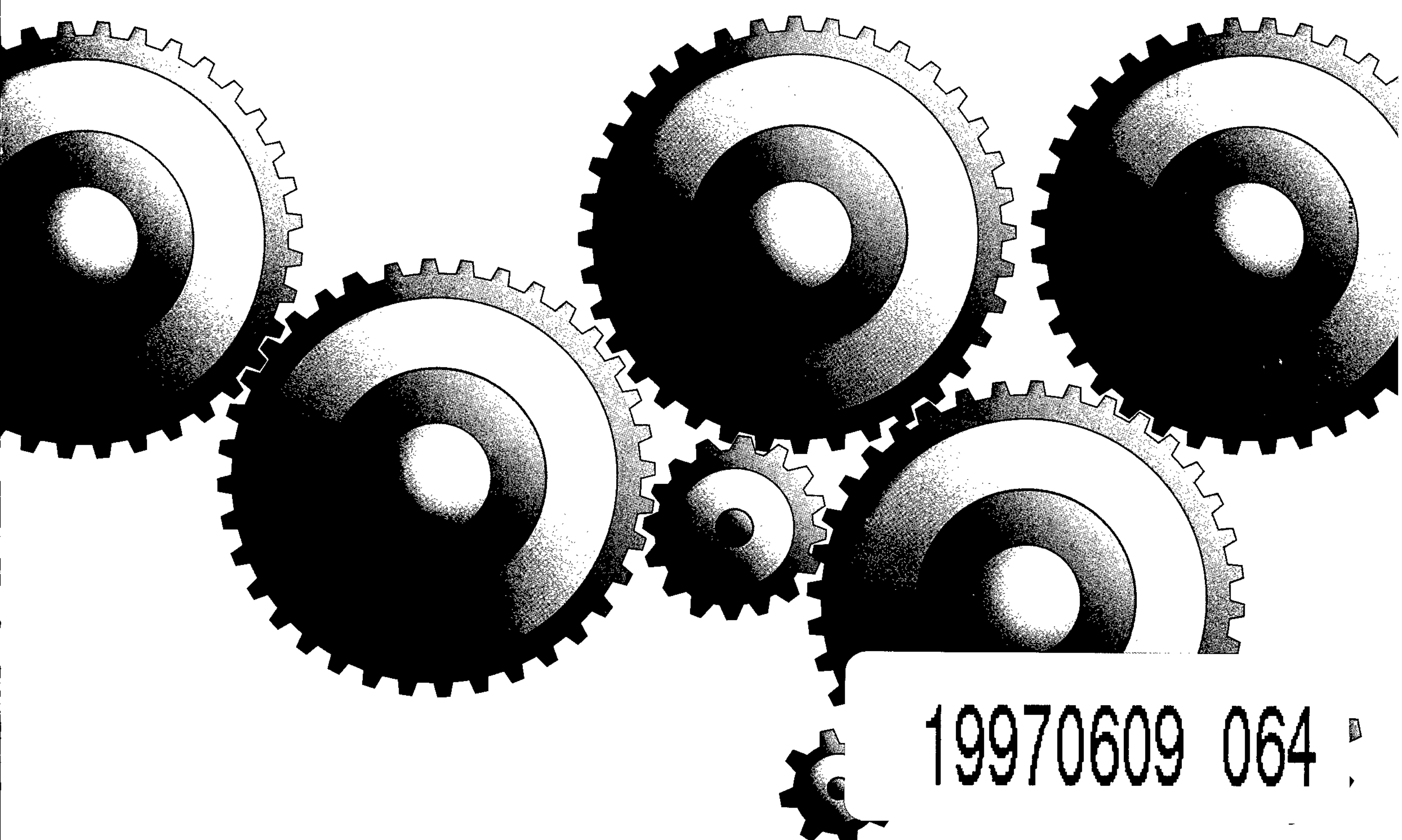
U.S. Army Corps of Engineers
Water Resources Support Center
Institute for Water Resources

Consolidated Performance Report on the Nation's Public Works: *An Update*



Federal Infrastructure Strategy Program

December 1994

IWR Report 94-FIS-13

Federal Infrastructure Strategy Reports

This is one in a series of reports prepared during the Federal Infrastructure Strategy (FIS) Initiative, an intergovernmental program exploring the development of an integrated or multi-agency federal infrastructure strategy. These documents have been used to facilitate the dialogue within the federal and non-federal infrastructure communities as policy deliberations continue. This report updates the results of an early product of the National Council on Public Works Improvement which provided the performance measurement construct for *Fragile Foundations*.

The FIS program will culminate with a summary report to be published later in 1994. The documentation contained herein is not intended to foreclose or preclude the program's final conclusions and recommendations. Within this context, comments are welcome on any of the FIS reports. Other reports in the series include:

Framing the Dialogue: Strategies, Issues and Opportunities (IWR Report 93-FIS-1);

Challenges and Opportunities for Innovation in the Public Works Infrastructure, Volumes 1 and 2, (IWR Reports 93-FIS-2 and 93-FIS-3);

Infrastructure in the 21st Century Economy: A Review of the Issues and Outline of a Study of the Impacts of Federal Infrastructure Investments (IWR Report 93-FIS-4);

Federal Public Works Infrastructure R&D: A New Perspective (IWR Report 93-FIS-5);

The Federal Role in Funding State and Local Infrastructure: Two Reports on Public Works Financing (IWR Report 93-FIS-6);

High Performance Public Works: A New Infrastructure Investment Strategy for America (ACIR Report SR-16);

Infrastructure in the 21st Century Economy: An Interim Report - Volume 1 - The Dimensions of Public Works' Effects on Growth and Industry (IWR Report 94-FIS-7);

Infrastructure in the 21st Century Economy: An Interim Report - Volume 2 - Three Conceptual Papers Exploring the Link Between Public Capital and Productivity (IWR Report 94-FIS-8);

Infrastructure in the 21st Century Economy: An Interim Report - Volume 3 - Data on Federal Capital Stocks and Investment Flows (IWR Report 94-FIS-9);

Local Public Finance Impact Model: User's Guide and Technical Documentation (IWR Report 94-FIS-10);

Corps of Engineers Technology Transfer: Nondestructive Testing, Evaluation, and Rehabilitation Strategies for Roadway Pavements, (IWR Report FIS-94-11);

High Performance Public Works: Sourcebook of Working Documents (ACIR Report SR-16S); and

Infrastructure Report Summaries (Second Edition) (IWR Report FIS-94-12).

