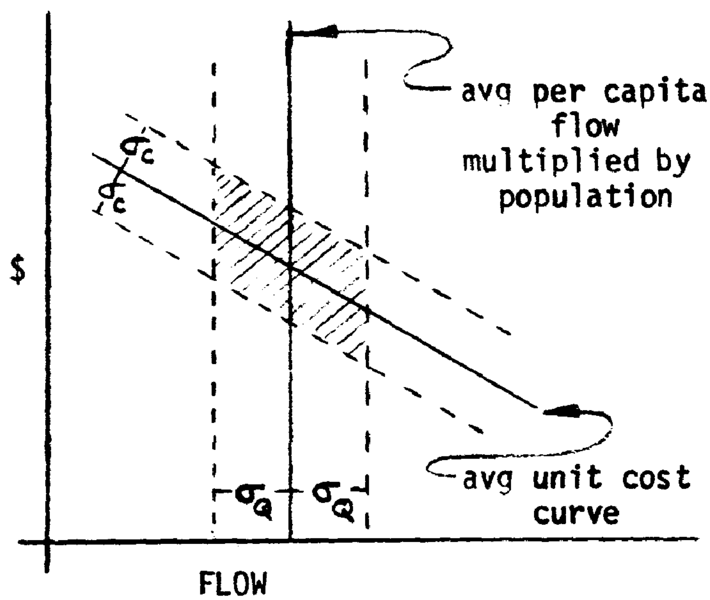
a. Calculate a population served for 25 years from the present based on growth factors by size of place (1-10). This yields a 25 year design population. Parametrically varying the growth rate by size of place by ±25% of the expected growth changed the cost answers less than 10%.

b. Calculate the total flow from the plant based on (a) and the average and standard deviation of the flow per capita as calculated in AV & SD of flow by using a normal (0,1) random deviate (RN) as follows:

Total Flow = population projection x (AQ + RN x SDQ).

Bounds were set on the flow value. The calculated flow value was then used to determine a cost as follows:

Using a cost curve which represents the average unit cost per total flow in a plant calculate the cost...but recognize that the average cost curve also has variability. So using the average and standard deviation of costs for that particular flow calculate costs in much the same manner as the total flow by using a normal (0,1) random deviate. Pictorially the process looks like this...



where the shaded area would represent the possible value of cost if both flow and costs were restricted to say one standard deviation (σ) about the mean.

At this point, it is appropriate to interject one paragraph relative to the calculation of in-place facilities value. The diagram above can best be used for this purpose. Assume that the abscissa FLOW represents design flow at present facilities as listed in the Municipal Waste Inventories. We can then use the average plant flow line on the diagram with no deviation for a representation of design flow which is given. We still must recognize the variability of costs. Therefore, instead of having an area over which the costs can vary, we recognize only a variability <u>along</u> the design flow line.

We return now to the discussion of backlog costs. A cost is calculated for each community expressing a need. The cost functions relate to the specified needs and where necessary include a factor for ancillary works. The costs for each community in a region are summed, and when all the communities in the region have been analyzed a total cost for the region is obtained. Each region was simulated either 10 or 25 times on a community by community basis and the 10 or 25 total cost values were analyzed to determine the mean and standard deviation of total costs likely from the region. Increasing the number of iterations for simulation of total regional costs from 10 times to 25 times produced almost no cost change (about 3 to 4%). On this basis, 10 analyses per region were used for most calculations. The mean cost was used as the indicator of the regional cost. The standard deviation is an indicator of the stability of the mean and generally followed the trend in the variance of the flow values in the regions.

There are seven basic needs categories reflecting the needs recognized by States and municipalities and included in the 1962 and 1968 Municipal Waste Inventories. Costs were calculated for each need, based on costs determined by analysis of unit costs for projects receiving Federal grant assistance and estimates of maximum reasonable costs where other information was not available. The numbers obtained can be challenged, but the orders of magnitude of these values are believed to scope the problem. It is noted that this approach is not applicable to reliable costing for the design of any particular plant, but rather provides valuable aggregate values. The seven needs categories follow, with an explanation of the method of analysis and the basic rationale:

New Plant

New plant indicates the need for construction of a facility where none presently exists.

