UNC-WRRI-84-212

FINANCING WATER SUPPLY AND WASTEWATER SERVICES IN NORTH CAROLINA IN THE 1980s

by

David H. Moreau and Dale Whittington

Department of City and Regional Planning
University of North Carolina at Chapel Hill
Chapel Hill, North Carolina 27514

The work upon which this publication is based was supported by funds provided by the Water Resources Research Institute of The University of North Carolina.

Project No. 70011

ACKNOWLEDGMENTS

The authors wish to thank Lee Steppacher and Lisa Marx, Research Assistants, Department of City and Regional Planning, University of North Carolina at Chapel Hill, for their considerable efforts in conducting the survey, compiling the data, and assisting in the preparation of the manuscript for this report. We are particularly indebted to the many city managers and finance directors in the state who took time from their other responsibilities to assemble the information that we requested of them.

The staff of the Water Resources Research Institute was most supportive in administering the financial details of the project and preparing the final report. Special thanks are expressed for the help of James Stewart, Linda Kiger, Eva McClung, Peggy Price, and Barbara Partington for their assistance. Also, we would like to acknowledge the assistance of Bertina Baldwin, Administrative Assistant, Department of City and Regional Planning.

NOTE: Two hundred and fifty copies of this public document were printed at a cost of $573.20, or $2.29 per copy.

ABSTRACT

This study takes a prospective look at the effects of recent changes in costs and intergovernmental grants on the prices for water and sewer services in North Carolina cities in the 1980s. Results of a survey of 41 of the largest cities in the state are used to estimate the present levels of revenues and expenditures. That survey is also used to identify the major components of revenues and expenditures, and trends in those components are estimated from time series data on relevant indicators. Trends for each of those components are then projected to assess probable revenue and price increases over the next several years. Actions that can be taken by local governments to offset cost increases and grant reductions are evaluated in the context of two case studies, one being the provision of a new source of water for the City of Durham, and the second being an evaluation of the capital improvement program for the Orange Water and Sewer Authority (OWASA). A cash flow model for financial planning of water and sewer services is formulated and applied to the evaluation of alternatives for OWASA.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study takes a prospective look at the effects of recent changes in costs and intergovernmental grants on the prices for water and sewer services in North Carolina cities in the 1980s. Results of a survey of 41 of the largest cities in the state are used to estimate the present levels of revenues and expenditures. That survey is also used to identify the major components of revenues and expenditures, and trends in those components are estimated from time series data on relevant indicators. Trends for each of those components are then projected to assess probable revenue and price increases over the next several years. Actions that can be taken by local governments to offset cost increases and grant reductions are evaluated in the context of two case studies, one being the provision of a new source of water for the City of Durham, and the second being an evaluation of the capital improvement program for the Orange Water and Sewer Authority (OWASA). A cash flow model for financial planning of water and sewer services is formulated and applied to the evaluation of alternatives for OWASA.

Findings and Conclusions

Revenue and expenditure data from the survey indicates that in Fiscal Year 1982-83:

(1) customers paid an average of $1.04 per 1000 gallons for water service and $0.87 per 1000 gallons of waste treated;

(2) revenues from customers covered 76 percent of expenditures by local governments, the major portion of the balance being derived from federal and state construction grants for waste treatment plants;

(3) 20 percent of the cities in the survey had revenues less than operating costs;

(4) 49 percent of all expenditures were for operating costs and 51 percent for capital investments and debt service;

(5) state and federal grants accounted for 41 percent of expenses related to capital investments; debt service accounted for 36 percent of capital-related expenses; and the remaining 23 percent was from internally generated revenues; and

(6) 42 percent of operating expenditures was for personnel, another 17 percent was for utilities, and chemicals contributed 6 percent of all operating expenses.

An analysis of trends in intergovernmental grants over the past decade indicates sharp reductions in federal support since 1977. Legislative actions in the past two years by both federal and state governments will lead to further reductions in that support. Other trends that will affect costs of water and service are:

(1) construction costs in the Southeast continue to increase at a rate of approximately eight percent a year;

(2) costs of financing new construction have been subject to large fluctuations over the past five years, and they are substantially higher;

(3) personnel costs continue to increase but at moderate rates of approximately seven percent a year; and

(4) utility costs in North Carolina continue to increase at approximately 10 percent a year.

The net effect of these trends on water and sewer costs in North Carolina cities could be dramatic if they continue to grow and provide the same levels of service. An average city could experience cost increases at a rate of 15 percent a year over the next five years, at approximately 10 percent a year over the next 10 years.

There are several actions that local governments can take to offset these cost increases. First, rate structures can be reformed. At present prices for water and sewer services, there is ample opportunity to make

adjustments that would not be unduly burdensome on consumers. Increasing service charges instead of subsidizing rates through taxes would be consistent with current trends in local government financing in North Carolina as well as in most other states.

Second, there are opportunities to reduce costs through improved planning for capital investments and making greater use of existing facilities through management of demands. Improved sequencing of smaller proejcts as an alternative to single investments in larger projects can lead to significant savings. Deferring capital projects through a combination of conservation and load management techniques can also produce more cost-effective solutions.

Finally, the use of improved planning models can be of significant value to local decision makers in estimating the effects of alternative financing strategies.

Recommendations

These findings and conclusions lead to the following recommendations:

(1) local governments should improve their financial planning with particular emphasis being given to alternative capital investments and their sequencing;

(2) rate structures for water and sewer should be reformed to reflect the full cost of service; in making these reforms, local governments should improve accounting techniques for capital assets, and they should move toward rate structures that lead to more efficient use of resources;

(3) local governments should more effectively exploit management techniques that make greater use of existing facilities, including the use of load management and conservation techniques and regional interconnections and intergovernmental agreements;

(4) state government should adopt, as a requirement for permits and financial assistance, minimum framework plans for local governments that would include projections of need over the next 10 to 15 years, identification of alternatives to meet these needs, and a financial plan to pay for them; and

(5) state government should seek new ways of assisting local government financing.

Chapter I

INTRODUCTION

Purpose

Within the past five to six years several significant changes have occurred that will have important effects on the cost of water and sewer services in the cities of North Carolina. Two of the most important factors are the large increase in the cost of financing capital investments and the sharp reduction in federal grants for water and sewer facilities. In addition, the rate of inflation in the cost of building new facilities persists despite recent declines in the general rate of inflation. Even if cities in North Carolina were not growing, these factors would have some effect by pushing up the cost of replacing obsolete facilities. But, these effects are more pronounced because of the continued growth in population and the related need for expanding the capacities of existing facilities, as well as replacing them as they become obsolete.

In this study, effects of these changes on the financing of local water and sewer services are examined, and techniques for mitigating price increases that may follow are evaluated. Results of a survey of current revenues and expenditures in 41 cities in the state, each serving over 10,000 persons, are presented as a baseline for assessing the effects of those changes. Expenditures are broken out by components, and trends for each components are estimated. The net effect of probably changes in consumer prices is then estimated using an "average" city. Objectives, criteria, and management techniques that will guide planning in the 1980s are re-examined. Finally, selected management options are evaluated in two case studies.

Prices for water and sewer services to urban residents in North Carolina are increasing. That fact is obvious to most consumers who have to pay for these services. Price indexes for cost-of-living indicators, maintained by the North Carolina Office of Budget and Management, showed that over the period 1974 to 1980 these prices rose at an average annual rate of 7.5 percent. During that period water and sewer prices rose at rates comparable to those for food but less than those for medical care, fuel and electricity, and home ownership. Some of the increases in water and sewer rates can be attributed to the general rate of inflation that occurred during that period. However, North Carolina

continues to experience growth in its urban population, and several of the contributing factors affecting costs show persistent increases despite reductions in general inflation. That is particularly true for the costs of replacing older facilities and for expanding their capacities to meet the needs of growth. In addition, there are important policy changes that affect the financing of these facilities, especially the reductions in federal construction grants.

As shown later in this report, the current cost structure of the water and sewer industry in North Carolina indicates that approximately one-half of annual expenditures is for direct operating and maintenance cost, and the other half is for capital-related expenses, including replacement of worn-out or obsolete equipment and facilities, capacity expansions, and debt service. Individual categories of cost that have the largest contributions to direct operating expenses are personnel, electricity, and chemicals. Together, these account for approximately 65 percent of operating costs. Of the capital-related expenditures, grants from federal and state sources account for 41 percent, debt service accounts for another 36 percent, and internally financed capital outlays contribute 23 percent. Significant changes in the cost of any one of these factors will have a proportionate effect on total costs for these services.

Operating Costs. Although increases in operating costs have had and probably will have less dramatic effects on water and sewer consumer prices, they have persistently moved upward over the past decade or more. Over 40 percent of the operating expense is for personnel. A good indicator of how these costs have increased over the past five years is the average wage of city and county employees in North Carolina. That value rose from $187.50 per week in 1978 to $241.85 in 1982. That increase is equivalent to an average annual rate of 6.6 percent (N. C. Employment Security Commission, 1983).

Electricity is another major contributor to operating costs; and as shown in Figure 1, it has been increasing at even higher rates. A readily available index of its cost, the cost of 1000 kw to a residential customer in North Carolina, is maintained by the Public Staff of the North Carolina Utilities Commission (Turner, 1983). For the period January 1, 1973, to January 1, 1983, the cost increased at an average annual rate of 10.8 percent for customers of Duke Power and 12.5 percent for Carolina Power and Light, the two major suppliers of electricity in the state. Over the past five years, from 1978 to 1983, price increases for both companies have averaged 9.7 percent a year.

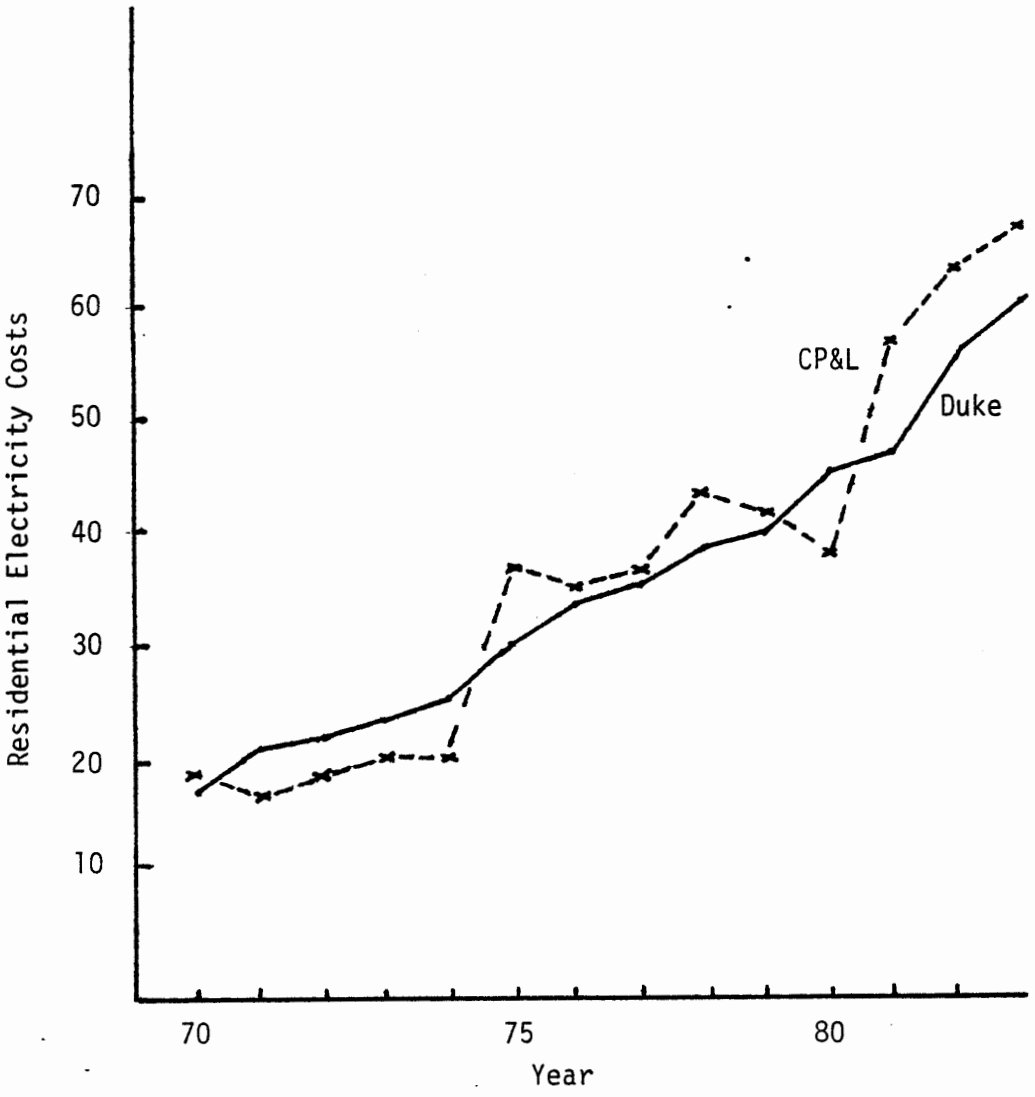


Figure 1. Residential Electricity Costs.

The other easily identifiable category of operating cost is chemicals. Their prices have been erratic over the past several years. For example, the price of caustic soda was relatively constant from 1977 to 1980; then, it increased sharply. The average rate of increase over that period was 13 percent per year. During that same period chlorine prices dropped slightly, rose, and dropped again in 1982 to approximately their 1977 level. Prices for hydrated lime have increased steadily at a rate of about six percent a year (Purchasing, 1982 and prior years).

Capital Costs. More dramatic changes are occurring with capital-related expenses. The cost of actually constructing capital facilities shows no sharp departures from past trends, but it continues to rise at near double-digit rates. The most dramatic effects are in the cost of financing new construction and the shifting of the burden more fully to local government.

One widely recognized indicator of general construction costs is the Engineering News Record (ENR) construction cost index (CCI). Trends in that indicator are shown in Figure 2 where the index for Atlanta is illustrated (ENR, March 24, 1983). These trends have been remarkably consistent. From 1967 to 1983, the average rate of increase was 9.0 percent per year; over the past ten years the rate of increase was 8.1 percent, and for the last five years 8.2 percent. A more specialized and less widely recognized index for waste treatment plants and complete urban sewer systems has been developed and maintained by the U. S. Environmental Protection Agency. This index shows changes that are quite consistent with the ENR index. Over the period 1977 to 1982, EPA's index for a five-million-gallon-per-day (MGD) plant increased at an annual rate of 7.1 percent based on prices prevailing at Roanoke, Virginia. During that same period, the cost of a 50-MGD plant at Atlanta would have increased at the rate of 8.5 percent, and a complete urban sewerage system would have experienced an increase of 8.2 percent per annum if built using prices in Atlanta.

Of course, a big change has occurred in the cost of financing new facilities. Most major expansions of local water supply facilities are financed with borrowed capital, usually in the form of tax-exempt general obligation bonds. Before 1978 these bonds were sold at a stable interest rate, generally below six percent. As shown in Figure 3, discount rates on these bonds, as reflected by the 20-city average rate in the Municipal Bond Buyer's Index, began to rise in 1978; by 1980 the market was showing large fluctuations, but the trend was upward. Prices

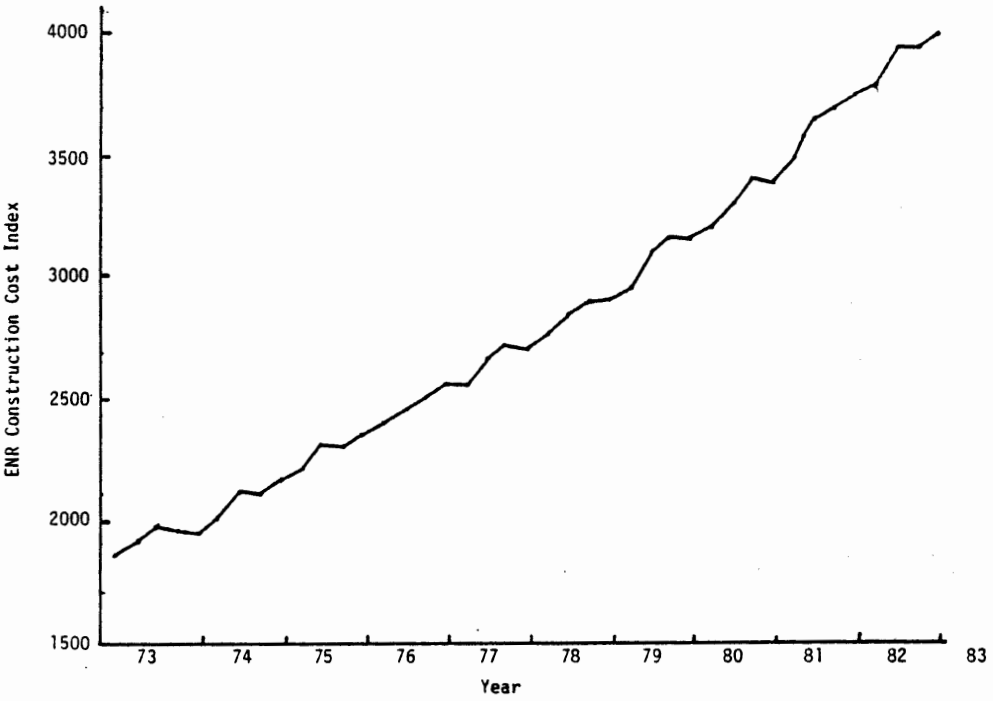


Figure 2. Trends in Construction Cost Index (Atlanta)