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The Federal Infrastructure Strategy Program

CONSOLIDATED PERFORMANCE REPORT ON THE NATION'S PUBLIC WORKS: AN UPDATE

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ACKNOWLEDGMENTS

This report provides a compilation of current information collected by agencies and associated entities on various performance measures of selected infrastructure modes. The report was prepared as part of a broad administrative directive, facilitated by the U.S. Army Corps of Engineers and aimed at the development of a Federal Infrastructure Strategy (FIS).

The FIS program is being administered by the Corps as a collaborative interagency effort. Policy guidance for the program is provided by the Office of the Assistant Secretary of the Army (Civil Works) through Dr. Robert N. Stearns, Deputy Assistant Secretary for Project Management, while program execution is overseen by the Corps of Engineers Directorate of Civil Works through Mr. Donald Kisicki, Chief, Office of Interagency and International Activities.

The Corps Institute for Water Resources (IWR) has detailed management responsibility under the direction of Mr. Kyle E. Schilling, Director, IWR; Dr. Eugene Z. Stakhiv, Chief, Policy and Special Studies Division; Mr. Robert A. Pietrowsky, Program Manager for the Federal Infrastructure Strategy; and the FIS Study Team which includes Dr. Cameron Gordon, Economic Studies Manager and Mr. James F. Thompson, Jr., Engineering Studies Manager.

This report was prepared by Apogee Research, Inc., except for Chapters 1 and 2 which were written by Cameron Gordon. Dr. Gordon and Mr. Pietrowsky also edited the overall report.

While this report attempts to accurately capture existing information as collected by various infrastructure agencies, the Institute for Water Resources bears sole responsibility for the views expressed herein. It does not necessarily represent the official views or policies of the Department of the Army or the Corps of Engineers, and does not purport to represent the views of the Administration.

CONSOLIDATED PERFORMANCE REPORT ON THE NATION'S PUBLIC WORKS: AN UPDATE

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PURPOSE AND DATA OVERVIEW

PURPOSE

This volume, *Consolidated Performance Report on the Nation's Public Works: An Update*, is a revised and expanded version of a report commissioned by the National Council on Public Works Improvement (NCPWI) in preparation for the issuance of *Fragile Foundations*. Like that original report, this report provides information on the performance of infrastructure in the following selected categories:

- Highways, streets, roads and bridges;
- Airports and the nation's air traffic control system;
- Mass transit systems including light rail and buses;
- Community water supply systems;
- Municipal wastewater treatment facilities;
- Water resources development for flood control, inland navigation, and coastal ports;
- Solid waste management facilities including recycling, landfills, resource recovery units;
- Hazardous waste management facilities.

For data reporting purposes, this report retains the framework for performance measurement used in the 1987 report which was organized into five categories:

- Physical assets;
- Product or service delivery;
- Quality of service to users;
- Cost-effectiveness; and
- External effects.

Although data are still collected and reported across these categories, the thinking surrounding performance measurement has advanced. Most of the measures applied within the above categories deal with either *inputs* (physical assets) which are used to deliver goods and services, or *outputs,* which represent the goods and services themselves. Current thinking about performance emphasizes *outcomes*, which are changes in situations or states-of-the-world which citizens desire such a quality of life or mobility. Of the categories above, only external effects, which covers such things as pollution can be said to be an outcome measure.

This report attempts to update the findings of NCPWI's report by (1) extending the data set to include post-NCPWI information (1986-1990); (2) discussing recent changes in thinking about performance; and (3) providing a new framework under which the infrastructure programs considered here can be discussed. This new framework is outlined in Chapter 1 and applied broadly to the individual programs in Chapter 2.

DATA REFERENCE

A great deal of data are presented in this report for individual programs. Those interested in the details can consult the individual chapters organized by mode. To provide an overview for those interested in the broad picture, a ready reference is provided as part of this introduction. The discussion is divided into two parts:

Net Capital Stocks: If infrastructure programs are seen as investments, then the annual expenditures of these programs can be added up and adjusted appropriately to derive estimates of public capital stocks. In effect, these numbers represent the value of the capital investments which the public has made over time.

Selective Time Series Analysis: The net capital stocks are a summary measure of the value of programs. Most of the information available on infrastructure programs deal with particular aspects of programs at a particular point in time. Viewed over time (as a time series), changes in these statistics can indicate trends in program performance.

Both net capital stock measures and selective time series analyses are provided in the following pages.

NET CAPITAL STOCKS IN PUBLIC WORKS

While the rate of growth in capital assets does not necessarily reflect how well a given public works mode is performing, the value of the assets is important in relation to the level and quality of service provided. This discussion of trends in capital assets is, therefore, provided as an overview to the more detailed discussions included in subsequent chapters.

Capital Stock Estimation

Capital stocks are presented for the following categories:[1]

- Aviation (or Air Transportation);
- Highways;
- Mass Transit;

- Water Resources;
- Water Supply;
- Wastewater Treatment (or Sewerage); and
- Solid Waste Management.

Due to data limitations, capital stocks for hazardous waste are not constructed. Water resources capital stock is estimated from two different capital expenditure series: state and local government capital expenditures for water transport and terminals, from Census data; and U.S. Army Corps of Engineers expenditures for navigation, flood control, and multipurpose facilities (primarily hydro-electric power). Other federal level agencies that provide direct capital outlays for water resource related projects, such as the Bureau of Reclamation and Tennessee Valley Authority, are not included here due to lack of available data.

Aviation capital stock includes expenditures by all levels of government, federal, state, and local.[2] The remaining categories are estimated using only state and local government expenditures, as federal direct capital outlays in these areas are either minimal (highways) or zero. However, state and local government expenditures include all sources of funds, so that federal grants to state and local governments for the respective functions are included.