Where the plant analyzed was noncoastal, secondary treatment was used as the need in the form of an activated sludge plant with a multiplicative factor for ancillary works included in the costs. The basic equations for cost are:

a. Log(cost) = 5.6062 - 0.3537 x log(flow)

b. log (random component of cost) = RN x 0.175

$$\text{Total cost} = 10^{(a+b)} \times \text{Flow} \times (\text{factor for ancillary works} + 1.0)$$

Where the discharge was to a coastal outfall, primary treatment was assumed to be adequate under current water quality standards. The multiplication factor was used again in this calculation for ancillary works.

The basic equations follow:

a. log (cost) = 5.3704 - 0.44604 x log (flow)

b. log (random component of cost) = RN x 0.188

The total cost equation is the same as above.

Enlarge Existing Facilities

These costs were based on primary treatment plant costs for coastal discharges with the ancillary factor set to zero; and secondary treatment plant costs with zero ancillary factor for non-coastal discharges. The rationale here was that it would cost more to enlarge facilities than to just add on the component of the plant, because existing facilities would have to be worked around during construction and provisions would have to be made to keep the plant in operation for as much of the time as possible.

Upgrading

These costs for upgrading facilities based on construction grants costs for similar activities was formulated as follows:

a. log (cost) = 5.450 - 0.4073 x log(flow)

b. log (random component of cost) = RN x 0.231

Total cost = $10^{(a+b)}$ x Flow

Replacement of Existing Plant

These costs are the same as for a new plant, except that no factor has been added for ancillary works. In the instances where the plant discharges to a coastal zone the treatment is primary; where discharge is to a non-coastal zone, treatment is secondary.

Chlorination Costs

Chlorination costs were calculated from: A Compilation of Cost Information for Conventional and Advanced Wastewater Treatment Plants and Processes, FWPCA, Cincinnati, 1967.

a. log (cost) = 3.958 + 0.469 x log(flow)

b. log (random component of cost) = RN x 0.030

Total cost = $10^{(a+b)}$ x Flow

Improved Operation or Better Use of Existing Facilities

The cost here was considered basically administrative in nature, with some possibility of minor modification of treatment methods. Chlorination, a minor capital modification, was used as a surrogate for all investment in this category. Therefore, the chlorination costs were used as explained previously.

Connection to Adequate Existing Sewer System

This cost was considered to be no greater than building a new facility with the associated ancillary works. Therefore, these costs were used. The rationale was that if the cost were less, a rationally administered community would choose to build its own plant.

Scheduling Procedures

Values derived from the procedures described above are the basic inputs to the investment scheduling model, which takes the derived current replacement value of facilities together with the derived value of needed facilities (the "backlog"), and calculates their condition under any chosen assumption about amount of investment.

The scheduling procedure utilized to develop this report depended largely on trial and error applications of investment amounts over a series of time frames. (Subsequently, a more sophisticated procedure was developed in which the program was calibrated to increase or decrease amount of investment, according to the degree to which a schedule attained established success boundaries--defined in terms of backlog reduction. Such a searching program proved to be necessary to deal with the time-consuming calculating problems involved in dealing with a range of requirements for fifty-four individual investment units.)

The calculations performed are, in order:

1. Before each set of passes, increase the value of both plant in place and backlog to 1.035 of its previous value--to account for the assumed level of inflation.

2. Establish .029 of the value of capital in place as the amount of the annual recapitalization requirement.

3. Establish .033 of the value of capital in place as the amount of the annual growth requirement.

4. Reduce the amount of the assumed investment by the amount of the recapitalization requirement.

5. Reduce the amount of the assumed investment by the amount of the annual growth requirement: if the amount of the investment remaining after step (4) is equal to or greater than the amount of the annual growth requirement, the value is transferred entirely to the value of capital in place; if the amount of investment remaining after step (4) is less than the amount of the annual growth requirement, the value of investment remaining after step (4) is transferred to capital in place, and the difference between that amount and the total growth requirement is transferred to the backlog.

6. If a positive value remains after the investment amount has been reduced by step (4) and step (5) that amount is transferred as a negative value to the backlog and as a positive value to the amount of capital in place.

The procedure is then repeated, using the newly established values of capital in place and backlog, until the backlog is either eliminated or begins to increase.

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