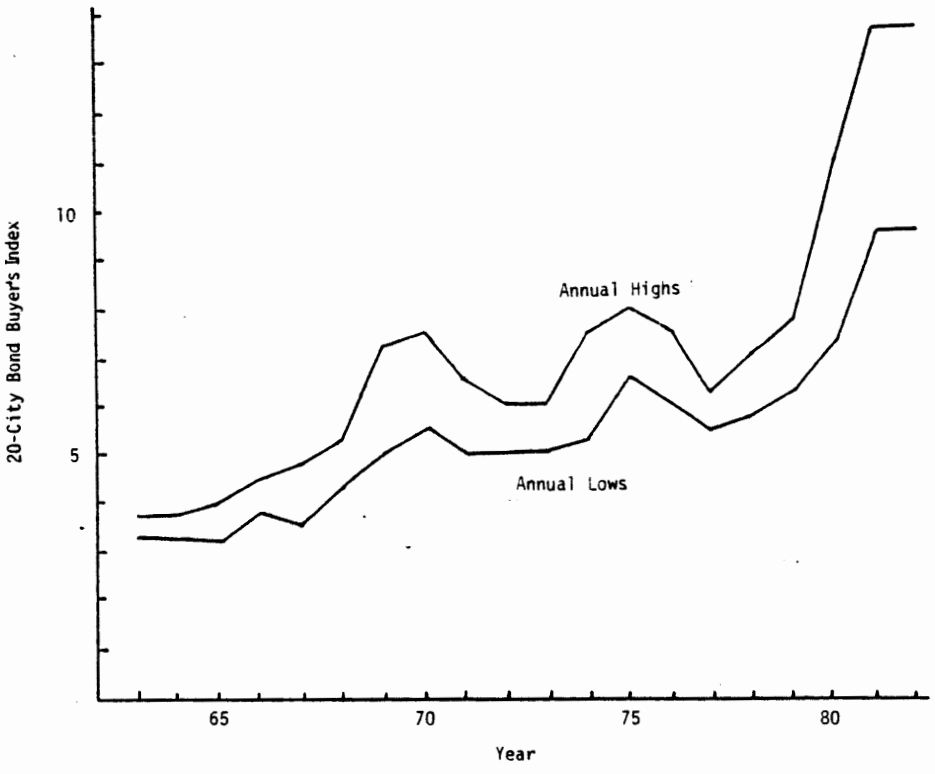


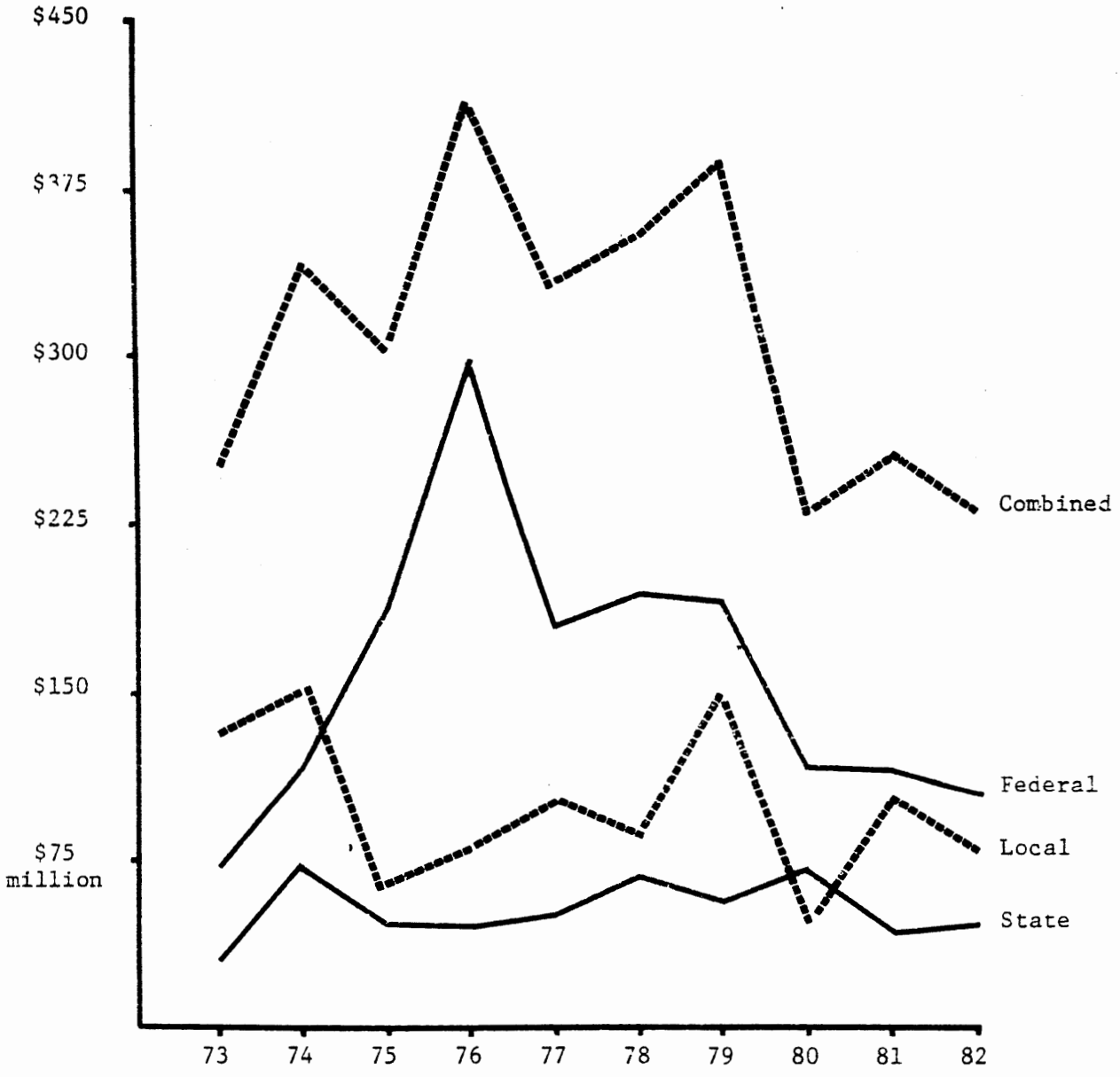
Figure 3. Twenty-City Average Rate in Municipal Bond Buyer's Index

increased sharply in 1981 and reached a peak in January 1982. In January 1978 the MBBI stood at 5.66; in January 1982 the index was 13.4 The significance of that increase is illustrated by the fact that the annual debt service on a 25-year bond at 5.66 percent is $75,700 per million dollars of debt, while the service on that same debt at 13.4 percent is $140,000 per year. That change represents an 85 percent increase. A more modest shift in the discount rate from 5.7 to 10 percent would represent an increase in that annual expense to $110,200, a jump of 46 percent.

Changes in the cost of construction and the cost of financing that construction will have important impacts on local prices, but the largest single factor that will affect these prices is the reduction in federal grants. If cities in North Carolina continue their current rates of capital investments, they will have to substitute their own or borrowed capital for much of what they have received in the past from the U. S. Government. In a companion study to this one, Whittington and Snyder (1983) have tabulated the spending on water supply and waste treatment facilities in North Carolina over the past decade. Expenditures were tabulated by local, state, and federal sources. State contributions are from the Clean Water Bonds, $150 million issued in 1971 and $220 million in 1977. Federal grants are dominated by the construction grants program under Section 201 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500); but there have been other important sources, including grants and loans from the Farmers Home Administration and the Economic Development Administration. A summary of the expenditures from these various sources is given in Figure 4. The data indicate that when the expenditures are adjusted to a common base (1982 dollars), the rate of state contributions has been relatively constant over the period; local expenditures have been erratic, showing no definite trend; and expenditures of federal funds have dropped sharply after a dramatic increase in the early 1970s. The big change reflected in this data is the rise and fall of construction grants for wastewater treatment plants. While it may be assumed that without the federal construction grants there will be some declind in rates of investment in those facilities, the statutes and regulations requiring local communities to comply with effluent limitations and stream standards remain in effect.

Growth. In the absence of growth, cities in North Carolina would be experiencing the direct effects of increasing operating costs for the same level of services delivered. They would also experience the effects of changes in

Figure 4. Federal, State, and Local Expenditures on Wastewater Treatment and Water Supply Facilities from 1973 to 1982 in Millions of 1982 Dollars*[1]



*Local spending includes bond issues for water supply and waste-treatment facilities each year. State spending includes Clean Water Bond commitments per year. Federal spending is the sum of EPA Section 201 grants, FmHA grants and loans, EDA grants and CDBG expenditures. Combined is Federal + State + Local.

capital-related costs as they are required to upgrade treatment facilities to meet more stringent standards for drinking water and waste effluents and as they replace deteriorated facilities. However, the urban areas of North Carolina, like the state as a whole, continue to experience growth. A list of the counties in the state that now have more than 75,000 residents is shown in Table 1, along with their 1970 and 1980 populations. County populations are used as an indicator of growth in order to avoid most of the problems of central city-suburb migration associated with the use of city data alone. That list contains 23 of the state's 100 counties and covers 58.1 percent of the state's 1980 population. Fifteen of the 23 counties in that list are located in the urban Piedmont Crescent, extending roughly from Raleigh to Charlotte.

Table 1. Population of Counties in North Carolina Over 75,000 Persons

County	Population 1970	Population 1980	Annualized Rate of Increase
1. Alamance	96,502	99,319	0.3
2. Buncombe	145,056	160,934	1.0
3. Cabarrus	74,629	85,895	1.4
4. Catawba	90,873	105,208	1.5
5. Cleveland	72,556	83,435	1.4
6. Cumberland	212,042	247,160	1.5
7. Davidson	95,627	113,162	1.7
8. Durham	132,681	152,785	1.4
9. Forsyth	215,118	243,683	1.3
10. Gaston	148,415	162,568	0.9
11. Guilford	288,645	317.154	0.9
12. Iredell	72,197	82,538	1.3
13. Mecklenburg	354,656	404,270	1.3
14. New Hanover	82,996	103,471	2.2
15. Onslow	103,126	112,784	0.9
16. Orange	57,567	77,055	3.0
17. Pitt	73,900	90,146	2.7
18. Randolph	76,358	91,728	1.9
19. Robeson	84,842	101,610	1.8
20. Rockingham	72,402	83,426	1.4
21. Rowan	90,035	99,186	1.0
22. Wake	229,006	301,327	2.8
23. Wayne	85,408	97,054	1.3
SUBTOTAL	2,954,637	3,415,898	1.46
NORTH CAROLINA	5,158,311	5,971,959	1.48

None of the counties over 75,000 experienced population declines over the 1970s. Five of the counties had population growth rates of less than one percent per annum, twelve had rates in the range of 1.0-1.5 percent, four in the range of 1.5-2.0 percent, and four had growth rates over 2.0 percent per year. In the aggregate, these 23 counties grew at an average annual rate of 1.46 percent, and the state as a whole grew at a rate of 1.47 percent per year. With the exception of New Hanover (Wilmington), Orange (Chapel Hill), Pitt (Greenville), and Wake (Raleigh) Counties, these growth rates are not large; but when coupled with increasing per-capita consumption, they present significant needs for the expansion of facilities to accommodate new growth.

Outline of Report

Concerns raised by these indicators of inflation, real changes in costs, and continued growth are addressed in the remainder of this report. To understand current conditions in financing water and sewer services, results of a survey of 41 cities in North Carolina are presented in Chapter II. Revenues and expenditures for those cities are aggregated to give a general picture of current conditions. That data is also used to produce estimates of revenues and expenditures per 1000 gallons of water sold and waste treated. Expenditures are broken down into operating costs and capital expenditures. Operating costs are further disaggregated into personnel, utilities, chemicals, and other categories while capital expenditures are broken down into internally funded capital outlays, debt service, and grant-supported investments. Estimates of the impacts of changes in cost and grant support on consumer prices are also included in Chapter II. Several management options for coping with these impacts are discussed in Chapter III, as well as the objectives and operational criteria that will guide the evaluation and selection of those techniques. Chapter IV contains selected case studies used to evaluate these techniques. The City of Durham and the Orange Water and Sewer Authority are used to evaluate the effects of improved sequencing of projects, deferrals of capital projects through a variety of techniques, and new methods of finance. A linear programming revenue model for evaluating these effects is presented. Chapter V is a summary of findings, conclusions, and recommendations.

Chapter II

CURRENT COSTS AND REVENUES AND PROBABLY IMPACTS OF CHANGES

The Survey

Current revenues and expenditures for water and sewer services in North Carolina were estimated from two primary sources of information. First, a survey was made of all municipalities and water and sewer authorities in the state serving over 10,000 persons. That information was supplemented by a tabulation of federal and state grants and bonded indebtedness on each of the cities from data available through the North Carolina Department of Administration. In the survey, each of the suppliers was asked to respond to a short list of questions to determine the number of residential and non-residential customers and the volumes of water sold and waste treated in each of those categories. They were also asked to attach to their response copies of their financial statements for Fiscal Year 1982 (July 1, 1981 - June 30, 1982) to show the breakdown of their expenditures and revenues. Questionnaires were originally sent to 53 cities and water and sewer authorities identified from the list of water suppliers maintained by the Division of Health Services in the N. C. Department of Human Resources. Through a series of follow-up letters, responses were received from 45 cities (85 percent). Four cities were subsequently dropped from the survey because they were both at the margin of the size category and the data they supplied was of insufficient detail to be useful in the study. The list of the 41 cities remaining in the survey is shown in Table 2.

Table 2. North Carolina Cities Included in Survey

Albemarle	Gastonia	New Bern
Asheboro	Goldsboro	Chapel Hill-Carrboro
Asheville	Graham	Raleigh
Boone	Greensboro	Reidsville
Burlington	Greenville	Rocky Mount
Cary	Henderson	Roxboro
Charlotte	High Point	Salisbury
Clinton	Jacksonville	Sanford
Concord	Kinston	Shelby
Durham	Lenoir	Thomasville
Eden	Lexington	Wilmington
Elizabeth City	Lumberton	Wilson
Fayetteville	Monroe	Winston-Salem
Garner	Morganton	

As anticipated, a number of difficulties were encountered in analyzing survey responses, first in creating categories of expenditures, and then in assigning expenditures for each of the cities to those categories. North Carolina cities do not have standard formats for revenue and expenditure reports for water and sewer enterprises. There is no standardization by functions such as water supply, water distribution, waste treatment, waste collection, customer services, and administration. Neither is there any standardization by categories such as personnel, chemicals, utilities, expendable supplies, or capital investments. Thus, the initial analytical task was to construct a set of cost categories that were common to a large number of cities. In several instances the assignment of expenditures required judgments to match categories of costs reported by individual cities with those adopted for all the cities. Errors could have been introduced through these assignments. In other instances, expenditures and revenues were reported only for combined water and sewer operations. For those cases, costs and revenues were assigned to "joint cost" or "joint revenue" categories.

There are special problems in using the survey data to estimate capital expenses. One problem is that most cities keep separate accounts for large capital improvement projects that involve receipts and expenditures over more than one year. For the most part those accounts are not shown in the general fund budgets and expenditures that were used to respond to the survey.

A second difficulty in estimating capital costs from the survey data is that the items included under "capital outlays" range over both the replacement and capital expansion items, and they include numerous small items such as valves, meters, and motor vehicles as well as large costs for the replacement of water and sewer lines. Thus, considerable care must be employed in using information in that category. Data reported in this study have been reviewed to remove any contributions to large-scale projects such as reservoirs and treatment plants where it was evident that they had been reported under "capital outlays." Remaining entries in that category still contain a wide variety of items.

A major barrier to the use of these reports to estimate capital costs is the omission of depreciation on all fixed assets. Few, if any, of the cities in North Carolina maintain inventories on all of their capital assets, let alone the inclusion of depreciation on those assets as an annual expense. Depreciation was reported as a significant expense item only in a few instances; and where depreciation was reported, it is doubtful that those expenses were based on a full accounting of all fixed assets. Depreciation should be charged on

all internally financed capital assets, on all facilities that must be replaced periodically from internally generated funds, including large portions of distribution and collection systems that are financed by developers and deeded to cities for maintenance and replacement. Thus, only an unknown fraction of actual capital costs are reflected in the capital expenditures reported here.

Aggregate Expenditures and Revenues

Despite these difficulties, considerable insight into the present pattern of revenues and expenditures is available from the data. The results for all 41 cities for combined water and sewer services are illustrated in Figure 5. Survey results indicate an annual operating cost of $126.4 million to deliver 107,450 million gallons of water and treat 93,670 million gallons of waste. Of that operating cost, $52.3 million was clearly assignable to water services, $47.5 million to sewer services, and $26.6 million to joint costs. If the joint operating costs are allocated to water and sewer accounts in direct proportion to the separable costs in those accounts, then the operating cost for water is $66.2 million, and the operating cost for sewer service is $60.2 million. Thus, if data from all 41 cities is used, the unit operating cost of water is $0.62 per 1000 gallons and unit operating cost for sewer service is $0.64 per 1000 gallons. There is a large amount of variation in these costs from city to city, as is shown later.

The operating costs are broken down into components, as shown in Table 3. Personnel costs, including salaries, wages, and fringe benefits, are the largest single contributor, accounting for 42 percent of the total. Other important readily separable costs are those for chemicals and utilities. Chemicals account for 6.3 percent of the total, while utilities accounted for another 17 percent. The remaining 35 percent covers a wide variety of costs for office supplies, maintenance materials, gasoline, and other items.

Estimates of capital and capital-related expenses came to a total of $129 million, including $30.2 million for internally financed capital outlays, $46.2 million in debt service, and $52.7 million in federal and state construction grants. Thus, the total expenditure for the combined water and sewer services in the 41 cities is estimated to be $255 million, with approximately 51 percent for capital and capital-related expenses and 49 percent for operating costs. Unfortunately, with the data compiled in this study, the capital expenditures could not be broken down into water and sewer services. Some breakdown is given later for the federal and state grants.