Net stock values presented in this report are prepared by Apogee using the perpetual inventory method, accumulating expenditure flows, in constant 1987 dollars, from 1932 to 1990.[3] Gross capital stocks are defined as the cumulative value of public works investment flows, less accumulated retirements, or discards. Net capital stock is the difference between cumulative gross stocks and cumulative decay. The amount of initial investment that decays over time depends upon the decay pattern and the useful life of the asset assumed in the calculation. For non-highway modes, useful lives are assumed to be 50 years for structures and 15 years for equipment, based upon BEA's assumptions for government nonresidential structures and equipment.[4] Highway investment is composed of expenditures for paving, grading, and structures, with useful lives of 14, 80, and 50 years, respectively.[5]

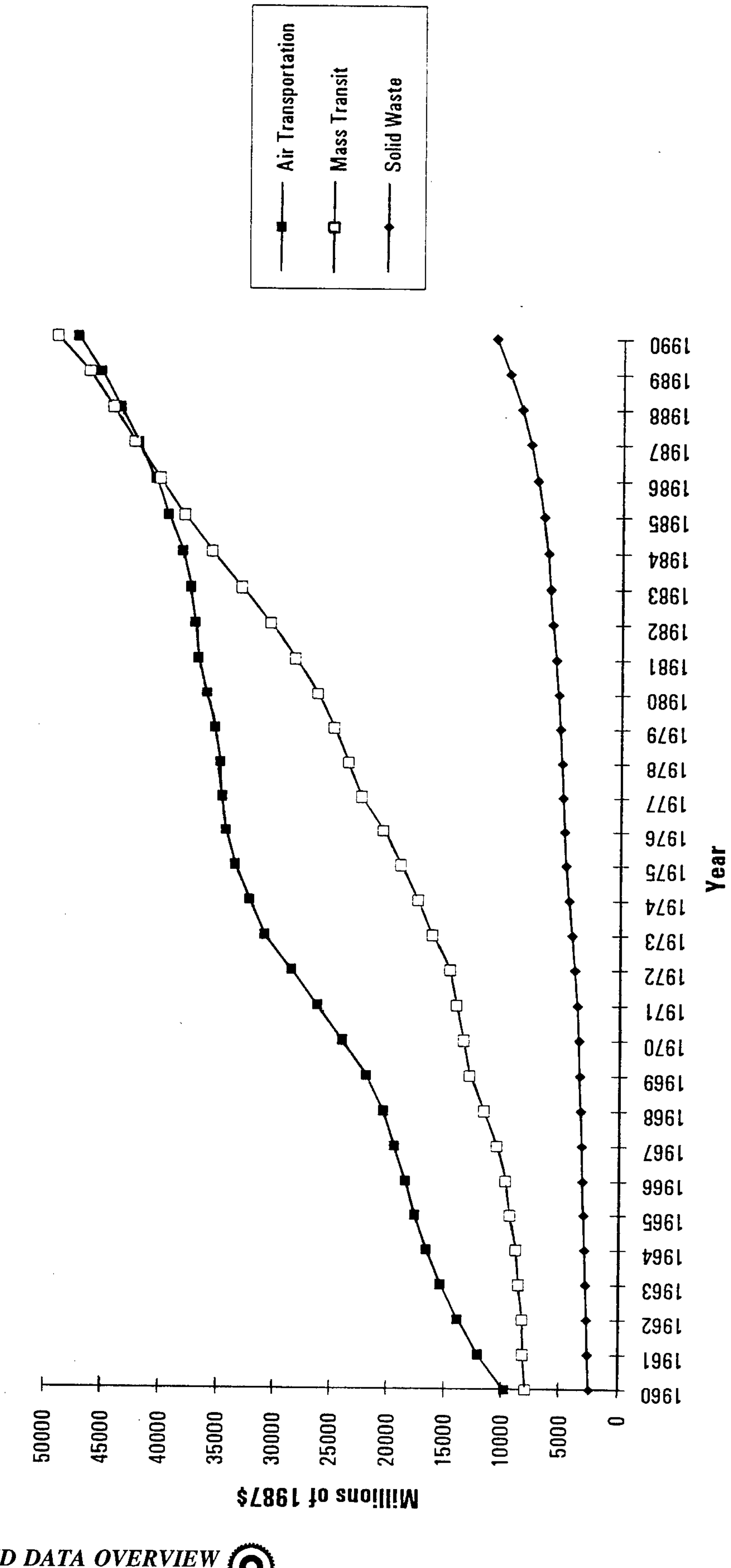
The capital stock series presented in this report are based upon a straight-line decay pattern, which assumes a constant rate of decay over the life of the asset. This assumption is employed by the Bureau of Economic Analysis, and is generally consistent with the methodology used to calculate asset values presented in the 1987 performance report.[6]

Growth and Distribution of Net Capital Stocks

From 1970 through 1985, total public works assets increased 19.2 percent in constant dollars, from \$713.7 billion to \$850.7 billion.[7] This represents an average annual growth rate of 1.3 percent. Annual growth in total assets from 1985 to 1990 averaged 2.0 percent, reaching \$939.3 billion in 1990. The growth of individual infrastructure categories also varies over these time periods, as indicated in Figures 1 through 4.