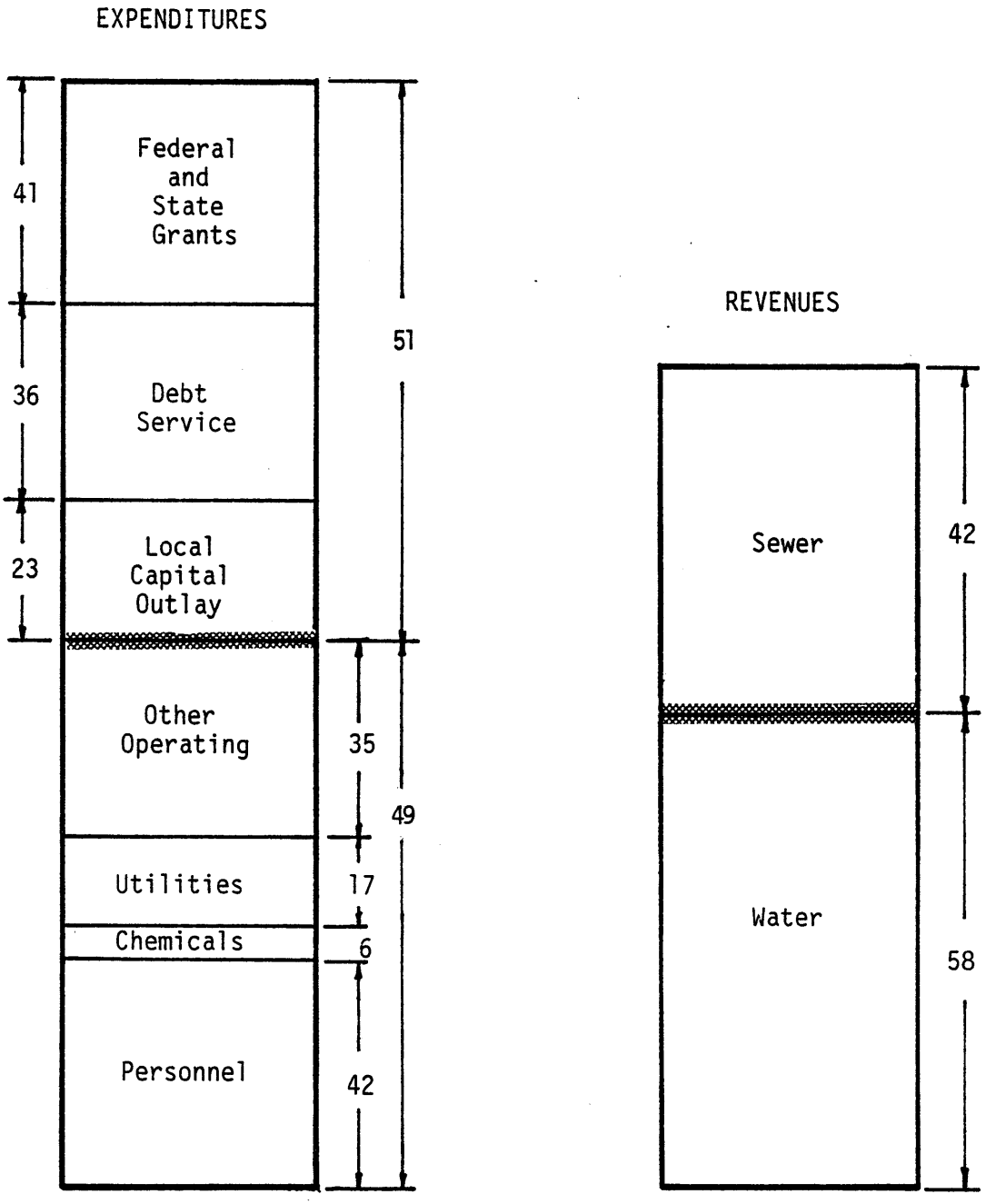


Figure 5. Revenues and Expenditures for Water and Sewer Services in NC Cities - 1982

Table 3. Operating Costs for Water and Sewer Services in 41 Cities in North Carolina, 1982

	Amount ($ millions)	Percent of Total
Personnel	$ 54.09	41.8
Chemicals	8.10	6.3
Utilities	22.02	17.0
Other	45.04	34.8
TOTAL	$129.25	100.0

Reported revenues from these services, excluding grants, totaled $192.6 million. That total is divided among several sources as shown in Table 4. By far the largest source is monthly charges to customers, which contributes 84 percent of the total. Interest on investments accounts for 3.4 percent and fund transfers for another 3.5 percent. Of the $162.2 million in monthly charges, $78.3 million was clearly assignable to water services and $56.9 million clearly assignable to sewer services. The remaining amount was reported simply as monthly charges for water and sewer services. If all the revenues are allocated to water and sewer accounts in direct proportion to the separable amounts stated above, then the revenues from water services would be $111.5 million and the revenues for sewer service would be $81.1 million. With this allocation of revenues, the average customer cost would be $1.04 per 1000 gallons for water and $0.87 per 1000 gallons for sewer service.

Table 4. Revenues from Water and Sewer Services in 41 Cities in North Carolina, 1982

	Amount ($ millions)	Percent of Total
Monthly Charges	$162.20	84.2
Service Initiation Fees	4.33	2.2
Project Assessments	0.92	0.5
Interest Income	6.64	3.4
Fund Transfers	6.80	3.5
Other	11.74	6.1
TOTAL	$192.6	100.0

City-to-City Variations in Operating Costs and Revenues

Water. All the preceding results are based on information aggregated for all of the 41 cities. There are significant variations from one city to another that have important policy implications. Many cities in the survey reported expenditures and revenues in separate water and sewer accounts, and for others it was fairly obvious that joint costs could be allocated without much error. That is especially true where employee benefits are reported as joint costs. However, in some cities the joint costs were large in comparison with readily identifiable separate costs, and cost allocations were considered unwise in those circumstances.

Operating costs and revenues for water services could be separated from sewer service accounts in 28 of the 41 cities. In all those cases, revenues from water services were reported separately from sewer revenues. Ten of those cities reported no joint costs, while some allocation of joint costs was necessary for each of the other 18. These 28 cities accounted for 80.3 percent of the water sold in all 41 cities in the survey.

The average operating cost for water in this group of cities was $0.61 per thousand gallons, and the average operating revenue was $0.84 per thousand gallons. That average operating cost is practically the same as the estimate derived earlier from aggregate data. The average revenue estimate shown here is lower than the estimate derived from aggregate data, but in this case the estimate is based only on revenues from monthly charges. In the aggregate data, monthly charges accounted for 84 percent of the total revenue; and if the estimate derived from the 28 cities is adjusted by that factor, the average revenue would be $1.00 per 1000 gallons. That value is similar to the $1.04 estimated from the aggregate data.

Both the unit operating cost and the unit revenue figures varied considerably from city to city. Unit costs ranged from $0.36 to $0.92 for 27 of the 28 cities that were self-supplied. Cary is a special case because it purchases all its water from Raleigh. Its cost was $1.64. Revenues ranged from $0.38 per thousand gallons to $1.50 for the self-supplied cities. Cary received $1.52 per thousand. The average ratio of operating revenues to operating costs was 1.37, ranging from 0.82 to 2.17.

Frequency curves for unit operating costs and revenue-to-cost ratios are shown in Figure 6. The median operating cost for water was $0.58 per thousand

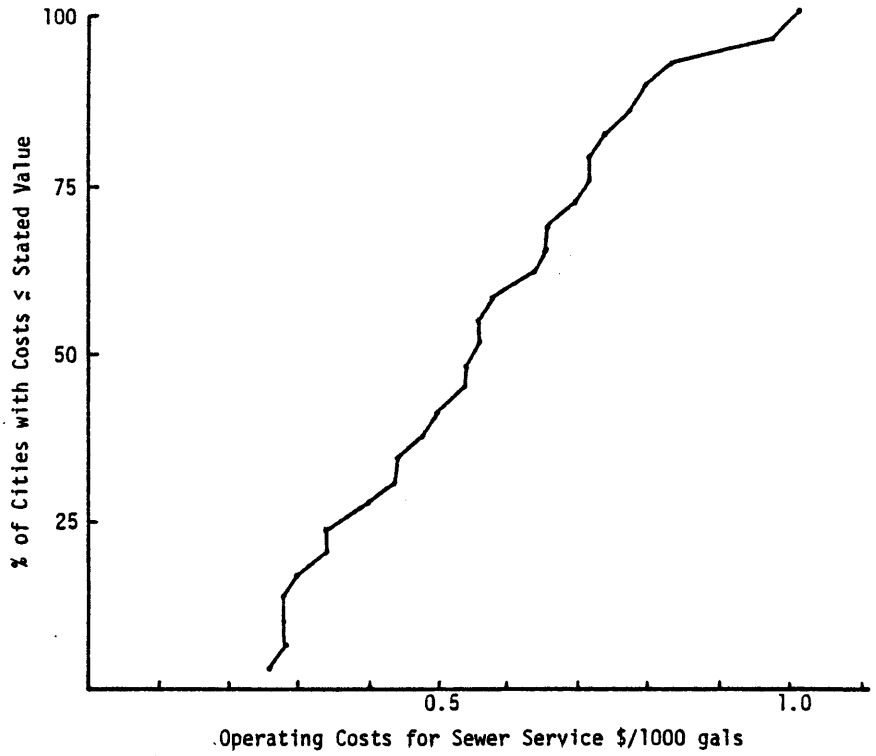


Figure 6. Cumulative Frequency Distribution of Operating Costs for Water Services

while 25 percent of the cities had costs of $0.50 or less and 25 percent had costs of $0.73 or more. Figure 7 indicates the median revenue-to-cost ratio was the same as the average; namely, 1.37 while 25 percent had ratios greater than 1.73.

Sewer. A similar analysis was performed as operating costs and revenues for sewer services. Twenty-seven cities were included in this analysis. They accounted for 78.1 percent of the waste treated in all 41 cities in the survey.

The average unit operating cost in these cities was $0.65 per thousand gallons treated, and the average operating revenue was $0.76, implying an average revenue-to-cost ratio of 1.17. These estimates compare with values of $0.64 per 1000 gallons for operating cost and $0.87 per 1000 gallons for revenues estimated from aggregate data on all 41 cities. If the operating revenue estimate is adjusted to reflect the fact that operating revenues are 84 percent of total revenues, then the average revenue for the 27 cities would be $0.90 per 1000 gallons.

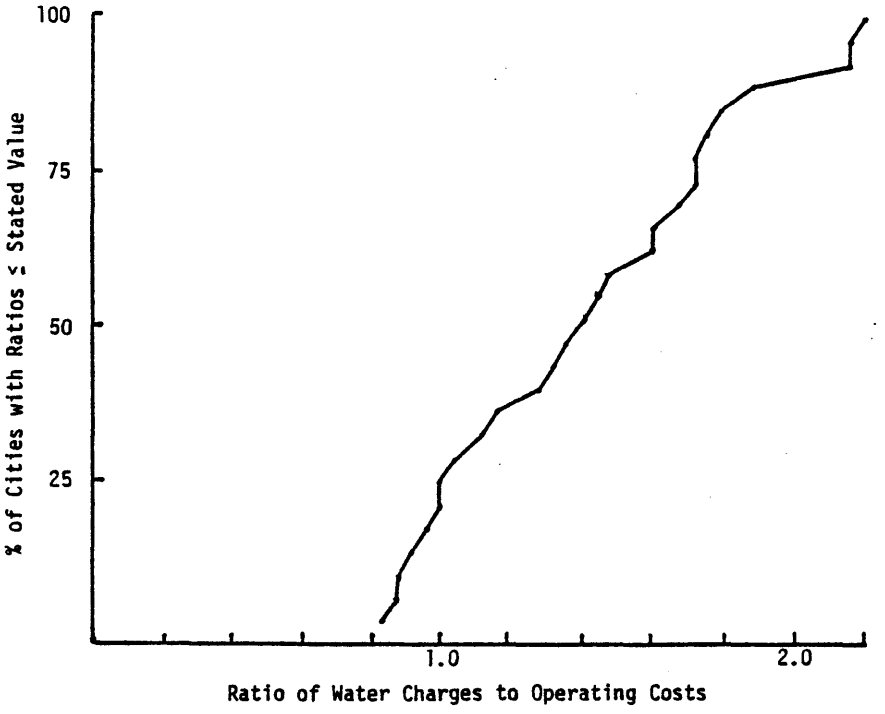


Figure 7. Cumulative Frequency Distribution of Ratio of Water Charges to Operating Costs

Again, the variability from city to city was significant. Unit costs ranged from $0.27 per thousand to $1.01, while unit operating revenues ranged from $0.33 to $1.07 per thousand. Frequency curves for unit costs and revenue-to-cost ratios are shown in Figures 8 and 9. Particularly noteworthy in these figures is the fact that 5 of the 27 cities, or 19 percent, reported operating revenues less than operating costs.

Capital Costs and Grants

Capital outlays reported by cities in the survey totaled $30.3 million for 1981-82, and debt service was reported at $46.2 million. Neither of these costs could be broken down into water and sewer accounts.

Estimates of federal and state capital grants were obtained from the North Carolina Department of Administration for the cities covered by the survey. Data were available for the five-year period 1977-82 and included:

1. Federal grants for water supply from the Economic Development Administration

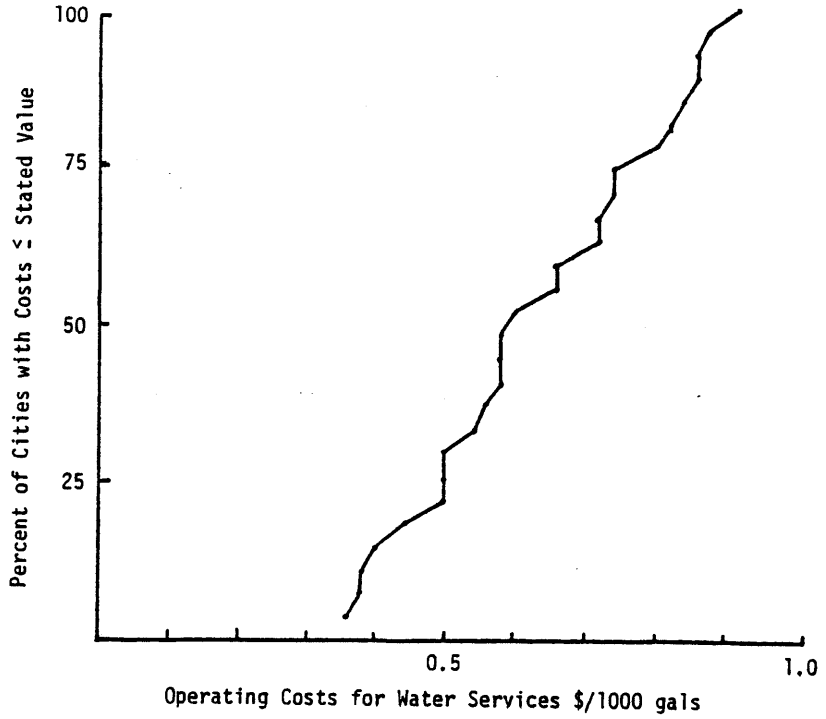


Figure 8. Cumulative Frequency Distribution of Operating Costs for Sewer Services

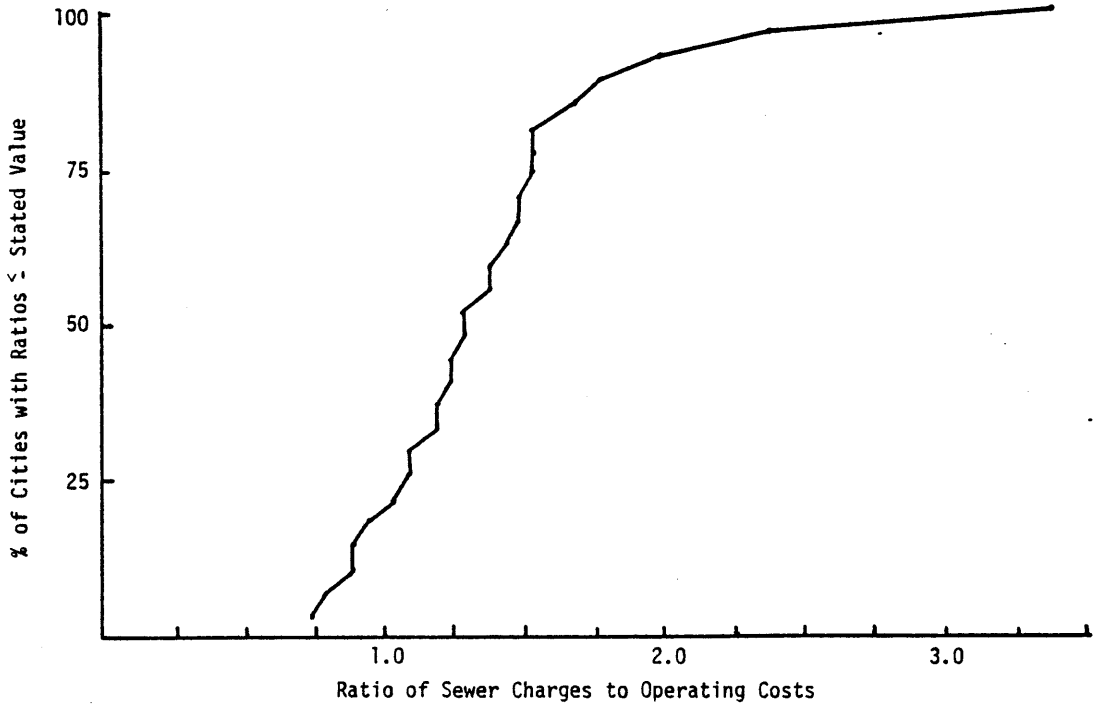


Figure 9. Cumulative Frequency Distribution of Ratio of Sewer Charges to Operating Costs

2. Federal grants for waste treatment facilities from the Environmental Protection Agency under Section 201 of the Federal Water Pollution Control Amendments of 1972

3. State grants for water and sewer facilities provided by Clean Water Bonds

Those data were used to compile the estimates shown in Table 4. Annual expenditures tend to vary considerably from one year to the next depending upon the exact dates at which certain large projects were funded. Instead of using a single year value for estimating these expenditures, a more representative value is the average annual rate over the five-year period 1977-1982. That average range was $52.7 million, of which $7.3 million was for water projects and $45.4 million was for sewer facilities under the federal-state construction grant program. When added to the estimates of internally financed capital outlays and debt service, the annual rate of capital expenditures is $129 million, as reported earlier. This figure could contain some double-counting errors because some of the grant money could have been included in the $30.2 million of capital outlays reported by local governments in their expenditure accounts. However, that amount is probably small and would not alter the general observation that operating costs and capital expenditures are approximately equal.