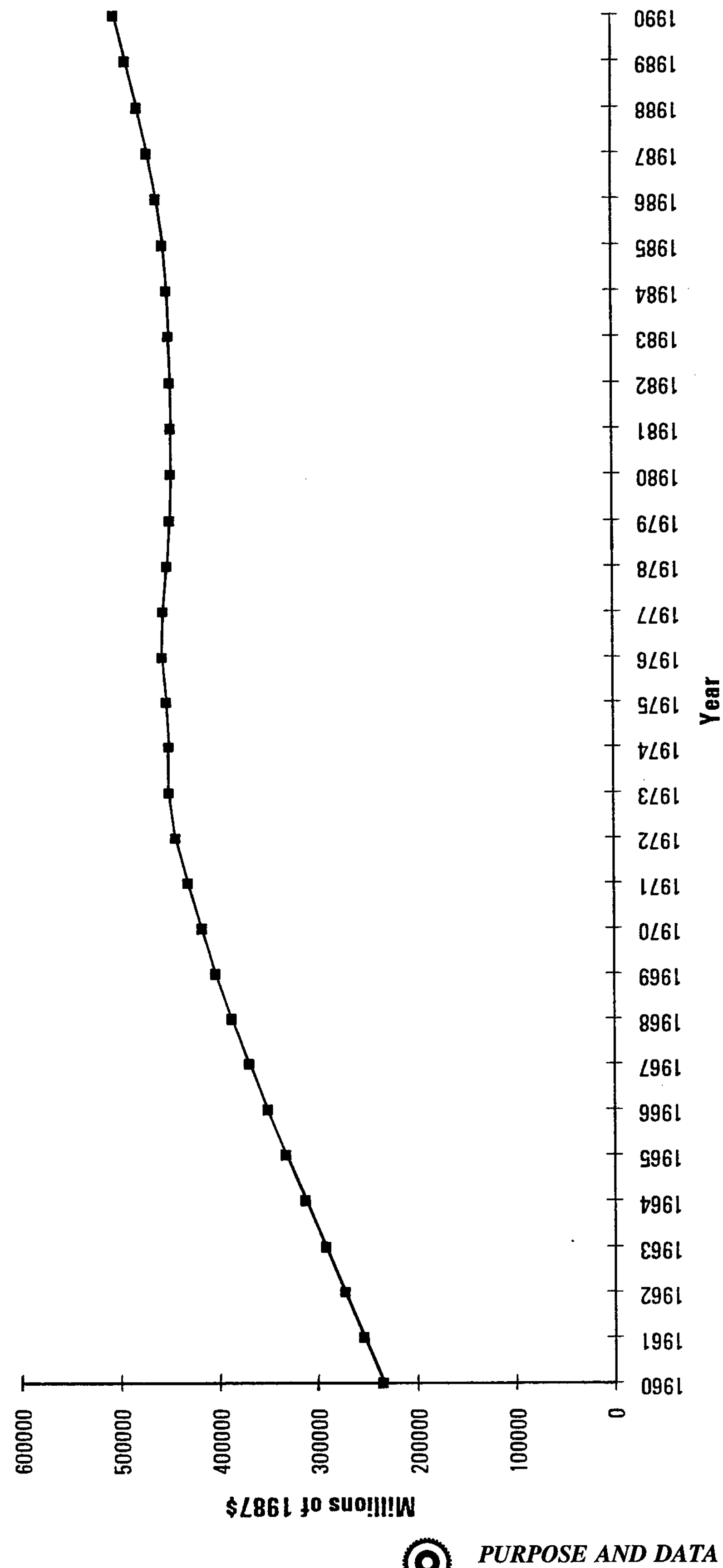
Air transportation capital stock rose from \$36.2 billion in 1980 to \$47.5 billion in 1990, a total of 31.1 percent. The increase in mass transit capital stock from 1980 to 1990 has been the most dramatic, rising from \$26.4 billion in 1980 to \$49.2 billion in 1990, or 86.3 percent (Figure 1).

Figure 1: Air, Transit, Solid Waste Net Capital Stock



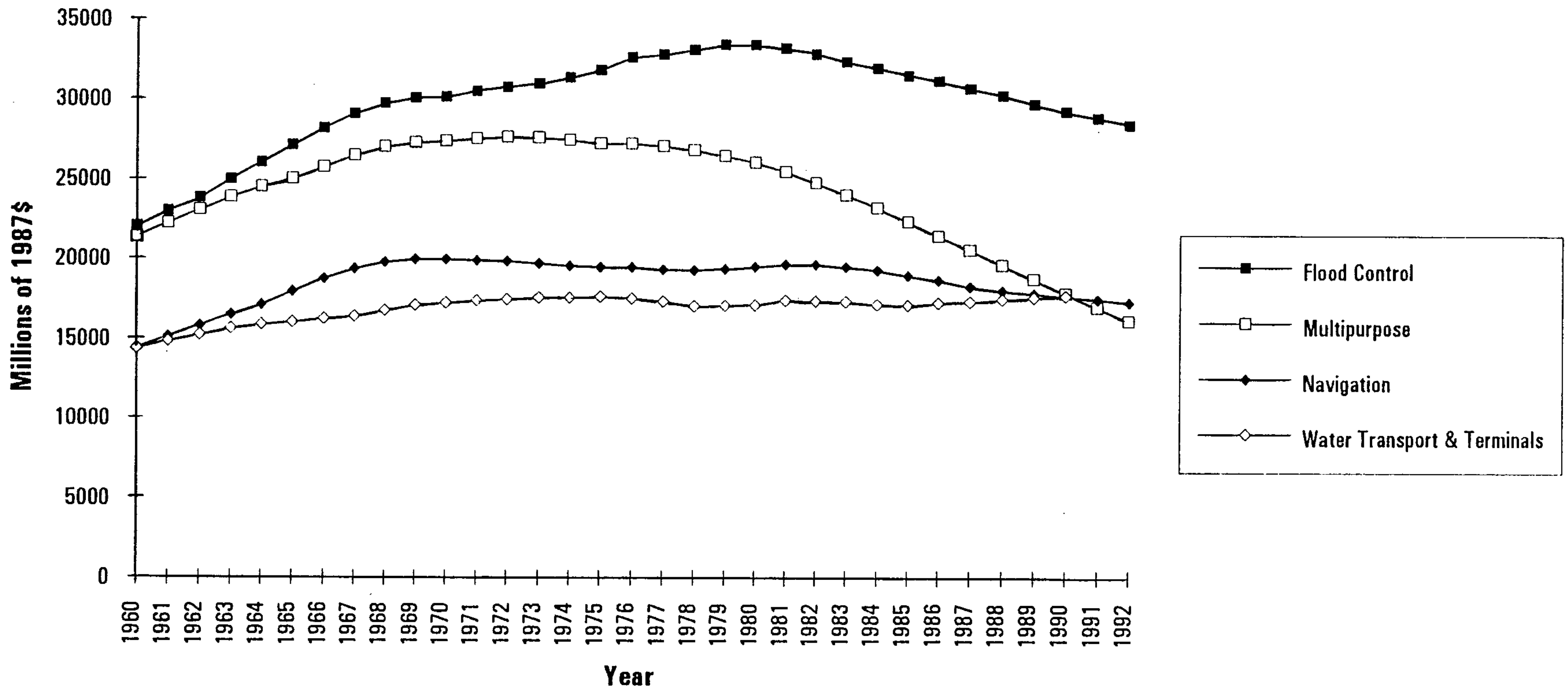
Source: Apogee Research, from Census Government Finances data