It is noteworthy that federal and state grants accounted for approximately 40 percent of capital-related expenditures at the local level. The impact of these grants on local rates can be seen by prorating them over water consumption and the volume of waste treated. The $7.3 million grants for water spread over the 107.5 billion gallons of water produced amounts to $0.068 per thousand gallons. Average operating costs for water in those cities was $0.61, and average revenues were $1.04 per thousand gallons. Thus, if the cities had to replace all federal and state grants with local revenues, the average increase in local revenues would be 6.5 percent.

When sewer grants of $45.4 million are averaged over the 93.67 billion gallons of waste treated, the grants amount to $0.48 per thousand gallons. That figure can be compared to the estimated operating cost of $0.64 and the average revenue of $0.87 per thousand gallons. Obviously, state and federal grant programs have a large impact on these services. Replacing those grants with local rate increases would mean a 55 percent increase in sewer charges.

Impacts on Consumer Prices

Not all the impacts from grant reductions will be felt at once by all municipalities. When those impacts are felt will be determined in large part by the schedule for wastewater projects in each city and the pact at which previously authorized grant funds are used. Furthermore, impacts resulting from grant reductions should be assessed in the context of other changes in costs that confront local governments.

One approach to the estimating of all of these changes on prices is to consider effects on an "average city," one that represents an average of the 41 cities reported in the survey. Such a city would be selling 7.18 MGD of water and treating 6.26 MGD of wastewater; its population would most likely fall in the range of 50-70,000. Its current revenues and expenditures would be as follows:

Revenues			
Water			2,768,000
Sewer			1,988,000
Total			4,756,000
Expenditures			
Operations and Maintenance			3,087,000
	Personnel	1,297,000	
	Utilities	525,000	
	Chemicals	194,000	
	Other	1,071,000	
Capital			3,140,000
	Local Outlay	722,000	
	Debt Service	1,130,000	
	Grant-supported	1,288,000	
Total			6,227,000

Future expenditures for operating costs can be projected in a straightforward manner by projecting levels of consumption and unit costs consistent with current trends. Consumption rates were projected to increase at a rate of 1.5 percent, the average annual rate of growth for urban counties in North Carolina over the past decade. Consistent with the trends shown in Chapter I, unit costs for personnel were increased at a rate of seven percent, utility costs at ten percent, and chemicals and other operating costs at six percent. Projections for future capital expenditures were more difficult and are dependent upon the cost of financing and federal and state grant programs. It

was assumed that rates of capital investment per unit of output will remain constant in real dollars, and the inflation rate for capital was set at eight percent per year. Investments currently financed by borrowed capital were assumed to continue to be financed in that manner, and the debt service was rolled over with new investments financed at interest rates of six, eight and ten percent. Effects of reductions in federal and state grants were accounted for by shifting a stated percentage of those to the local level and financing them at the stated rates.

When expenditures are projected in that manner with no reduction in grant support and new investments are financed at six percent interest, expenditures per unit of output are increased at an annual rate of 7.2 percent. That rate is the same as the historical rate of increase for water and sewer services over the period 1972-80, as reflected in cost-of-living indicators maintained by the North Carolina Office of Budget and Management. However, as the cost of financing is increased and the percentage of investments financed intergovernmental transfers is reduced, local expenditures and revenue requirements are accelerated. Effects of these two factors on local revenue requirements per unit of output are reflected in the following table:

Percent of Current Grant-Supported Investments Still Eligible for Grants	Percent Annual Increase in Revenue Requirements per Unit of Output	
	8% Interest	10% Interest
100	8.5	8.9
75	9.2	9.6
50	9.7	10.3
25	10.3	10.9
0	10.9	11.6

Thus, it appears that even under the most favorable outlooks, local revenues would have to be increased at average rates of over nine percent a year for the next five years. Under less favorable forecasts, revenue increases might have to approach eleven percent a year.

Chapter III

PLANNING FOR THE 1980s

The current patterns of revenues and expenditures for water supply and sewer services described in Chapter II and the trends in demands, costs, and intergovernmental revenues shown in Chapter I indicate that changes are necessary in the way cities in North Carolina (and elsewhere) plan for the 1980s. Costs of construction continue to increase, costs of financing has increased sharply, and levels of federal and state funding have decreased dramatically. The result is that local governments will have to either raise prices or taxes to pay for these services if they are to be maintained and expanded. Because capital projects are the most important contributor to cost increases, greater attention must be given to capital budgeting processes, including the scheduling of projects and the development of financing strategies. Some increases in local revenues cannot be avoided, but their effects can be mitigated through the use of a variety of management and financing techniques that have been given inadequate consideration in the past. Two types of techniques are available: those that can be used to defer the construction projects through management of demand and those that defer payments for capital expenditures.

Although evaluation of the merits of any of the management and financing strategies must be made on a case-by-case basis in the context of local facts and opportunities, there are some generally applicable objectives, operational criteria, and management approaches that should be considered in the process. These objectives include the well-established goals of urban water management, as well as the renewed emphasis on capital budgeting that is highlighted here. These objectives and related operational criteria relevant to capital budgeting are discussed in this chapter. Also discussed are a range of management techniques that may be of value in particular circumstances. Evaluations of these approaches for selected cases are presented in the next chapter.

Objectives

Although there is not a simple, single-value measure for discriminating among the options, the basic social objectives in planning for urban water supply and wastewater management are well established. The most important of

these is to provide these services in a manner that protects public health at reasonable cost. That objective has been consistently stated by the American Water Works Association and the U. S. Environmental Protection Agency's Advisory Committee on Drinking Water in providing guidance to the industry in the selection of public water supplies. North Carolina's earliest efforts to control pollution were also based on the protection of public health, and that objective remains a very real one today. In addition to the objectives of protecting public health at reasonable cost, the National Environmental Policy Act of 1969 (NEPA), the State Environmental Policy Act of 1970 (SEPA), and the Federal Water Pollution Control Act Amendments of 1972 (FWPCA) made explicit the objective of minimizing adverse effects on the environment both in the development of new facilities and in the disposal of wastewater. NEPA and SEPA require comprehensive evaluations of proposed projects with respect to several objectives, especially the impacts on the natural environment. The FWPCA and its revisions make specific reference to the protection of stream quality to a level that makes them fishable and swimmable.

Another basic objective that is served by urban water and sewer systems, although not embodied in formal legislative actions, is the provision of an urban infrastructure necessary to support the expansion of economic opportunities. While provision of these services may not be sufficient to attract new industrial employment, the absence of adequate water and sewer services puts a municipality at a disadvantage in industrial recruitment.

Although these basic objectives are not likely to change during the 1980s, greater attention will likely be given to cost, as the burden of paying for these services increases. North Carolinians, like other Americans, have come to expect high-quality drinking water, and the support for environmental protection remains strong. Despite higher prices for these services, commitments to those objectives are not likely to be seriously eroded. However, water managers may be expected to make greater use of cost-saving measures to increase the efficiency with which those services are delivered. While this study focuses on techniques for improving efficiencies, and the equity with which those costs are borne by present and future customers, it should be remembered that all of these techniques must be evaluated with respect to the full range of objectives relevant to urban water resource decisions.

Criteria

There are several criteria that are related to these objectives, criteria that make the general objectives operational. First, there are those criteria that are relevant to the evaluation of alternatives. While cities in this state have never adopted cost minimization as a pure objective in deciding among alternatives, it is clear that they would prefer one alternative to others that cost more, if all other consequences are equal. Thus, one pertinent criterion is the minimum cost at which an alternative can be realized. Within that framework the relevant measure of cost is the present value of all future costs. Water resource investments are characterized by the periodic expenditure of capital funds and a time stream of annual operating, maintenance, and replacement costs. Any two alternatives are likely to have different time streams of those costs, and the appropriate way to compare those two time streams is to reduce each of them to their discounted present value of costs. Calculation of those present values requires that both the time horizon and the discount rate be specified. The choice of a time horizon is often related to the anticipated economic lives of major projects in the capital investment program or it may be limited by the level of uncertainty associated with projections of future demands and beneficial uses of those projects.

The choice of an appropriate discount rate is the subject of much discussion in the literature on public investment theory. If projects are to be undertaken by a tax-free public body and they are to be evaluated in nominal terms (without adjustments for inflation in costs), then the rate to be used should include the true time rate of social preference for expenditures, a factor for inflationary expectations, and a factor that reflects risks associated with the investment. Although there is no method for determining the exact value that should be assigned to the discount rate, a reasonable approximation to its value and one that is widely used is the market rate for tax-free municipal bonds.

Another criterion that should be used in evaluating alternatives is the issue of equity between present and future consumers of these services. Moak (1981) discusses the equity issue in differentiating between "pay-as-you-acquire" financing mechanisms and "pay-as-you-use" mechanisms. Pay-as-you-acquire mechanisms reduce levels of uncertainty in financing, and they preserve future flexibility, but they place a heavy burden on present customers to pay the cost of future users. Pay-as-you-use mechanisms, while incurring

more risk to investors, have the advantage of spreading the cost more equitably between present and future users. One measure of that equity is the cost per person, measured in real dollars, that is paid in each year of the life of the project.

There are two other criteria affecting the formulation of rate structures that are widely supported within the industry. The first is the proposition that total revenues for water and sewer services should be balanced with total costs. In other words, transfers should not be made from other sources of revenue to offset the cost of water and sewer services. A related principle is that those who benefit from the services should pay in direct proportion to the cost of delivering the services; that is, water and sewer rates should not be used as a means of subsidizing one group at the expense of another. The argument goes that if water and sewer costs are subsidized from other sources of revenue or if artificially low prices are charged to one group at the expense of another, the economically efficient allocation of resources will be distorted. Water and sewer rates should not be used as a means of redistributing income. Both of these criteria, while stating sound economic and fiscal policies, must be recognized as politically conservative viewpoints.

In some instances there may be good reasons for not strictly adhering to these criteria. For over 25 years the U. S. Government, through its various grant and loan programs, has chosen to subsidize the construction of water and wastewater facilities as incentives to stimulate the development of systems in local communities that otherwise would not or could not undertake the projects. Critics of these programs have argued that they have lead to economically inefficient investments by biasing localities toward capital-intensive projects. They have also argued that federal construction grants have decreased rates of local investments because local governments will not act until the federal grants are made available. The fact that municipalities have lagged behind industry in bringing their pollution sources into compliance with applicable standards is cited as evidence to support that position (Freeman, 1979). However, a particularly difficult problem to solve within the constraints of these criteria is the provision of services to that segment of the population that is both the least able to pay and that, by its use of the service, would provide the greatest benefit to the community as a whole. The poor are by definition the least able to pay, and they are often the group

where public health protection would yield the greatest benefit to the community as a whole. In these circumstances some form of transfer payments may be desirable to protect both the susceptible group and the community.

A final set of criteria relevant to alternative financing mechanisms includes legal constraints on arbitrage and the political acceptability of unstable price changes. There is a large body of regulations by the Internal Revenue Service that prohibit tax-free enterprises from borrowing at tax-free rates and reinvesting the proceeds at higher commercial rates. While that practice can be exploited to some extent, there are limits to its use. There are also limits to which the public will accept sharp price increases or large fluctuations in prices for water and sewer services. Those limits are not usually prescribed by regulation, but prudence dictates that care should be taken to avoid development of programs and financial strategies that lead to large, sudden shifts in prices.

Alternatives

Given these objectives and criteria, the problem becomes one of finding what action or combination of actions best satisfies the objectives. It is convenient to divide the alternatives into two categories: those actions that can be taken at the initiative of state government to assist local governments and those that can be initiated by local governments themselves. In a companion report to this one, Whittington and Snyder (1983) have examined a number of possible actions by state government. This report focuses on those that can be initiated by local governments.

There are at least three interrelated sets of actions that local governments can initiate. First, there are a number of steps that may be taken to defer major capital investments; second, there is a need to reform rate structures to reflect the full costs of providing services; and third, there are a variety of new financial instruments that should be considered. All these possibilities point to the need for greater attention to load management techniques and improved procedures for capital budgeting and financing strategies.

Deferring Capital Investments. Included in the first set of actions are:

1. reductions in demand through conservation, including the use of pricing mechanisms as incentives;

2. improved efficiencies in the operation and maintenance of existing facilities;

3. acceptance of a higher level of risk on the part of the consuming public;

4 management techniques to reduce peak loads;

5. improved sequencing of capital projects to reduce excess capacity in large-scale projects.

The importance of these options can be seen by the following simple calculation. Consider a one-million-dollar investment. If that expenditure is made now, its present value of cost is exactly one million dollars. If that investment is postponed for one year and the discount rate is four percent after adjusting for inflation, the present value of that expenditure is $961,538, a savings of 3.8 percent in cost. If the investment is postponed two years, there is a 7.5 percent savings; for three years, an 11.1 percent savings. If the investment is delayed for five years, the present value of that investment is reduced to $821,927, a savings of 17.8 percent. These savings will be realized despite inflationary increases for deferred construction costs so long as the inflation rate for construction is the same as the general rate of inflation.

The fact that a broad range of new, non-structural management techniques are coming of age is well illustrated by recent implementation of the water supply management plan for the Washington, DC, metropolitan area (Civil Engineering, 1983). Implementation of that plan ended a 30-year search for the solution to a major water supply problem. The plan was developed with the use of state-of-the-art analytical techniques and through cooperative arrangements among the three major suppliers in the region, the Washington Suburban Sanitary District, the Fairfax County Water Authority, and the Washington Aqueduct Division of the U. S. Army Corps of Engineers. The most important feature of that plan is that it requires only one new, relatively small reservoir to serve the needs of the area over the next 20 years. The plan relies on: (1) improved operating rules for the several existing reservoirs in the system; (2) a new river forecasting system; (3) a model for predicting demand and the use of those results to operate the system; (4) the use of distribution systems analysis to improve the delivery of water to points of demand throughout the region; and (5) the use of risk analysis in managing the system under

drought conditions. This plan is projected to save the region between $200 million and $1 billion when compared with other alternatives, some of which called for the construction of up to 16 new reservoirs.

Opportunities for achieving improvements in system operation are more abundant in regional situations with complex supply systems and multiple service areas such as that in the Washington metropolitan area. Similar opportunities are available in some regions of North Carolina, particularly in the Research Triangle and Piedmont Triad regions. Some of those opportunities have already been identified (Moreau, et al., 1973; Higgins and Okun, 1972), but they have been given less weight in planning processes than they should have. Even in relatively simple situations involving single service areas and one single-purpose reservoir, there are opportunities to mitigate the effects of large price increases that may result from "doing business as usual."

Load management is a technique that is maturing in the electric power industry but is rarely discussed in water and sewer utilities. The objective of load management is to reduce peak demands, thereby reducing the rates of expansion of facilities necessary for supplying those peak demands. A relatively simple application of this approach would be the institution of odd-even lawn sprinkling to reduce peak demands on water treatment plants and distribution systems when those facilities are approaching their capacities. Most of the analogies to the electric power industry are better made with water systems than with sewer systems, but even in waste management there are opportunities to reduce peaks to extend the useful life of existing facilities. Industrial customers could be induced to alter their timing of discharges through appropriate incentives. Despite the regulations for infiltration-inflow studies that accompanied the federal grants, many urban sewer systems are not well managed. Infiltration from stormwater remains a major contributor to peak loads of pumping stations and waste treatment plants. In fact, very little attention is given to monitoring, analysis, and real-time management of flows in these systems.

Land management may be viewed as a form of conservation with the special purpose of reducing peak loads. Other conservation measures may also pay dividends by leading to the deferral of capital expenditures. These options have been discussed nationally and in North Carolina (Stewart, 1975), but

few have been put into practice. The Orange Water and Sewer Authority serving Chapel Hill and Carrboro has been offering reduced-flow shower heads and plastic dams to its customers free of charge. Their action was promoted by a series of recurring shortages while their decision to expand the supply has been delayed by court action.

Yet, another way to defer capital expenditures is to improve the sequencing of capital projects by using a sequence of smaller-scale projects to defer large projects, thereby improving the balance between supply and demand and reducing excess capacity. The problem of finding optimal timing and scales for expanding capacity has been well developed in the literature, and general rules for practice have been derived. However, much of that literature and practice are not appropriate to the present economic climate. When the cost of capital increases, the benefits of economies-of-scale are diminished if the larger projects result in excess capacity. Traditional design periods for water supply and waste management facilities have been upwards of 20 years. With those design periods, a city needs to make an investment now to supply needs for extended periods into the future, even though present needs may be substantially less than those for which facilities are designed. Traditional selection criteria tend to favor projects that can meet long-term needs and reject smaller projects as being infeasible. In the present economic climate, where smaller-scale opportunities are available, a sequence of small projects can lead to a less-costly time stream of investments than a single, large investment.

Rate Reform. One incentive that could lead to reduced demands, and thus, to the deferral of capital expenditures, is a change in the price structure. In an era of increasing costs for expanding water supplies and waste disposal systems, the promotional effects of declining block rate structures have little justification; yet, many cities in North Carolina still use this structure in setting their water and sewer rates. Although the effects of changing these structures may be small relative to total water demands, some changes, such as seasonal surcharges, could have significant effects on peak demands. There is a need for greater attention to this possibility as well as to other structures that may be appropriate to the present economic climate. Guidelines for industrial surcharges have been developed for North Carolina cities (WRRI, 1972), and the problem of water and wastewater pricing has been explored (Stewart, 1978).

Of course, there is another obvious reason that water and sewer rates should be reformed. Data presented in Chapter II indicate clearly that revenues

are insufficient to cover costs; in some cases the revenues do not even cover operating costs. Rates should be revised to recover the full cost of service, including adequate allowances for depreciation and replacement of all capital assets that are to be financed with internally generated funds.

As noted earlier, there are valid reasons for using state and federal sources of revenue to subsidize local governments. Under some circumstances the use of local general tax revenues may also be justified, especially for the extension of service into low-income neighborhoods. However, the use of intergovernmental transfers of revenues and the use of property tax revenues are both contrary to existing trends in North Carolina and the nation as a whole. The decline of federal support has been documented in Chapter I; state support for local facilities will also decline as a result of action by the General Assembly in 1983 when it rescinded the third issue of the Clean Water Bonds. Property taxes are also declining as a percentage of local revenues. Spain and Wooldrige (1981, p. 115) estimated that in 1972, property taxes contributed 59.6 percent of local revenues in North Carolina. That percentage dropped to 52.7 percent in 1977 and to 50.2 percent in 1979. At the national level, that percentage dropped from 63.5 in 1972, to 60.0 in 1977, to 53.5 in 1979. These trends are offset by increased reliance on service charges such as those for water and sewer services. In North Carolina in 1972, service charges accounted for 24.0 percent of local revenues, increasing to 27.3 percent in 1977 and 28.7 percent in 1979. Similar shifts have occurred in almost all other states. Thus, revisions in water and sewer rate structures to recover all costs would be consistent with national trends in local finance.

Alternative Methods of Borrowing. Another trend in local finance is the use of a variety of new financial instruments that are collectively referred to as "creative financing." These instruments include new or revived methods for both short-term and long-term borrowing that have entered the financial markets within the past three years. Comprehensive reviews of these methods are available in publications of the Municipal Finance Officers Association and the International City Management Association, including those by Moak (1982), Matzer (1983), and Peterson and Hough (1983). Williams (1982) has a good review of these methods as they have been used for the financing of water utilities.

Creative techniques for long-term bond financing include the following: (1) tender option bonds, (2) insured bonds, (3) original issue discount bonds, (4) zero-coupon bonds, (5) stepped-coupon bonds, and (6) floating-coupon bonds.

Creative techniques for long-term bond financing include the following: (1) tender option bonds, (2) insured bonds, (3) original issue discount bonds, (4) zero-coupon bonds, (5) stepped-coupon bonds, and (6) floating-coupon bonds.

Conventional financing typically uses serial bonds that are sold at par value and are structured to have constant annual debt service: interest rates are the same for all the bonds regardless of their date of maturity. Tender option bonds are similar to conventional bonds, but they include an option for the investor to redeem the bonds at par value at specified intervals of time; say, every three to five years. That option protects the investor from the loss of reinvestment opportunities if interest rates rise during the period the bond is held. Bond insurance is available to municipalities as an option for increasing their bond rating, thereby qualifying them for lower interest rates in the market. To benefit from this option, the cost of insurance must be less than the savings that would result if the bonds are sold at lower interest rates. Original issue discount bonds are also similar to conventional bonds except for the fact that they are sold originally at below par value. Thus, returns to the investor come in the form of capital gains as well as in annual interest payments. An extreme version of this type of bond is the zero coupon bond, which carried no interest payment; all returns for this type of bond are in the form of capital gains, the difference between the purchase price and par value. Stepped coupon bonds are also serial bonds, but unlike conventional bonds that carry constant interest rates throughout the range of maturing, these bonds have specified interest rates that increase from the first year of maturity to the last. All bonds outstanding in a given year carry the same interest rate for that year. Floating rate bonds do not carry fixed interest rates; the rates are allowed to fluctuate according to market conditions according to a specified index, with the possibility that maximum and minimum limits on rates may be fixed.

These new instruments are designed primarily to enhance the marketability of bonds by transferring investment risks from investors to the issuer. Conventional bonds with fixed rates that lock investors into long-term commitments are now selling at higher rates to reflect investors' risks. The variety of new techniques are also designed to attract investors from different segments of the market. They may offer opportunities for lower costs than conventional bonds, especially in the early years of maturity, but these lower costs come at the expense of increased risks.

For the most part, these creative instruments work against the goal of improving equity between present and future customers of water and sewer services. Least-cost design principles lead to the situation described earlier; namely, that utilities invest now to provide for growth over extended periods into the future. Present customers must then bear the cost of providing excess capacity in the early years because the structure of conventional bonds does not permit costs to be shifted completely to future customers. For example, consider a city of 50,000 persons growing at a rate of two percent a year, where inflation is five percent a year. If that city issues one million dollars of bonds maturing over 25 years with a ten percent interest rate, then the annual debt service will be $110,168 in nominal terms. In real terms, the debt service will decrease from $104,922 in the first year to $32,533 in the last year. Real per capita payments will decrease from $2.06 to $0.40 over that time period.

That inequity is aggravated by most of the new techniques because they are designed to reduce risk by paying off a larger proportion of the debt in the early years. Of course, that feature is attractive to those who are primarily concerned with the fiscal soundness of local governments. However, it is possible to structure some of these techniques or combinations of techniques to get a better match between debt service and anticipated inflation and growth rates. Zero coupon bonds can be easily structured in that manner. For example, consider an issue with a present value of one million dollars where the yields range from 7.4 percent in the first year to 17 percent in the twenty-fifth year, increasing by 0.4 points per year. If the annual debt service on these bonds is allowed to increase by four percent a year, nominal payments will be $96,376 in the first year and increase to $247,041 in the last year. If the same conditions apply as in the earlier example, the real per capita payment will decrease from $1.80 in the first year to $0.89 in the last. This result is clearly more equitable than with conventional bonds, but in this example the true interest cost is 12.2 percent, higher than the 10.0 percent for the conventional bonds with which it is being compared. It is possible to structure the zero coupon bonds so that real per capita payments will be constant over the 25 years at a level of $1.44. To achieve that annual debt, service would have to grow at a rate of 7.1 percent, true interest cost would be 12.6 percent, and the payment in the final year would be $400,097. Thus, equity can be achieved, but it must be purchased at a price. Also, the ballooning of debt service in this case may exceed legal or advisable limits.

Chapter IV

ANALYSIS OF ILLUSTRATIVE CASES

There is no general analysis that can be used to estimate the benefits of using any of the alternatives described in Chapter III. Those benefits must be estimated in the context of specific local situations on a case-by-case basis. The contextual factors that must be considered include: (1) the specific water supply and wastewater disposal needs of the city or region; (2) the kinds, amounts, and timing of growth in demand for these services; (3) the particular opportunities that exist for expanding the use of existing facilities; (4) the particular set of opportunities available to the region for expanding its water supply and waste management facilities; (5) the current financial position of the region, including its current levels of debt, its financial reserves, its current rate structure, and the availability of grants; and (6) the general political and economic climate of the region.

In the absence of any general analysis, evaluations of specific cases can provide useful insights into the potential benefits that may be realized if those alternatives are utilized. In this chapter several of those possibilities are evaluated in the context of water supply and wastewater management in the Durham-Chapel Hill area of North Carolina. The first of these cases focuses on the water supply expansion decision by the City of Durham. The second case examines the capital-improvement program developed by the Orange Water and Sewer Authority, the supplier of services to the Chapel Hill-Carrboro area. These cases include: (1) an evaluation of the effect of eliminating State and Federal grants; (2) the savings that will accrue from the deferral of capital expenditures through a combination of load management and conservation techniques; and (3) an evaluation of the use of creative financing as an alternative to conventional annuity bonds.

At least two approaches can be used to evaluate the consequences of using any of these techniques. One approach is to perform a conventional economic and financial analysis on a discrete set of alternatives, estimating the costs of each alternative and estimating the impacts of each on cash flow requirements. That is the approach taken here for the evaluation of regional integration of facilities for Chapel Hill and Durham and for the evaluation of improved sequencing of capital projects in Durham. A second approach is the

use of a formal optimization model. Such a model has been developed here for the evaluation of the capital-improvement program developed by OWASA.

Introduction

The conventional approach to water supply planning often divorces the issues of project selection and timing of investments from financing and water pricing concerns. In the standard planning process, water use is forecast as a function of population and economic growth, usually 25-50 years into the future. The total water available from the existing system is then compared with this forecast, and a variety of projects are examined which would bridge this gap between supply and demand. One of the project alternatives is then selected based on a variety of objectives, such as to minimize costs, create recreational opportunities, protect environmental quality, and increase equity. The municipality then determines whether it has the financial capacity to pay for the proposed project, given grant sources, water revenues, and present indebtedness. If financing is possible, construction may begin. This approach ignores the costs incurred by idle, excess capacity over the planning horizon and the additional risk incurred by the possibility that the forecast demand may not materialize. It also ignores the implications of financing arrangements and prices to be paid by consumers as determined by the rate-setting procedure. The profile of future prices may affect the quantity of water demanded and, thus, the scale and timing of the projects to be built.

The objective of this case study is to illustrate the relationship between water capacity expansion and financing decisions using a specific example; namely, the water supply capacity decision of the City of Durham.

The choice of Durham as a case was made in large part because of the detailed evaluations of a large number of alternatives, available in the environmental assessment submitted to the U. S. Army Corps of Engineers in support of Durham's application for a dredge and fill permit under Section 404 of the Clean Water Act (PL 92-500). This permit is required for the construction of the reservoir on Little River at Orange Factory. The analysis developed in this case study is not intended as a comprehensive evaluation of Durham's decision to proceed with the project on Little River. It is intended to demonstrate the economic and financial advantages of scheduling a sequence of smaller projects as an alternative to a single large project in which

there is idle capacity in the early years of the life of the project. This analysis does not address water quality issues nor the problem of uncertainty about the future availability of prime reservoir sites when projects are deferred. There is little doubt that the Little River project would be necessary as a future water supply for Durham. The analysis presented here simply asks the question: What savings could be achieved by deferring that project for a period of time while a series of smaller projects are used to meet demands in the interim?

This question is addressed by examining the projected needs for water in Durham and comparing those needs with the current supply. Then, the various options for expanding the supply are examined; and finally, the implications of three financing arrangements are assessed for two of the options.

Water Supply and Demand Situation in Durham

Durham is located in the central Piedmont region of North Carolina and is part of the Triangle area, which also includes Raleigh, Chapel Hill, and Research Triangle Park. Each of these three cities operates its own water supply system. Chapel Hill obtains water from University Lake; Raleigh uses water from Beaverdam Lake, the Neuse River, and Butner Lake in emergency situations (Figure 10). In addition, the B. Everett Jordan Lake and Falls of the Neuse Reservoir have recently been constructed by the U. S. Army Corps of Engineers. Jordan Lake is a multipurpose reservoir located twenty-five miles southwest of Durham and has not yet been approved by the North Carolina Department of Natural Resources and Community Development, Division of Environmental Management, for use as a public water supply. The Falls of the Neuse Reservoir to the east of Durham has just recently reached its conservation pool level and will supply water to Raleigh.

The primary source of water for Durham is Lake Michie on the Flat River. It has a storage volume of 3.5 billion gallons and an estimated safe yield of 21 million gallons per day. Two water treatment plants are currently in use: (1) Williams plant, with a treatment capacity of 22 MGD, and (2) Wade Brown plant, with a 12 MGD capacity (potentially expandable to 96 MGD). Treated water is distributed both inside and outside the Durham city limits. Additional water lines have been extended into the surrounding area of Durham County, and the Durham water supply also serves a portion of Research Triangle Park within Durham County, as well as the Raleigh-Durham Airport.

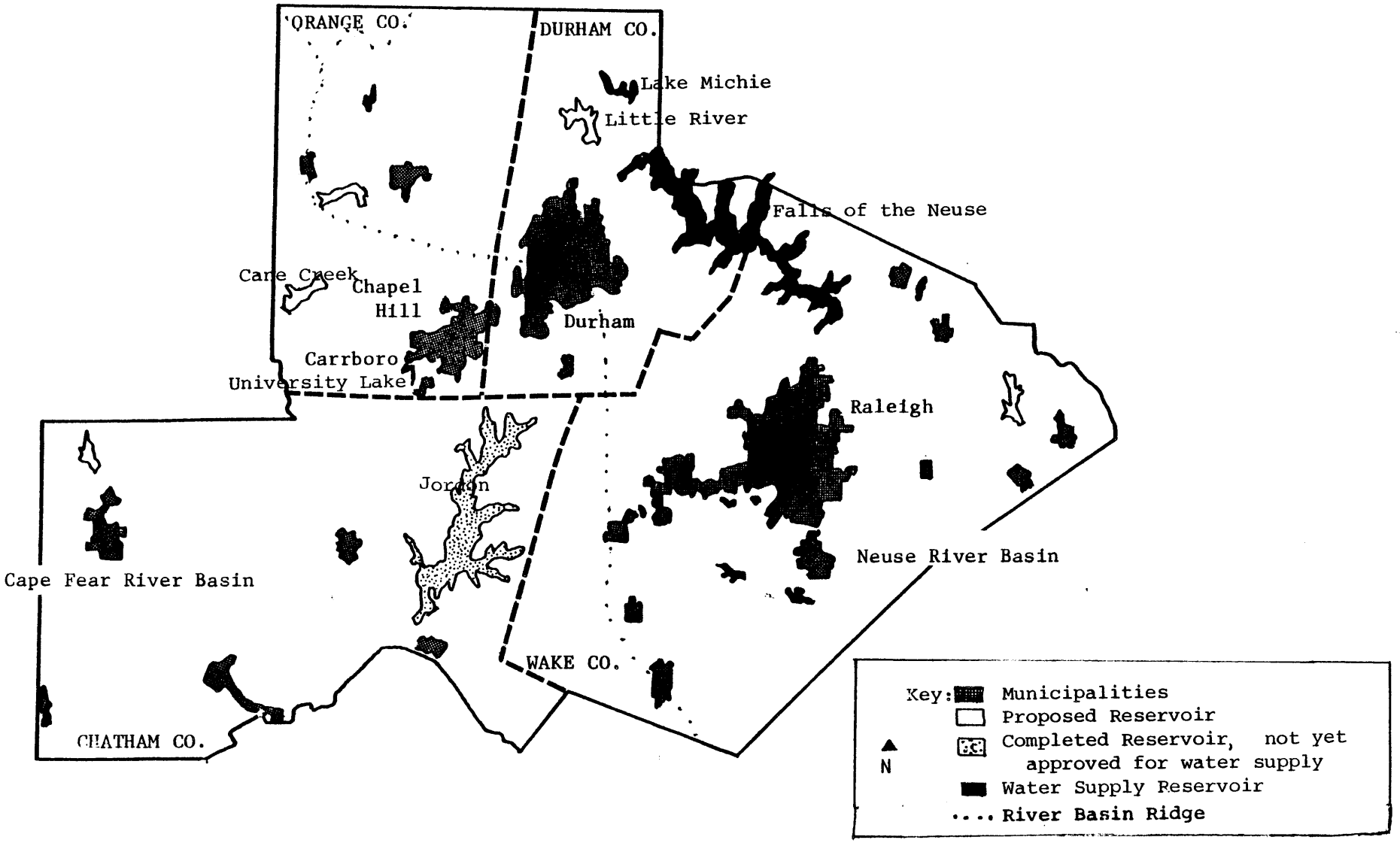


Figure 10. Present and Proposed Water Supply Sources in the Research Triangle Park Area.

Figure 11 presents average and maximum daily water use for Durham from 1972 to 1981. Average daily water use increased 48 percent over the ten-year period; maximum daily use rose 74 percent. Per capita water use has also increased over the period and is now about 184 gallons per person per day.

Approximately 40 percent of Durham's water use is by residences; another 40 percent is used by industries, institutions, and commercial establishments. The remaining 20 percent is lost or unaccounted for. Durham currently charges water users based on a declining six-block rate schedule. Within each block, rates differ between users inside and outside the city limits; users outside the city limits are charged rates twice as much as those inside the city limits. The unit charge differential between the largest and smallest blocks is about 50 percent.

Long-range water use forecasts for the City of Durham were prepared by the Triangle J Council of Governments (1977), North Carolina Department of Natural Resources and Community Development, Office of Water Resources (reported in a study of water supply alternatives for the Upper Neuse River Basin, undated), and the City of Durham (reported in Hazen & Sawyer, 1979). The Triangle J Council of Governments and City of Durham forecasts are contrasted in Figure 12; substantial variations exist by the end of the planning period. According to these water-use forecasts, the 21-million-gallon-per-day safe yield from Lake Michie will be capable of meeting the water requirements in the City of Durham until about 1985-1990. By the year 2000, water demand would exceed supply by about 12 MGD, and by the year 2010, the shortfall would be between 20 and 30 MGD. Thus, the conventional approach concludes that additional capacity in the order of 20 MGD is required to balance supply and demand.