Figure 2: Highway Net Capital Stock



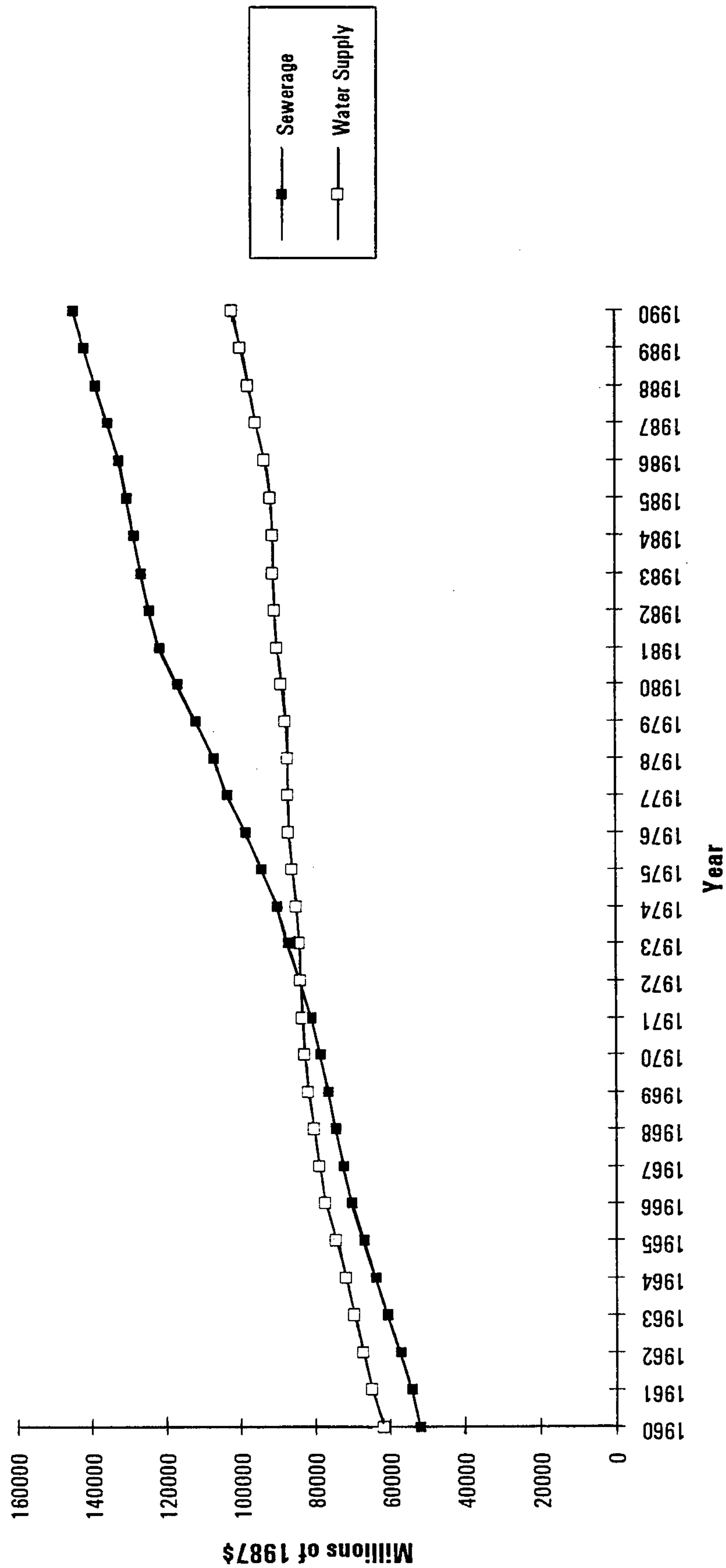
Source: Apogee Research, from Census Government Finances data

Figure 3: Water Resources Net Capital Stock



Source: Apogee Research, from U.S. Army Corps of Engineers and Census Government Finances data

Figure 4: Sewerage and Water Supply Net Capital Stock



Source: Apogee Research, from Census Government Finances data

As the Interstate Highway System became a reality through the late 1960s and early 1970s, net assets in highways grew rapidly (Figure 2). Highway net capital stock was 59 percent of total assets in 1970, for the categories listed above. The Interstate program peaked in the late 1970s, with highway assets showing some decline shortly thereafter as highway funding was diverted to repair and reconstruction of the existing system. As of 1980, highway's share of the total declined to 55 percent, and has remained relatively constant through 1990, with a share of 54 percent.

Total water resources, after increasing a total of only 1.5 percent from 1970 to 1980, have declined 14.2 percent through 1990 (Figure 2B-3).[8] Wastewater treatment (sewerage) has shown a substantial increase in net assets from 1970 to 1990, while growth in water supply capital stock was relatively flat through the 1970s and early 1980s (Figure 4). Wastewater treatment assets increased 65.6 percent from 1970 to 1985, while water supply assets increased only 10.9 percent over the same period.

While other infrastructure modes have exhibited more rapid growth through the 1980s, our nation's highways continue to comprise the dominant share of public capital stock (Figure 5). The distribution of assets as a percentage of total capital stock has changed little from 1985.

SELECTIVE TIME SERIES ANALYSIS

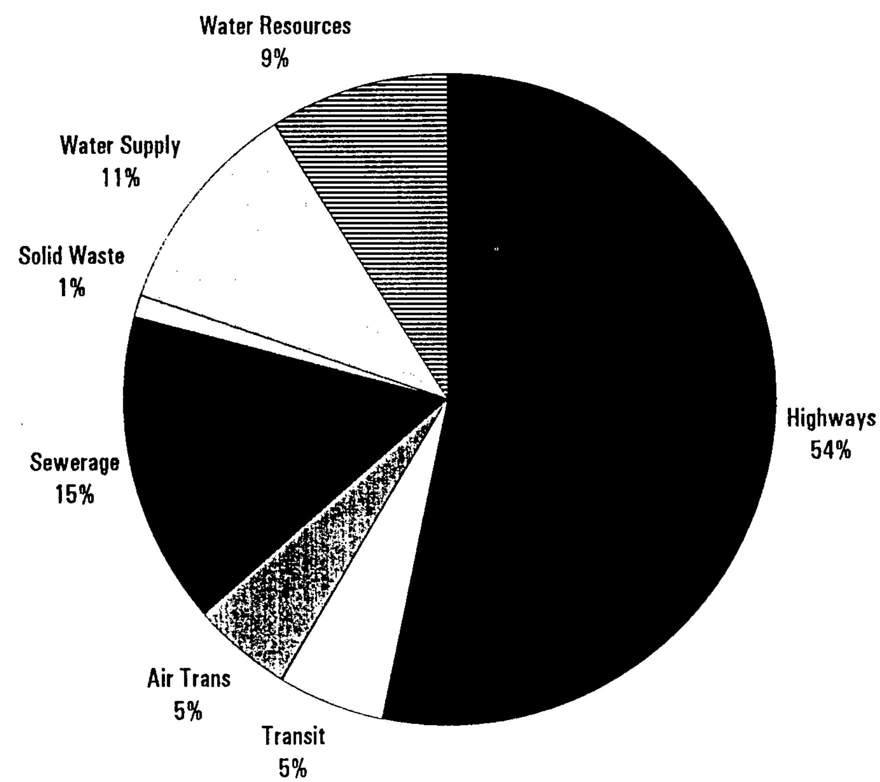
As discussed later in Chapter I, due to the public nature of the infrastructure categories considered in this study, a single performance measure does not adequately convey the multiple dimensions within each category. For this reason, multiple measures of performance are necessary to provide an overall assessment, including measures of inputs, outputs, and outcomes. In addition, the time period over which performance is measured impacts the perception of how well or poorly a particularly mode may be performing. The time period presented in this chapter focuses primarily on the period since the previous report. However, as data availability and length of time series available differs by mode and data element, some variation in time period cannot be avoided. The analysis presented concentrates on the time period 1985 to 1990, or later if available. This time period is intended to be representative of current conditions, as well as extending the time period presented in the 1987 report. If data for selected measures are not available for this time period, the most recent data are provided.

While a reasonably common time frame is useful for comparing performance measures both within and across modes, some data series fluctuate more than others over time; as a result, the average growth rates presented in the following tables may leave the impression of a smooth trend, when in fact that may not be the case. Thus, the summary tables below are not intended as a substitute for the more detailed information provided in the following chapters.

Tables 1 through 8 summarize performance measures for each mode. The summary measure provided in these tables is average annual rate of growth, in percentage terms, over the time period specified. This allows comparison of performance measures within a particular mode as well as across modes. However, not all performance indicators have adequately representative time series, suggesting the need for additional or improved data collection on the part of respective agencies and groups.

Generally, each performance category should be considered as parts of a whole, rather than separately, in order to best understand categorical performance. Together with the discussion of each mode that follows, these measures begin to portray an understanding of system status.

Figure 5: 1990 Distribution of Net Capital Stock



Source: Apogee Research

Aviation

The aviation system has responded relatively well to increasing demands for air service within the confines of limited capacity. Despite a recent slowdown in the growth of demand for airline travel, projected long term growth in demand suggests that capacity limitations may present problems in the future. Declining airline revenues per passenger mile (1987 dollars) continue as large operating losses and mergers work to consolidate the number of commercial airlines.

Because of the lengthy time period required for the planning and construction of airport facilities, capacity enhancement is a difficult and expensive process. To compensate for this, airports have recently been building more runways and using existing facilities more efficiently, including technological advancements in air traffic control. In addition, many of these expenditures have been targeted to reliever airports that provide an alternative to more congested commercial airports. However, as air demand continues to grow, further capacity enhancements will be required.

As shown in Table 1, growth in net capital stock and commercial fleet size have exceeded growth in the number of airports. Enplanements and passenger miles have grown at moderate rates, while growth in domestic air cargo, in ton-miles, has been strong from 1985 to 1991. As passenger miles and aircraft operations (takeoffs and landings) have grown, so have delays. Delays cost consumers and the airline industry millions each year and directly reflect a quality of air service. However, not all delays are due to factors within control of airport and airline authorities, and are often required for safety reasons -- the percentage of delays over 15 minutes attributed to weather have increased an average of three percentage points per year from 1985 to 1990.

Highways

Passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) has changed the management and financing environment of the nation's highway system. While ISTEA will have limited near term impact on highway funding, and transportation funding in general, local governments and non-highway groups will have input into transportation planning.

The overall performance of the highway system is mixed. During the 1960s, while the country was constructing the Interstate Highway System, net highway capital stock grew continuously and at a rapid pace. As the Interstate system neared completion in the late 1970s, the accumulation of net capital stock slowed, and even declined in the early 1980s. However, because of expenditures made possible through the federal five-cent tax increase on motor fuels and similar increases by state and local bodies, net capital stocks are once again increasing (Table 2).

The growth in net capital stock is reflected in recent increases in highway route-miles and lane-miles. However, the growth of highway lane-miles differs between rural and urban areas; lane-miles in rural areas have actually declined in recent years, while urban lane-mileage is increasing slightly, corresponding to increased use of the urban system. In fact, travel in urban areas has increased beyond the capacity of the system in several cities, resulting in higher rates of traffic congestion. While system use is increasing, measured in terms of vehicle-miles (VMT) and ton-miles of travel, the number of fatalities per 100 million VMT is declining.