Water Supply Alternatives for Durham

Alternatives to meet Durham's water demand were explored in the Environmental Impact Statement (EIS) for a reservoir project on Little River at Orange Factory. This EIS was prepared by Hazen and Sawyer, Consulting Engineers, under contract with the City of Durham. It is, in effect, a project evaluation document comparing nine project alternatives for increasing Durham's water supply. The characteristics of these nine projects are briefly described in Table 5, and their locations are shown in Figure 13. The EIS rejected the Nello Teer Quarry and Lake Butner Municipal Reservoir because

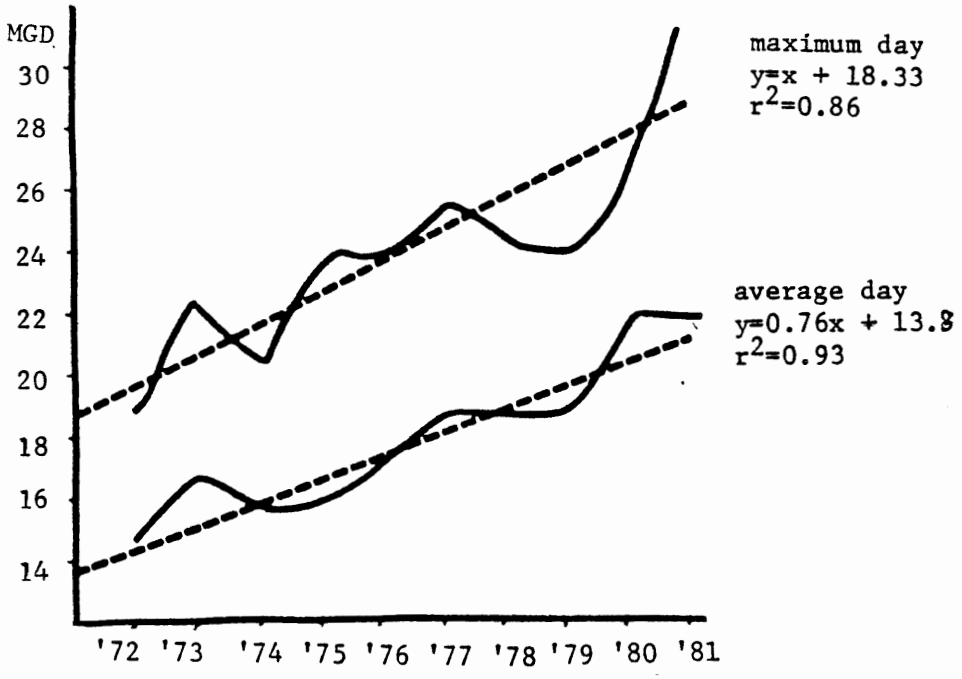


Figure 11. Average and Maximum Daily Water Use in Durham

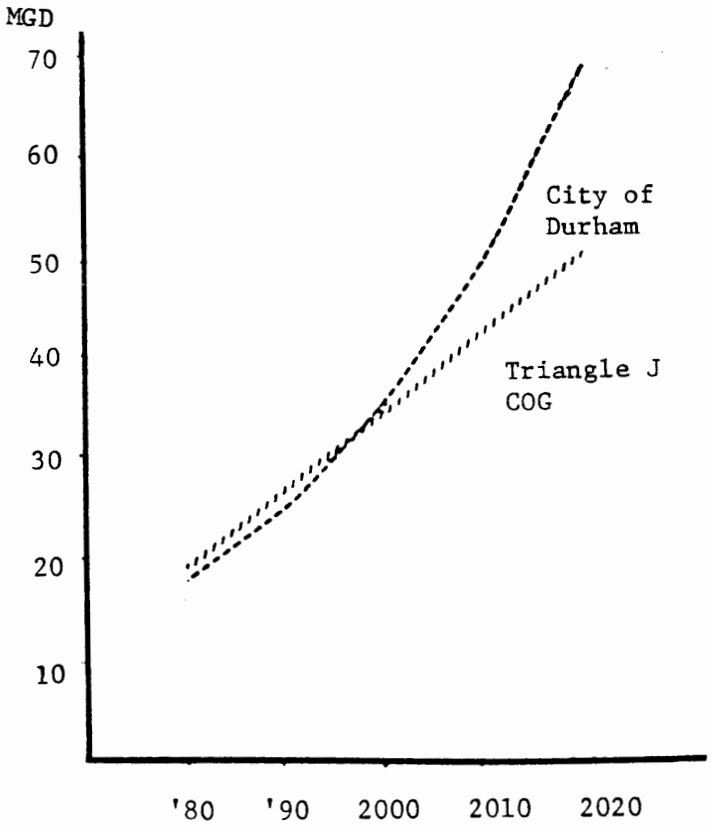


Figure 12: Water Demand Projections for Durham to the Year 2020

Table 5. Alternative Project Descriptions

Project Alternative	Characteristics and Comments				
Reservoirs	Storage Volume	Safe Yield	Acreage	Drainage Area	Comments
Little River at Orange Factory	4.5 billion gallons	24.6 MGD	548	97 sq.mi.	Preferred by City of Durham Recreational benefits High water quality
Little River at S.R. 1461	4.3 billion gallons	23.6 MGD	666	78 sq.mi.	Requires relocation of many houses, roads, bridges High water quality
Enlargement of Lake Michie	9.3 billion gallons	45 MGD	940	171 sq.mi.	Requires new pumping facility City must rely on one river for all its water
Flat River at S.R. 1471	6.5 billion gallons	23.6 MGD	860	145 sq.mi.	Reservoir extends into Person County--may be legal implications for land condemnation Electrical transmission line relocation required City must rely on one river for all its water
Flat River at Moore's Mill	5 billion gallons	23.6 MGD	1041	100 sq.mi.	Legal implications similar to Flat River at SR 1471 Loss of Moore's Mill--a building of historical significance City must rely on one river for all its water Numerous relocations
Nello Teer Quarry	2 billion gallons	8.5 MGD			Quarry to be used as storage for water pumped from Eno River Being mined at present No relocations required
Butner Lake		4.5 MGD			Transmission line exists--only pumping facilities required No relocations required

(continued)

Table 5 (continued)

Project Alternative	Characteristics and Comments		
Pipeline	Length	Capacity	Comments
Pipeline from Falls of the Neuse Reservoir	95000 feet	18 MGD	All water from reservoir has been allocated to Raleigh-Durham may obtain water only until Raleigh's demand is less than the available supply. By the year 2020 Durham will be unable to obtain any water from this source. No recreational benefits No relocations required High O&M costs due to cost of utilities required for pumping
Pipeline from B. Everett Jordan Reservoir	138000 feet	24 MGD	Reservoir has not been designated as a drinking water source Uncertain water quality No recreational benefits No relocations required High O&M costs due to cost of utilities required for pumping

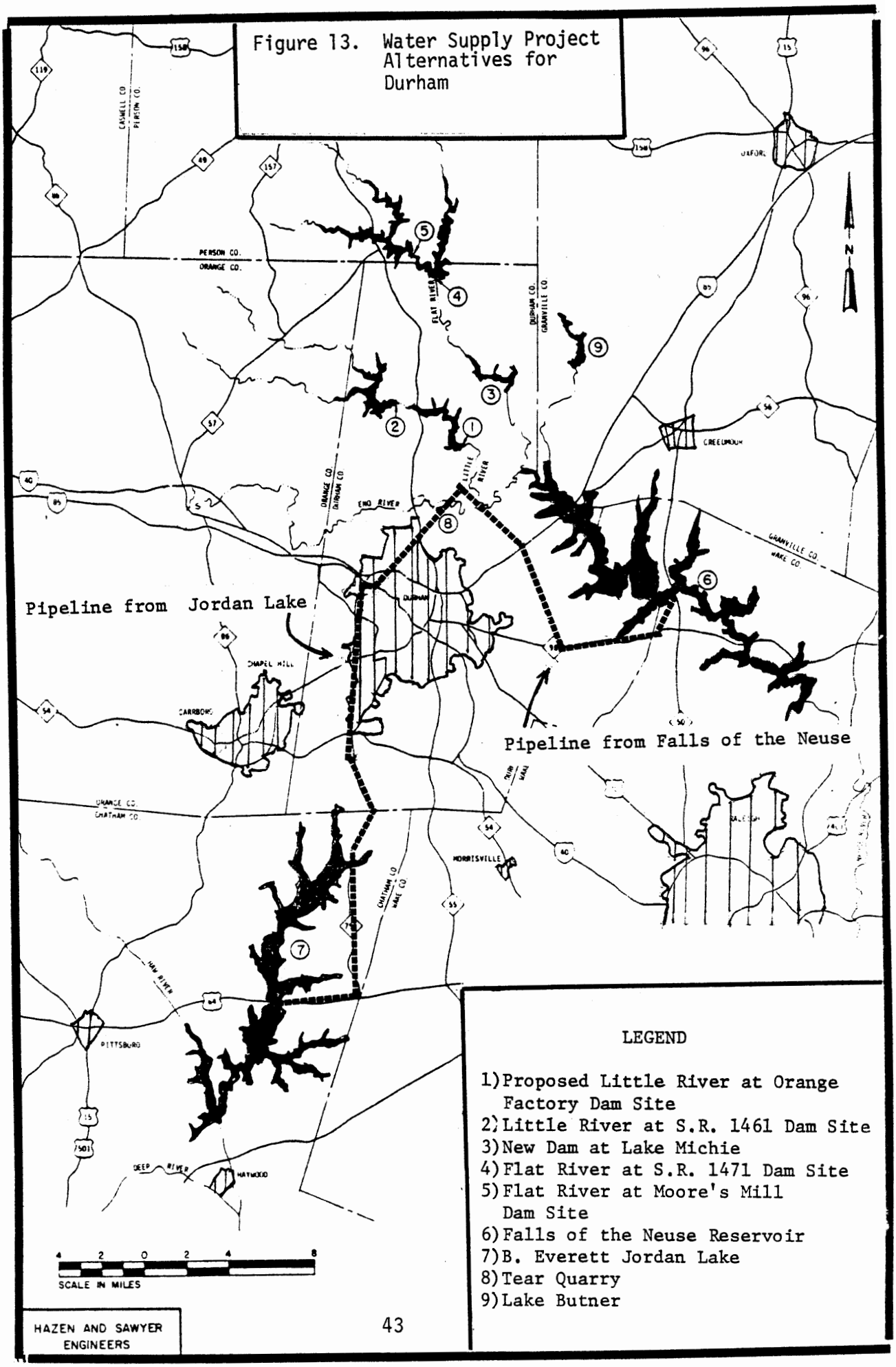


Figure 13. Water Supply Project Alternatives for Durham

LEGEND

1) Proposed Little River at Orange Factory Dam Site
2) Little River at S.R. 1461 Dam Site
3) New Dam at Lake Michie
4) Flat River at S.R. 1471 Dam Site
5) Flat River at Moore's Mill Dam Site
6) Falls of the Neuse Reservoir
7) B. Everett Jordan Lake
8) Tear Quarry
9) Lake Butner

HAZEN AND SAWYER ENGINEERS

neither could meet the projected water use throughout the planning horizon. Primarily, on the basis of construction and O&M cost estimates and recreational considerations, the EIS concluded that the reservoir at Little River at Orange Factory was the preferred project. The City of Durham has received voter approval for floating bonds for the Little River project, and Durham has subsequently contracted with Hazen & Sawyer to design and oversee the construction of the project.

In addition to the nine projects in the EIS evaluation, there are several others that could have met projected demands. Rather than rely on a single, large project built at the beginning of the planning period, the City of Durham could meet its forecast water needs by employing a sequence of smaller projects, thus deferring the construction of a large reservoir or pipeline for many years. The advantage of such a strategy is that the capital is not used now to build facilities which will not be fully utilized until some time far in the future. The present water users can thus avoid the interest and principal charges on borrowed capital for many years. Moreover, the risk associated with the demand forecasts is reduced because more time is available to revise the project plans if demands prove to be lower or higher than expected.

The three principal disadvantages of this investment strategy are: (1) that inflation will make the facilities more expensive in the future in nominal (and perhaps real) dollars; (2) there are economies of scale in most water supply projects, which means that unit costs fall as the total capacity increases, and thus, downsized projects have higher average unit costs; and (3) water supply projects are often politically very controversial, and delaying an approved project may entail increased legal and administrative costs, including even new permitting proceedings.

Whether the advantages of a particular plan for deferring capital expenditures outweigh the disadvantages is an empirical question. Clearly, some balance must be struck. Projects are rarely, if ever, built to meet demands far into the future; nor are projects designed to meet next summer's demand forecasts. However, when large federal and state grants were available for construction of water supply and wastewater treatment projects, there was a very strong incentive to build larger projects sooner than was economically justified. Moreover, waiting could prove disastrous because grants might not be available in the future, and water users would then have to pay the full costs themselves (after already contributing indirectly to the grants of others). As discussed in Chapter I, this era of large federal and state grants for capital projects

has now passed, and the strategy of building now to capture grant monies is no longer possible.

To illustrate the benefits of deferring capital projects, seven alternative sequences of projects have been identified (Figure 14), all of which meet the water demands for Durham forecast by the Triangle J COG, the basis for the EIS evaluation. Construction and O&M cost estimates for these seven alternative project sequences and for the Little River at Orange Factory reservoir project were developed using the Army Corps of Engineers' computer program, Methodology for Areawide Planning Studies (MAPS). The purpose of MAPS is to provide an easy, fast, and reliable way of developing preliminary cost estimates for various components of regional water supply alternatives such as reservoirs, pipelines, pump stations, storage tanks, and wellfields, as well as water and wastewater treatment facilities (Walski, 1980). MAPS is inappropriate as a tool for detailed design studies or site-specific problems.

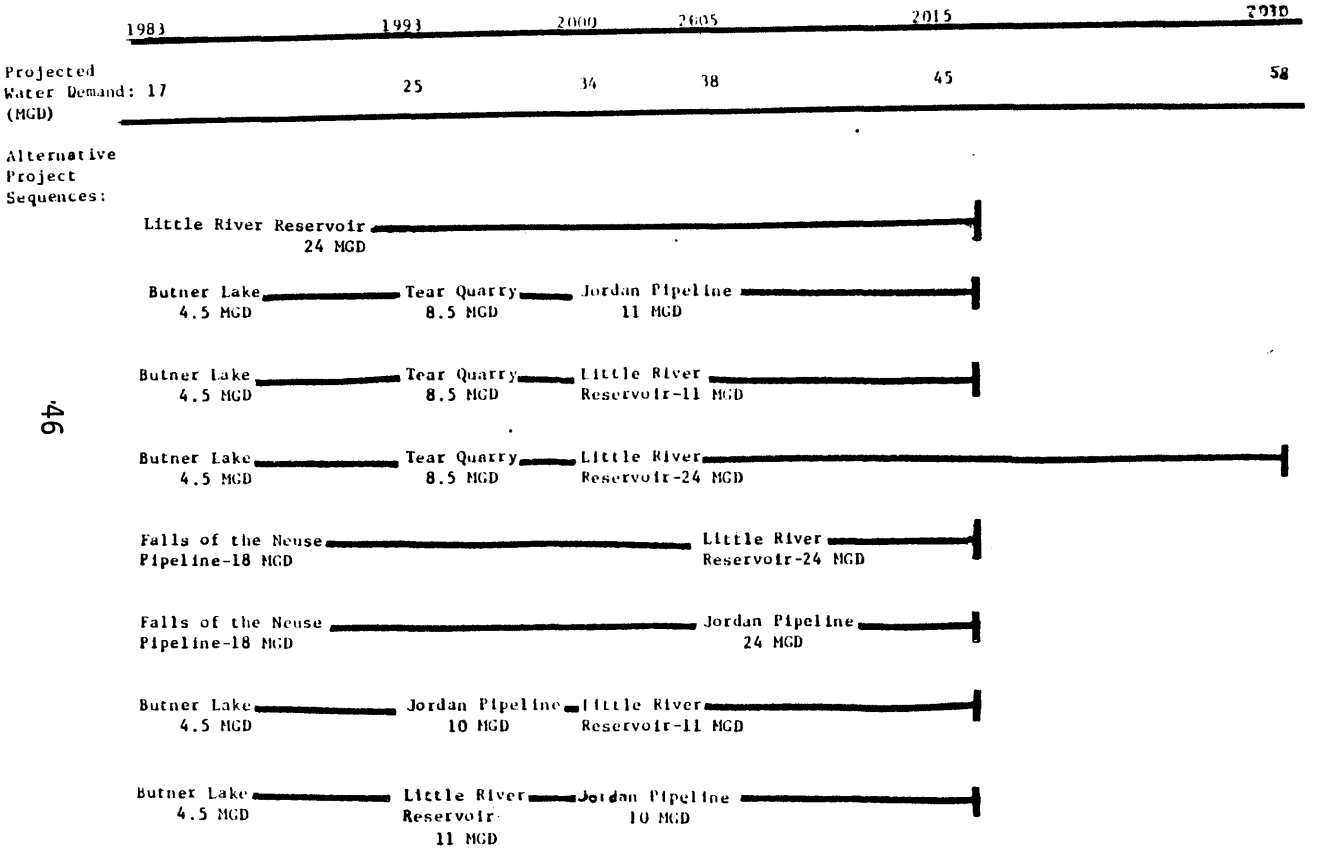
Although there are some differences in the MAPS cost estimates and the estimates in the EIS for the same projects, the ranking of the seven original projects by the EIS and MAPS are identical. This analysis is based on the MAPS estimates because the EIS estimates are available only for the original seven projects, not for downsized versions of these projects. MAPS cost estimates were used for all projects to calculate the present value of the seven alternative project sequences presented in Figure 14, using four percent real rate of discount (approximately equivalent to a nine percent interest rate and a five percent rate of inflation).

To simplify the presentation, the MAPS cost estimates have been indexed to show only the relative magnitudes of the costs of alternative project sequences. All have been referenced to a value of 100 assigned to the cost estimate for the Little River at Orange Factory reservoir project; all other cost estimates are assigned values relative to that basis.

Figure 14 presents the assumed timing and scale of the components of each of the seven alternative project sequences and the original Little River at Orange Factory reservoir project, as well as their indexed present value of construction costs and indexed 1983 annual operation and maintenance costs. The alternative project sequences using Butner Lake, Teer Quarry, and then either Jordan Pipeline or Little River reservoir all have substantially lower present value of construction costs than building Little River reservoir in 1983. The Butner Lake-Teer Quarry-Little River reservoir (24 MGD) actually has the

Figure 14. Alternative Project Sequences

Timing, Scale, Indexed Present Value Cost and 1983 Annual Operation and Maintenance Costs



Indexed Present Value Construction Cost Estimates* +	1983 Indexed Annual Operation and Maintenance Costs (i.e. in initial period)
100	0.5
49	3
60	1
61	1
148	3
163	6
108	3
87	3

Note: Lake Michie, the existing water supply in Durham, will supply 21 MGD in all of these sequences.

*for each sequence which includes a reservoir, land is purchased in 1983.
+in 1983 dollars.

additional advantage of meeting forecast water demands until 2030. Thus, there appear to be substantial economic benefits from using the two small projects dismissed in the EIS--Butner Lake and Teer Quarry--to meet water demands until 2000 and deferring larger capital projects.