Capital outlays (1987 dollars) per vehicle mile of travel have increased only slightly from 1985 to

1991, while maintenance expenditures per VMT have declined over this same period. However, the percentage of urban Interstate pavement rated in poor condition has actually declined from 1985 to 1991. These trends suggest several possible factors at work: maintenance dollars are being spent more efficiently; improvements in highway construction technology may require less maintenance; or, alternatively, it may indicate a public sector unwilling or unable to invest in highways to meet the growing use of the highway system.

Mass Transit

For decades, changes in urban form and increases in personal income have favored automobiles at the expense of mass transit and, for decades, all measures of transit's condition pointed downward. In recent years however, some, though by no means all, performance measures have shown signs of recovery. Annual ridership, as measured by unlinked passenger trips, was at its lowest in 1972, at 6.6 billion, and has since climbed to 8.7 billion in 1991, an overall increase of 32 percent. Labor productivity, measured by the number of vehicle miles per employee, has increased from 10,300 in 1985 to 11,900 in 1991. Service areas have expanded, assets repaired, and service quality upgraded. The number of public transit vehicles quadrupled from 1960 to 1991. The age of the transit vehicle fleet has fallen from 10.9 years in 1981 to 9.1 years in 1990, reducing the share of vehicles which are beyond their useful service life. The number of light and heavy rail transit systems has doubled since 1974, and the number of route miles of track has increased 54 percent since 1981. Generally, the number of accidents, injuries, and fatalities per mile traveled have declined since 1984.

These gains have come at the cost of increased operating expenses and several decades of massive capital investment. Net mass transit capital stock increased 5.2 percent from 1985 to 1990, exceeding ridership, labor productivity and service growth. Although operating costs per VMT declined from 1985 to 1991, growth in capital assets and vehicle miles traveled exceeded growth in passenger trips and passenger miles. These factors contribute to increases, in real terms, in operating costs per passenger mile traveled, and per passenger trip, from 1985 to 1991. While it is difficult to say what proportion of capital investment represents improvements in asset quality, it is not clear that these assets are used as efficiently as in the past.

Water Resources

Measuring the historical performance of the nation's water resources development program is difficult because of the wide spectrum of services delivered. Broadly defined, water resource programs consist of services that support domestic and foreign and waterborne commerce (ports and inland waterways); prevent or contain natural hazards affecting land, property, and lives (flood control, urban drainage, dam safety, shoreline and streambank protection); enhance crop production (irrigation and agricultural drainage); produce electricity (hydropower); and provide water-related recreation as well as enhancement to fish and wildlife habitat areas. The facilities that provide these services include a vast number of ports, locks, dams, levees, channels, breakwaters, storm sewers, and other drainage facilities. Compounding the analysis is the fact that a single facility -- a multi-purpose dam, for example -- can be designed to deliver a multitude of services such as water supply, flood control, hydropower, recreation, and others. As with the previous performance report, this report singles out flood control (the U.S. Army Corps of Engineers' program only) and navigation (coastal ports and inland waterways) for detailed study.

Federal water resources programs operate under policy guidelines that define federal interest in financing the development of various types of projects. The 1986 Water Resources Development Act (the WRDA of 1986) set forth new policies for sharing project planning and construction costs between the federal government and project sponsors. Under the WRDA of 1986, local sponsors finance up to 60 percent of the cost of navigation projects and up to 25 percent of flood control projects with mandatory non-federal contributions during the construction period. Local governments pay for half the costs of project feasibility studies that were at one time fully federally financed.

Flood Control. As previously shown in Figure 3, net capital stock in flood control facilities has declined since the late 1970s, as the Corps' completed many of their large projects. Flood control capital stock includes local protection and reservoirs. The number of flood control reservoirs has increased minimally from 1985 to 1991, as has flood storage capacity (Table 4).

From 1982 to 1992, Corps' flood control projects prevented $141 billion (1987$) in potential flood damages at a total cost of over $14 billion for construction and operations and maintenance (1991$). Damage prevented from 1982 to 1992 averaged $12.8 billion per year, in real terms. During this same period, floods caused approximately $22.8 billion in damages, resulting in the death of over 1,100 persons. From 1985 to 1992, annual flood damages averted averaged $11 billion per year, while flood damages sustained averaged $1.6 billion. During this period, in effect, Corps flood control structures prevented 87 percent of total damages that could have occurred from floods, excluding damages sustained during the 1993 flooding of the Mississippi and Missouri Rivers. While many of the 313 Corps major flood control reservoirs in operation today are over 50 years old, dam safety data suggest that the integrity of the Corps' structures is basically sound.

Navigation. Capital expenditures for navigation includes two primary divisions: channels and harbors, consisting primarily of deep draft dredging; and inland waterways, which consist of locks and dams. Physical capital stock in navigation has shown little growth through the 1970 and 1980s, declining somewhat from 1985 to 1992. Capital stock in multipurpose facilities, including hydro-electric power generation, has also declined during this time period. There has been little or no growth in the number of terminals, ports, or berths from 1985 to 1992.

State and local government financed capital stock in water transportation and terminals includes the provision and construction of public waterways and harbors, docks, wharves, and related marine terminal facilities.[9] Net capital stock of these facilities has increased a mere 0.67 percent from 1985 to 1990, and was very stable throughout the 1970s and 1980s.

Performance of the nation's navigation system is based on the ability of private and public investments to meet the country's demand for waterborne transport of bulk and containerized goods. Considering this goal, the nation's system appears to have performed well over the past several years. Total tonnage carried on the inland waterway system increased by slightly more than two percent per year from 1985 to 1992. While ton-miles traveled increased almost four percent annually from 1985 to 1989, the cost per ton-mile declined by almost one percent annually from 1982 to 1990. Cargo tons handled by coastal ports and Great Lakes ports have increased 5.6 percent and 3.3 percent, respectively, from 1985 to 1989. As commercial traffic increases, there are continuing concerns regarding the effects of aging locks on inland waterway performance, congestion at selected facilities, and the need for deeper coastal ports to handle larger ships.