Implications of Different Financing Alternatives

The means selected to pay for water investments have important consequences for the equitable distribution of the costs, the optimal timing and scale of the investment, and the efficient use of the facilities. If grant monies are unavailable, Durham has two basic options for financing new capacity: (1) capital costs can be paid for by water revenues or other current income, or (2) bonds can be issued which must be paid off over a specified number of years. The first option will result in the largest initial rate increases because funds would be required to pay for the project "up-front." Current water users would thus subsidize future water users, which could lead to excessive water use in the future if water services are priced below their real marginal cost.

These issues are examined by estimating the impact of three different bonding arrangements--constant nominal bond payments, constant real bond payments, and constant real per capita bond payments--on the distribution of costs to existing and future customers. The analysis proceeds on the assumption that the City of Durham has the flexibility to devise a financing package of bond issues to replicate any of these three methods. For purposes of illustration, the following parameters have been specified: the real rate of discount is 4 percent; inflation is 5 percent per year; annual population growth is 3 percent; and projects are financed over a 25-year period.

In Table 6 the consequences of the Little River at Orange Factory reservoir project are compared with the costs of the Butner Lake-Teer Quarry-Jordan pipeline sequence in terms of increased annual operating costs and the estimated percentage increase in the average cost of water due to the project, for the three financing arrangements. No attempt has been made to distribute the increased annual operating cost due to a new project to different blocks of Durham's rate structure. However, the data on the percentage increase in the average cost of water due to the project does indicate the magnitude of the average price increase which would be expected if all the cost increases were paid for by higher water revenues. Table 6 illustrates that constant nominal

Table 6. Impacts of Alternative Financing Arrangements

Financing Method	Little River at Orange Factory Reservoir	Butner Lake/Teer Quarry/Jordan Pipeline Sequence
Constant Nominal Bond Payments		
Real annual indexed costs in 1983 due to new project*	11	8
% increase in average cost of water in 1983 due to project++	39%	29%
Real annual indexed costs in 2008 due to new project	4	5
% increase in average cost of water in 2008 due to project	6%	7%
Decrease in quantity of water demanded due to increase in average cost of water in 2008**	1.4 MGD	1.7 MGD
Constant Real Bond Payments		
Real annual indexed costs in 1983 due to new project	7	6
% increase in average cost of water in 1983 due to project	25%	23%
Real annual indexed costs in 2008 due to new project	7	6
% increase in average cost of water in 2008 due to project	12%	11%
Decrease in quantity of water demanded due to increase in average cost of water in 2008	2.7 MGD	2.5 MGD
Constant Real Per Capita Bond Payments		
Real annual indexed costs in 1983 due to new project	5	5
% increase in average cost of water in 1983 due to project	19%	19%
Real annual indexed costs in 2008 due to new project	10	8
% increase in average cost of water in 2008 due to project	17%	13%
Decrease in quantity of water demanded due to increase in average cost of water in 2008	3.5 MGD	2.9 MGD

* In all cases this equals real annual bond payments plus real annual operation and maintenance costs. These costs are indexed to the present value construction cost of the Little River at Orange Factory Reservoir=100.

++ Total operating costs of water supply are assumed to be proportional to volume.

** Calculation assumes that total demand for water in 2008 is 45 MGD and price elasticity equals -0.5.

bond payments would entail rate increases at the beginning of the period over twice the increase that would be required by constant real per capita bond payments. As the end of the financing period approaches, constant nominal bond payments have in real terms largely paid off the loan, and the percentage increase in annual cost over present real operating costs due to either project declines. The advantage of the constant real per capita bond payments plan is that--assuming the debt payments are reflected in the water rates--the prices paid by future users more closely approximate their "fair share" of the costs of the project.

The different financing arrangements will thus entail different profiles of price changes over the planning period. By the year 2008 the different magnitudes of price changes may have significant effects on the quantity of water demanded. Assuming a long-run elasticity of demand for water with respect to price of -.5, the constant real per capita bond payments plan may reduce the level of water demand by as much as 3.8 MGD from the forecast 45 MGD, a 15 percent reduction. Water use is considerably higher at the end of the period under the constant nominal bond payments plan. If this first-round effect of price on quantity demanded is significant, it may require a revision of the size of the project.

Conclusions

Clearly, a realistic assessment of Durham's future water capacity expansion problem would include numerous other issues such as wastewater treatment needs and possible interconnections with other water systems in the Triangle area. However, based on the calculations presented in this case study, two important conclusions can be drawn.

First, deferring large capital projects can result in substantial financial savings, and smaller, less expensive projects should not be dismissed simply because they cannot supply enough water to meet a long-term forecast. Small projects can be sequenced with other projects--both small and large--in ways which should be considered. Permitting and legal procedures should be revised and simplified so that municipalities can take advantage of this option without fear of losing their construction permits or being continually embroiled in public controversy over the location of a reservoir or pipeline.

Second, financing packages should be used which more closely approximate the constant real per capita bond payments plan. This financing arrangement

is more equitable because present users do not have to bear all the costs for systems also enjoyed by future users. It is more efficient because both present and future users pay prices for water more closely related to the real costs of providing water; and thus, they have an incentive to use water more rationally.

OWASA's Capital Improvement Program

Although some management options may appear to be attractive on the basis of minimizing cost and enhancing equity, as in the Durham case, all investments and strategies should be evaluated with respect to their impacts on cash flow of the utility and on consumer prices. In a second case study, that of the capital improvement program for the Orange Water and Sewer Authority, a linear programming model is constructed for this purpose. Solutions to the model generate a set of consumer prices necessary to cover the operating and capital costs for the Authority over a 15-year time horizon. The model is then used to evaluate the effects of grant reductions, deferrals of selected projects, and alternative financing on prices and the present value of financial obligations of the utility and its consumers.

Other similar methods have been developed over the past several years, but none is directly applicable to the problem at hand. They include models for capital budgeting, models for the determination of optimal timing and scales for capacity expansions, and models for optimal pricing policies. Good reviews of the capital budgeting literature are presented in two recent texts by Clark, Hindelang, and Pritchard (1979) and Wilkes (1977). The principal limitation of these models for public decision making, especially when applied to local water and sewer programs, is the lack of operational measures of preference that can be assigned to discrete projects in the capital improvement package. Minimization of cost is an insufficient criterion because it ignores the benefits that may be foregone by delaying projects. The estimation of benefits, as difficult as that task is with large-scale independent projects, becomes meaningless with the high level of interdependencies among pipelines, storage tanks, treatment plants and other projects normally found in local capital improvement programs for water and sewer agencies. A second group of related models address the problem of determining the optimal timing and scale for capacity expansions for capital projects. Freidenfelds (1981) has a comprehensive review of those models in his recent book. A large number of relatively simple models have been developed for a variety of problem settings, but the more complex models that address multiple interdependent projects encounter substantial computational problems.

Furthermore, the more complex models do not include financing aspects of the problem. They are limited to cost minimization. There are at least two reasons why the large and diverse body of literature on pricing models is not directly applicable to the present problem. First, the principal objective of this investigation is not to determine optimal pricing policies. Instead, the primary purpose of this research is to determine, under a variety of pricing structures that are used in practice, the effects of inflation, growth, costs of financing, and reduction of grant support on the costs to local suppliers of water and sewer services. Also, most of the pricing models are mute on the question of financing arrangements and revenues, arguing that revenues and costs can be balanced through one of several forms of financing schemes or subsidies.

In several ways, the questions posed in this analysis are much simpler than those addressed by the models described in the preceding paragraph. The question here is: what combination of prices and bond issues over a given planning horizon will lead to the minimum present value of revenues paid by customers of the system while satisfying the cash flow requirements of local government? Those requirements are determined exogenous to the minimization problem through: (1) a forecast of water consumption and related waste generation; (2) a related forecast of operating and replacement costs; (3) a given schedule of capital improvements; and (4) a given rate structure.

The model does not explicitly account for feedback relationships between the prices that are calculated by the model and the exogenously specified inputs. Some of those relationships may be important. For example, the forecast of water consumption may be altered by the prices that are necessary to cover the cost of supplying those amounts. Specifically, if real prices generated by the model are significantly different from those for consumption rates on which the forecasts are based, effects of price elasticity could change the forecasts by non-trivial amounts. Another change may be necessary in the capital improvement program. If the revenues required to cover the costs of the program as initially specified are unacceptably high, then it may be necessary or desirable to modify the program. All projects in the initial schedule are not likely to be built regardless of their impacts on consumer rates. What these interdependencies between input specifications and output prices imply is that the analysis may have to be carried out iteratively until an acceptable combination of input requirements and output prices is found. More complex

models might be constructed to incorporate some of these interactions internally, but the model suggested here uses a well-known computational algorithm.

The analysis should include all important categories of expenditures, including those for operation, maintenance, and replacement as well as capital investments in new projects. It should also cover all important sources of revenues including charges to customers, interest on investments, bond issues, and grants.

To be useful for planning and decision making, the analysis must extend over a period of time of sufficient length to assess the effects of current decisions on the future flow of revenues and costs. At a minimum it should extend over a mid-range planning horizon; say, 10 to 15 years. While the choice of a particular time horizon is subject to some discretion, mid-range interval is close to the minimum time period necessary to evaluate the effects of mitigation measures, especially those involving deferrals of either capital investments or the debt service on these expenditures.

For convenience, the cash flow analysis can be divided into two funds, a general fund and a capital fund. The fundamental accounting equation for the general fund in the ith year of the time horizon can be written:

$$BG_i = BG_{i-1} + IG_i + RV_i - OC_i - RC_i - CC_i$$

where:

the subscript i refers to the ith year of the time horizon,

$i = 1, 2, 3, \ldots, n$;

BG = balance in the general fund at the end of the year;

IG = interest earned on the balance in the general fund invested in short-term opportunities;

RV = revenue from customer sales and services;

OC = operating costs;

RC = annual expenditures for the replacement of equipment and facilities;

CC = payments made into the capital fund.

For the capital fund the equation is as follows:

$$BC_i = BC_{i-1} + IC_i + CC_i + BR_i + CG_i - DS_i - CI_i$$

where:

BC = balance in capital fund at the end of the year;
IC = interest earned on the balance in the capital fund invested in short-term opportunities;
BR = revenues from bond issues;
CG = capital grants received;
CI = capital investments made during the year as specified in the capital improvements schedule; and
DS = debt service.

These equations do not explicitly account for depreciation of capital assets. However, that cost is accounted for indirectly by two terms in the equation for the general fund. That equation contains one term for the replacement of worn-out or obsolete equipment and facilities and a second for payments into the capital fund. Funds from that account are used to pay for capital projects that include both replacements and expansions. If the general fund and the capital fund are properly balanced over a sufficiently long-time horizon, the combination of replacement costs and contributions to the capital account should be sufficient to cover depreciation. Of course, good accounting practice would include fixed asset accounts that include depreciation. If replacement costs and contributions to the capital fund are not sufficient to cover depreciation, then contributions to the capital fund can be adjusted. The case chosen here is the capital improvement program of the Orange Water and Sewer Authority, which serves the Chapel Hill-Carrboro area. OWASA was chosen for several reasons, the most important of which is readily available data and a recently developed capital-improvements program. From the Environmental Impact Statements (U. S. Army Corps of Engineers, 1981; N. C. Dept. of NRCD, 1982) on its proposed Cane Creek reservoir, the future needs of the Authority are fully documented; and as a separate agency of government, its annual reports contain a rather complete set of operating costs and capital investments. OWASA has also recently completed a draft of a 15-year capital improvements program (OWASA, August 1983). The Authority serves approximately 55,000 persons, with customers divided into two classes; namely, residential and non-residential (commercial and institutional). Demands for water on the system averaged 5.96 MGD in 1981-82, and the average load on the waste treatment plant was 5.05 MGD during that period. Growth in this service area is between 2.5 and 3.0 percent per year.

Calibration of the Model

Further details of the model are specific to its application. The planning horizon selected for this analysis covers the 15-year period July 1, 1979, through June 30, 1994. That period was selected to cover the construction of a major expansion and upgrading of the waste treatment plant begun in 1979 and to include the construction of the Cane Creek reservoir, for which land acquisition and construction are scheduled for the period 1983-1989. Those projects and others, including expansion of the water treatment plant and the development of sludge handling facilities for that facility, construction of a new administration building, and investments in the water distribution and waste collection system, represent an ambitious capital investment program of over $40 million, a rather substantial program for a system of this size. Details of actual expenditures and that portion of the capital improvement program from FY 1984 through FY 1994 are given in Table 7. Values in that table for 1984 and beyond are stated in real dollars.

For this analysis the base year for water consumption, waste flows, and operating costs is taken to be FY 1982. Growth rates for the number of customers and their average consumption rates are consistent with population growth rates and recent trends experienced by the Authority. Other flows necessary for the estimating of revenues and costs can be obtained from those forecasts as simple multiples of water consumption under the assumption that the ratios of those flows to water consumption will remain constant over the planning horizon. More specifically, it is assumed that the ratios of water treated, waste flows billed, and waste treated to the amount of water sold remain constant. Values for those ratios are given in Table 8.

Operating costs for each of the water and sewer services can be forecast by the following components:

1. personnel costs
2. chemical costs
3. utility costs
4. other direct costs
5. costs for administration and customer records and collections

Values for these costs in 1982 and their assumed inflation rates are shown in Table 8. These costs were developed from OWASA's 1982 annual report, and the inflation rates are consistent with the trends discussed in Chapter I. Values prior to 1982 were estimated by deflating the costs at the stated rates and

Table 7: Capital Expenditures for the Orange Water and Sewer Authority: Actual 1980-1982; Proposed 1983-1994

	1980	1981	1982	1983	1984	1985	1986	1987
Water								
Supply	0.01	0.11	0.20	0.00	1.06	0.31	1.57	3.63
Pump/Trans							0.02	0.29
Treatment					0.74	0.25	2.23	
Pumping						0.01	0.18	
Storage					0.94		0.02	0.02
Distribution					0.06	0.31	0.30	0.10
Sewer								
Collection	0.01	0.23	0.03	0.03	0.44	0.20	0.75	0.66
Pumping					0.02	0.01	0.01	0.01
Treatment	0.12	0.23	5.32	3.77	2.19			
Admin. Bldg.				0.02	0.90			
Total	0.15	0.57	5.55	3.82	6.34	1.07	5.06	4.70
Grants	0.05	0.10	4.22	3.72	1.40			
Net	0.10	0.47	1.33	0.10	4.94	1.07	5.06	4.70

	1988	1989	1990	1991	1992	1993	1994
Water							
Supply	3.99						
Pump/Trans							
Treatment							0.38
Pumping							0.02
Storage		0.12	0.12	0.12	0.12	0.12	0.33
Distribution	0.13	0.15	0.15	0.15	0.15	0.15	0.15
Sewer							
Collection	0.20	0.49	0.49	0.49	0.49	0.49	0.23
Pumping	0.01	0.09	0.09	0.09	0.09	0.09	0.11
Treatment							
Admin. Bldg.							
Total	4.33	0.85	0.85	0.85	0.85	0.85	1.21
Grants							
Net	4.33	0.85	0.85	0.85	0.85	0.85	1.21

Table 8. Parameters for Projection of Consumption and Operating Costs.

	Base Year Values	Annual Growth Rates	Units
Consumption and Generation			
No. of Customers: Class I	9650	2.5	
Class II	270	1.0	
Ave. Use Per Customer: Class I	325	1.0	gal/customer/day
Class II	0	1.0	gal/customer/day
Sewer Customers/Water Customers	.78		
Water Treated/Water Sold	1.13		
Waste Billed/Water Sold	.86		
Waste Treated/Water Sold	1.24		
Cost			
Personnel	.9078	7	$ millions
Chemicals - Water	.0757	5	$/1000 gal treated
Sewer	.0558	5	$/1000 gal treated
Utilities - Water	.103	9	$/1000 gal treated
Sewer	.0830	9	$/1000 gal treated
Other - Water	.0854	5	$/1000 gal treated
Sewer	.0830	5	$/1000 gal treated
Overhead	.7028	7	$ millions

multiplying by appropriate flow rates, and values beyond 1982 were obtained by inflating 1982 costs at those rates and multiplying by appropriate projected flows. Existing debt service for OWASA is $700,000 per year, and that will remain constant throughout the planning horizon. In addition, OWASA was spending approximately $400,000 per year in 1982 for replacement costs, and for the purposes of this analysis, that value as well as the capital expenditures in Table 7, is inflated at the annual rate of five percent. Thus, the total cost for operating the system, paying the existing debt service, and paying for replacement can be projected as shown in Table 9.

OWASA's rate structure for both water and sewer service consists of two parts: (1) a fixed monthly charge for billing, record keeping, and maintenance; and (2) a flat rate commodity charge stated in dollars per thousand gallons (or any fraction thereof) consumed. For those customers that receive sewer service in addition to water service, the rate of sewage flow is taken to be 90 percent of water sold. Thus, revenues generated from these services is given by:

Table 9. Flows, Costs, and Revenue Coefficients 1980-1994

Year	Water Treated MGD	Operating Cost $ Millions	Capital Cost $ Millions	Total Fixed Cost*	Revenue Coefficient
1980	4.889	2.208	.1	3.351	3.331
1981	5.038	2.384	.47	3.924	3.430
1982	5.191	2.575	1.33	5.005	3.532
1983	5.349	2.782	.1360	4.050	3.637
1984	5.512	3.007	7.258	11.43	3.746
1985	5.680	3.250	1.697	6.152	3.858
1986	5.854	3.515	8.671	13.43	3.973
1987	6.034	3.802	8.699	13.78	4.093
1988	6.219	4.115	8.655	14.10	4.216
1989	6.410	4.454	1.835	7.675	4.343
1990	6.607	4.823	1.981	8.245	4.473
1991	6.811	5.225	2.140	8.865	4.609
1992	7.021	5.662	2.311	9.537	4.748
1993	7.238	6.138	2.496	10.26	4.892
1994	7.462	6.657	3.838	12.20	5.040

*Fixed cost = operating cost + capital cost + current debt service + annual replacement expenditures

$$RV_i = \sum_{h=k}^{2} \sum_{k=k}^{2} (f_{ijk}\, n_{ijk} + c_{ijk}\, Q_{ijk})$$

where f_{ijk} is the fixed charge for water or sewer in year i for customer class j, c_{ijk} is the corresponding commodity charge, and k=1 implies water service and k=2 implies sewer service. If the ratios of these prices relative to the residential commodity rate are ass-med to be constant over the planning horizon, then annual revenues are given by:

$$RV_i = K_i\, p_i$$

where $k_i = \sum_{j=1}^{2} \sum_{k=1}^{2} (f'_{ijk}\, n_{ijk} + c'_{ijk}\, Q_{ijk})$, p_i is the residential commodity

change in year i, and f′'s and c′'s are the ratios of the respective prices to the residential commodity rate. Values of these price coefficients over the time horizon are shown in Table 9.

In this analysis it is assumed that prices will not be changed every year; they can be changed once every three years. Furthermore, it is assumed that bonds would be issued only once every three years. Thus, the problem requires the determination of prices and bond issues for each of five three-year periods.

Bond payments required in each year are given by:

$$BP_i = \sum_{j=1}^{i-1} CR_{i-j} \, BR_j$$

where CR_{i-j} is the cost recovery factor for a payment due in year i for a bond issued in year j.

Other constraints must be added to prevent the model from generating unstable streams of prices and from generating bond issues that would violate arbitrage regulations. Stability in prices can be controlled by specifying that prices be non-declining and that price increases over successive three-year intervals be within specified tolerances. These constraints take the form:

$$p_i > p_{i-1} \text{ for } j = 1,2,3,4,5$$

and

$$p_i < (1+r_p) p_{i-1} \text{ for } j=1,2,3,4,5$$

where r_p is the maximum fractional change permitted from one time interval to the next. Arbitrage can be prevented by limiting bond issues to the level of expenditures specified in the capital improvement program for the three-year interval in which the bond is to be issued. That is,

$$BR_i < CI_i + CI_{i+1} + CI_{i+2} \text{ for } i = 1,4,7,10,13.$$

Evaluation of Alternatives

In its present form the linear programming model can be used to find a set of prices and a set of bond issues that will minimize a weighted sum of those prices while satisfying the following constraints:

1. The general fund and capital fund equations will be satisfied.
2. Minimum reserve requirements will be satisfied.
3. Prices will be constrained to be non-declining, and percentage increases from one period to the next will be less than a specified limit.
4. Bond issues will be constrained to prevent violation of arbitrage regulations.

Solutions generated by the model will be specific to the capital improvement program that is given as input and to the set of cost-recovery factors that are dependent upon: (a) the longest time to maturity in the bond series; (b) the discount rate for the bonds; and (c) the choice of types of bonds. Thus, by solving the linear programming problem for alternative specifications of the capital improvement program and alternative types of bonds, the impacts of these alternatives on consumer prices can be estimated. The set of indicators of these impacts that is generated by the solution is the time stream of prices that results from a given capital improvement program and repayment strategy. Differences among the alternatives are thus indicated by differences in the time streams of prices. A supplementary indicator that is also useful in assessing impacts of alternatives is the present value of the time stream of financial obligations incurred by the Authority and its customers. That indicator is the present value of revenues plus the present value of outstanding debt at the end of the time horizon and is given by the following:

$$z = \sum_{i=1}^{15} c_i K_i/(1+r)^i + \sum_{i=1}^{15} \sum_{k=15}^{i+T} CR_{k-i}\, BR_i/(1+r)^k$$

For convenience, that indicator is referred to subsequently as the present value of financial obligations.

Evaluations of all the alternatives in this analysis are based on a bond period of 25 years and the discount rate is set at 8.0 percent. Opportunities for reinvestment of balances on hand are set at 10.0 percent per year, and the present value of financial obligations is evaluated at a discount rate of 8.0 percent. Reserve requirements for any given year are set at 120 percent of bond payments required during the following year. Although OWASA has built up reserve funds as the Cane Creek project has been delayed, the effects of that initial balance has been eliminated by setting the initial balance in this analysis at 120 percent of the existing debt service. Also, OWASA's rates were

raised in anticipation of that project. Effects of that initial condition have been eliminated by setting the initial rate at that value where revenues would just equal expenditures. That value is $1.00, derived by dividing the sum of operating, replacement, and debt service costs by the revenue coeffcient for the base year in Table 10.

Table 10. Solutions to the Revenue Model

Cases	Period	Prices		
1. No Grants Conventional bond at 10%	1	1.256	PV of Outstanding Debt =	6.99
	2	1.583	PV of Revenues =	64.81
	3	1.994	Total =	71.90
	4	2.513	Final debt service =	6.955
	5	2.796	TIC =	10%
2. With Grants Conventional bonds at 10%	1	7.106	PV =	3.54
	2	1.394	PV =	57.68
	3	1.756	Total =	61.22
	4	2.213	Final debt service =	5.689
	5	2.568	TIC =	10%
3. With Grants Zero coupon bonds at 7.5 → 17.5% 4% growth in debt service	1	1.107	PV =	5.38
	2	1.395	PV =	58.57
	3	1.757	Total =	63.94
	4	2.214	Final debt service =	6.836
	5	2.738	TIC =	12.44%
4. With Grants Stepped bonds at 7.5 → 17.5%	1	1.104	PV =	3.52
	2	1.391	PV =	57.55
	3	1.752	Total =	61.07
	4	2.208	Final debt service =	5.651
	5	2.561	TIC =	9.92%
5. With Grants Conventional bonds at 10% Deferred Projects	1	1.00	PV =	1.83
	2	1.244	PV =	52.58
	3	1.567	Total =	54.41
	4	1.975	Final debt service =	6.859
	5	2.488	TIC =	10%

Effects of Grant Reductions. The first impact that is evaluated with the model is the effect of reducing Federal and State grants for waste treatment. That effect is estimated by solving the problem using the capital improvement program shown in Table 10 with and without the grants. Here, the only grants that are considered are those actually awarded to OWASA over the period 1979-1983; the analysis does not include any grants that may be available to support the projects scheduled for the next 10 years. Both cases are evaluated with the use of annuity serial bonds.

Results of these solutions are shown in Table 10. Solutions to the linear programming problem were infeasible when limits on price increases were set at 7.0 percent per annum; they were feasible at limits 8.0 percent per annum, and that is the limit used for all evaluations in this study. Prices for the case without grant support are 13.6 percent higher than prices with grant support in the first four time intervals; that difference dropped to 8.9 percent in the fifth period. A similar difference is seen in the present value of financial obligations with and without the grants. With grants, financial obligations are 17.4 percent less than without the grants.

This result is comparable to the impact estimated in Chapter II. From the analysis of statewide revenues and expenditures for water and sewer services, it was estimated that total revenues would have to be increased by 27 percent to offset the loss of Federal and State grants.

Alternative Methods of Financing. A second effect that was evaluated with the model is the difference in prices and present value of financial obligations that result when creative financing methods are used as an alternative to conventional bonds. Differences were evaluated with the capital improvement program shown in Table 10 with the historical pattern of grant support. Comparisons were made with zero coupon bonds and stepped bonds. In both cases the literature suggests that these bonds may sell for two to three points below conventional bonds. Thus, since conventional bonds were set at 10 percent in this case, yields in the first year of maturity for these bonds were set at a representative value of 7.5 percent. Then, yields were allowed to increase at a constant rate throughout the range of maturity, reaching a final year rate of 17.5 percent. Debt service for each issue of the zero coupon bonds was allowed to increase at a rate of four percent per year.

Results of these calculations are also shown in Table 10. There, it may be noted that at the assigned rates there is only a small effect of alternative methods on prices. For the case of zero coupon bonds there is a small increase in the price in the fifth period and a small increase in the present value of financial obligations. With the annual increase in debt service for each issue of these bonds, there is a movement toward greater equity between present and future customers, but that equity is purchased at the difference in cost shown in the table.

Stepped bonds, as structured in this evaluation, have practically the same effects on prices as conventional bonds at a 10 percent interest rate.

Deferral of Capital Expenditures. A third set of options that can be evaluated with the cash flow model is the effect of programs that defer capital expenditures, such as those for load management, conservation, regional integration, and leasing of space. In the context of OWASA's capital improvement program there are several possibilities: (1) the new water supply could be delayed for several years if nearby cities were to sign cooperative agreements; (2) expansion of the water treatment plant could be deferred through a load management program that reduced peak loads, the most obvious possibility being the use of an odd-even lawn sprinkling strategy; and (3) the new administration building could be deferred or eliminated either by accepting the present but inadequate facilities or by leasing space elsewhere. If either option (1) or (3) is to be used, the costs of purchasing those goods and services from alternate sources would have to be compared with the savings that accrue to the Authority from deferring capital investments and related operating costs.

Without elaborating on the details of how each of these actions would be accomplished, the effects are evaluated under the assumption that the water supply could be delayed five years, expansion of the water treatment plant could be delayed for five years, and construction of the administration building could be deferred indefinitely. More than 40 percent of the total capital improvement program is affected by these three projects. The modified time stream of capital improvements can be readily determined from Table 7.

Analysis of the effect of these deferrals was made with the given pattern of grant support. Prices in this case are consistently 8.9 percent less than in the original capital improvement program. When measured by the present value of financial obligations, these deferrals also result in a cost reduction of 8.9 percent.

Chapter V

FINDINGS AND RECOMMENDATIONS

The basis for findings and recommendations that follow from this study are based on several sources, including: (1) a survey of revenues and expenditures for water and sewer services in 41 cities in North Carolina in Fiscal Year 1982; (2) an examination of federal and state grants for water and sewer facilities in those cities; (3) estimates of the trends in the most important factors that contribute to the costs of water and sewer services; and (4) case studies of two systems with which to show, through detailed cost estimates and projected cash flows, the effects of alternative means of mitigating future increases in prices charged to consumers of these services. The study also includes the development of a cash flow model that can be of significant value to local governments in their financial planning.

Findings

There are several findings that follow from these data and analyses that describe the near future for financing municipal water and sewer services. First, the present cost of water and sewer services in North Carolina is relatively inexpensive. The average revenue for water service is $1.04 per 1000 gallons, and the average revenue for sewer service is $0.87 per 1000 gallons. For a family of four using 75 gallons per capita per day, these consumer costs would result in a monthly bill of approximately $17 per month or $200 per year for combined water and sewer services. Over the past ten years these costs have been increasing at approximately seven percent a year, a rate that has been less than that for other factors that contribute to the cost of living.

However, revenues collected through service charges have not covered the full cost of delivering these services. In the absence of complete inventories of capital assets and appropriate allowances for depreciation of the capital stock, the true value of the full cost of these services is not possible. Even though the true value cannot be determined from available data, one estimate of the cost--probably an underestimate--is the present rate of expenditures. In 1982, revenues from customers covered only 76 percent of expenditures; most of the difference was made up from federal and state grants for the construction of new facilities, predominantly for

waste treatment facilities. Estimates of expenditures indicate that 49 percent were for operating and maintenance costs, the other 51 percent for capital investments, including internally financed facilities, debt service on bonds, and federal and state grants. These grants accounted for 41 percent of capital expenditures, or 21 percent of all expenditures. Grants for waste treatment facilities accounted for 35 percent of capital expenses, or 18 percent of all expenses; revenues averaged 150 percent of operating and maintenance costs over all 41 cities, but approximately 20 percent of the cities in the survey had revenues less than operating and maintenance costs.

Trends in the most important components of these expenditures indicate that significant increases in consumer rates may be necessary in the near future if current levels of service are to be maintained. Continued increases in operating costs may be expected. Personnel costs, which account for 42 percent of operating costs, have increased at an annual rate of nearly seven percent. The second most important factor in total operating costs is electric power, contributing 17 percent of the total, and that cost has been increasing at a rate of ten percent a year over the past decade.

If these trends continue, they would tend to sustain the seven percent inflation rate that has been experienced in recent years, but the more important effects are likely to be associated with capital costs. Inflation in construction costs for new facilities has been persistently in the range of eight to nine percent a year. Dramatic increases in the cost of financing new facilities with borrowed capital have been experienced in the past four years. Local governments have been sheltered from some of the impacts of inflation and financing costs because of the large contributions from federal and state grants. That shelter is being removed as federal and state programs are being reduced sharply. The combined effects of an increased share of construction costs, inflation in those costs, and the increased cost of financing will force local government revenue needs to increase if present service levels are to be maintained. For the 41 cities in the survey, revenue needs can be expected to increase at 10 to 11 percent a year over the next five years.

The case studies illustrate that a combination of actions could reduce present values of future costs by as much as ten percent. Capital expenditures are clearly the most important target. Actions that will result in the reduction in size, elimination of unnecessary features, or simply deferral of capital expenditures should be evaluated to determine their potential to reduce

costs. Conservation, improvements in efficiency, improved capital programming, and regionalization of facilities to exploit excess capacity are some of the actions that could contribute to that end.

Creative financing techniques offer the possibility of increasing the marketability of financial instruments. However, they offer only modest opportunities to reduce costs, and in doing so they shift the risk from the investors to the municipalities.

Recommendations

From these findings flow several recommendations for action by local governments. There are also related recommendations for action by state government to create incentives for local action.

First, local governments should improve their financial planning and reform their rate structures. Particular attention should be given to mid-term (10-15 years) planning that includes operating and maintenance costs, annual replacement costs, and capital investments to replace and expand major facilities. Rates should be restructured to recover the full cost of services and to distribute the costs to customers in an appropriate manner.

- Conservation measures should be exploited to decrease base loads;
- Load managment techniques should be explored as a way of deferring expansion of facilities designed to meet peak loads;
- Regional interconnections and intergovernmental agreements should be explored as means of coping with shortages;
- Improved capital programming, including the use of sequences of small projects, should be undertaken to reduce idle capacities in large projects.

And second, state government should create incentives for local governments to adopt necessary changes, including the continuation of some form of financial assistance. In particular, the state should:

- adopt as a requirement for state permits and financial assistance a minimum framework water resource plan for local governments that would include: (a) projections of needs over the next ten to fifteen years; (b) an identification of the most promising alternatives and costs of meeting those needs; and (c) alternative methods for financing existing as well as future operating and capital costs; and
- continue some form of financial assistance through low cost loans or direct grants.

REFERENCES

Clark, J. J., T. J. Hindelang and R. E. Pritchard, Capital Budgeting: Planning and Control of Capacity Expansion, Prentice-Hall, Englewood, NJ, 1979.

Civil Engineering, "Water Supply," June 1983, pp. 50-53.

Durham City, Office of Water Resources. 1981. Information on water system users. Unpublished.

Engineering News Record, March 24, 1983.

Freeman, H. M., "Air and Water Pollution Policy," in P. Portney (ed.), Current Issues in U. S. Environmental Policy, Johns Hopkins Press, 1978, pp. 12-68.

Friedenfelds, J., Capital Expansion: Analysis of Some Simple Models with Applications, North Holland, New York, NY, 1981.

Hazen-Sawyer, Engineers, 1979, Final Environmental Impact Statement for Little River at Orange Factory Reservoir, Durham, N. C., Raleigh, NC.

Higgins, J. M. and D. A. Okun, Regional Development of Public Water Supplies, Report No. 72, WRRI-UNC, 1972.

Matzer, John (ed.), Capital Financing Strategies for Local Governments, International City Management Assoc., 1983.

Moak, Lenox L., Municipal Bonds: Planning, Sale, and Administration, Municipal Finance Officers Assoc., 1982.

Moreau, D. H., et al., Regional Water Resource Planning for Urban Needs, Report No. 77, WRRI-UNC, 1973.

North Carolina Employment Security Commission, personal communication, 1983.

North Carolina Water Resources Research Institute, "Surcharges for Industrial Wastes: Suggestions and Guidelines," 1972.

North Carolina Department of Natural Resources and Community Development, Final Cane Creek EIS, Raleigh, NC, September 1982.

Orange Water and Sewer Authority, 1982 Annual Report, Carrboro, NC, September 1982.

Orange Water and Sewer Authority, "Capital Improvement Program" (draft), August 1983.

Peterson, John E. and Wesley C. Hough, Creative Capital Financing for State and Local Governments, Municipal Finance Officers Assoc., 1983.

Purchasing Journal, 1982 and prior years.

Stewart, J. M. (ed.), Proceedings, North Carolina Conference on Water Conservation, WRRI-UNC, September 1975.

Stewart, J. M., (ed.), Proceedings, North Carolina Workshop on Water and Wastewater Pricing, WRRI-UNC, February 1978.

Triangle J. Council of Governments, 1977, Region J, North Carolina Water Resource Management, Research Triangle Park, NC.

Turner, B. R., "Electric Utility Bill Comparisons--Residential 1000 kwh Bulbs W/Water Heating," N. C. Utilities Commission, 1983

Walski, T. M., 1980, MAPS - A Planning Tool for Corps of Engineers Regional Water Supply Studies, Water Resources Bulletin, 16:215-19.

Whittington, D. and T. Snyder, Financing for Water Projects in North Carolina, study in progress for the N. C. Office of Water Resources through the Water Resources Research Institute of The Univ. of N. C., Raleigh, NC.

Wilkes, F. M., Capital Budgeting Techniques, John Wiley and Sons, London, 1977.

Williams, Paul C., "Creative Financing Techniques for Water Utilities," Journal of the American Water Works Assoc., September 1982, pp. 443-449.

U. S. Army Corps of Engineers, Final Environmental Impact Statement, Orange Water and Sewer Authority, Cane Creek Water Supply Reservoir, Wilmington, N. C., May 1981.

U. S. Army Corps of Engineers, Office of the Chief of Engineers, 1980, Methodology for Areawide Planning Studies, User's Guide, Engineering Manual, EM 1110-2-502.