Wastewater Treatment

Available data portray conflicting trends in the performance of wastewater treatment facilities. Physical assets have generally increased during the 1980s, although at very moderate rates (Table 5). Net capital stock increased 1.12 percent per year from 1985 to 1990, while growth in the number of collection systems and treatment plants has been less than one percent per year from 1982 to 1988. The volume of wastewater treated in the U.S. increased by slightly more than one percent a year from 1982 to 1988.

While the volume of wastewater treated has grown, corresponding in large part to the growth in physical assets, expenditures for operations and maintenance per unit of wastewater treated have increased at a more rapid rate during the same time period, 1982 to 1988. Although cause is unclear, possible explanations for this trend include decreasing labor productivity, operation of treatment plants below capacity, greater use of maintenance-intensive technologies, and growth in chemical and energy expenses over and above inflation. These explanations are partly supported by the unequal growth in the asset base in relation to volume treated as well as the trend toward more biological and chemical treatment of wastewater. An important indicator of wastewater treatment performance exemplifies this inconclusive picture: in the 1970s and early 1980s, trends suggest that ambient water quality remained largely the same; since then, trends indicate improvement in ambient water quality, although the amount attributable to wastewater treatment is unknown.

Water Supply

As indicated in Table 6, relatively little data and few analyses are currently available to evaluate the performance of community water facilities on a nationwide basis. Those few statistically significant samples of the nearly 60,000 water systems in the U.S. reveal a largely self-sufficient cross-section of publicly and privately owned utilities, the majority of which produce a high-quality product at reasonable cost. Since the last performance report, there has been little improvement in water supply losses at water supply facilities, and a continuation of the trend of increased personal water consumption. Nationally, average annual growth rate in net capital stock is 2.1 percent from 1985-1990.

A recent report by the Natural Resources Defense Council presents a less than optimistic picture of the country's public water supply.[10] The report represents the results of an extensive investigation into the extent of drinking water contamination in this country. Some of the problems cited by the report include:

- A breakdown in compliance with the Safe Drinking Water Act;
- Underestimates of the extent of noncompliance with the SDWA;
- Failure by the EPA to enforce the SDWA, and the health risks posed by this failure; and
- Outdated, and decaying water supply infrastructure.

While data presented in Table 6 indicate an increase in the percentage of systems in compliance with SDWA, the NRDC suggests that data of this type is subject to underestimation of the true compliance problem. In addition, while net water supply capital stock has shown an increasing trend, NRDC raises concerns regarding the quality of existing stock in terms of physical condition, and the use of advanced water treatment technology.

Revisions to the SDWA in 1986 strengthened drinking water regulations. This likely contributed to an increase in reported noncompliance, as water supply systems attempted to adjust to the new rules. To assist small water supply systems in complying with the more stringent regulations, NRDC recommends technical assistance be provided, as well as help with system consolidation and regionalization.

Solid Waste Management

Solid waste management has changed rapidly over the last decade due to new environmental regulations, technological innovation, and evolving waste management priorities and economics. Per capita municipal solid waste (MSW) generation increased from 2.7 pounds per person per day in 1960 to 4.3 pounds per person per day in 1990, a trend that is expected to continue. Since 1987, almost every state and many local governments have introduced legislation to reduce solid waste generation through source reduction, reuse, and recycling. In addition, federal and state governments have imposed stringent regulatory requirements on MSW landfills and combustors. These regulatory and legislative trends toward waste reduction and environmentally sound disposal have improved the quality of waste management in the United States at the expense of higher waste management costs.

Recovery of MSW for recycling and composting increased from 10 to 17 percent from 1985 to 1990. Combustion capacity increased from 42,760 tons per day in 1985 to 97,121 tons in 1990, more than 14 percent per year (Table 7). While almost half of the nation's MSW landfills have closed since 1984, actual landfill capacity has remained roughly the same as large, regional landfills replace smaller, municipal facilities that cannot meet new federal regulatory requirements. Per ton management costs have increased significantly the last few years due to stringent environmental regulations on disposal facilities and the shift from land disposal to alternative waste management techniques such as combustion, recycling, and composting.

Remaining challenges for solid waste management planning include difficulties associated with siting a disposal facility, the weak demand for recyclables, and lack of cost data regarding specific components of waste management. Improved data for relative costs of alternative waste management techniques would assist local planners in developing and implementing cost-effective integrated waste management plans.

Hazardous Waste Management

An assessment of the overall performance of hazardous waste management is severely constrained by a lack of performance data on a national level. The EPA only started collecting comprehensive data on hazardous waste generation and management activities in 1987, and this data is only available for 1987 and 1989 (Table 8). In 1989, a total of 197.5 million tons of hazardous waste regulated under the Resource Conservation and Recovery Act (RCRA), the major environmental statute regulating the generation and disposal of hazardous waste in the United States, were generated nationwide by 20,233 large quantity generators. The EPA reported approximately 196.5 millions tons of hazardous waste were managed in 3,078 treatment, storage, and disposal facilities (TSD). The private sector spent roughly $2.379 billion in 1989 to manage hazardous waste.

Federal expenditures on hazardous waste compliance and cleanup have increased dramatically the last few years; for example, the federal government will spend over $10.5 billion in 1993 for the

Superfund and Leaking Underground Storage Tank (LUST) programs and federal facility hazardous waste cleanup and compliance activities. federal agency expenditures for facility cleanup and compliance increased threefold from 1989 to 1993, from $3.019 billion to $9.9 billion, in nominal terms.

However, little data are available on the environmental, health, and economic impacts of hazardous waste management expenditures or the relative cost-effectiveness of different cleanup and compliance strategies. Therefore, it is difficult to measure the quality of service or investment efficiency of hazardous waste management infrastructure. Data of this type are necessary to ensure that private and public investments are utilized cost-effectively.

TABLE 1: ANNUAL RATES OF GROWTH: AVIATION PERFORMANCE

Performance Indicators	Annual Growth Rate	Years
Physical Assets:		
Number of Airports	1.40	1988-1992
Commercial Fleet Size	4.80	1986-1992
Net Capital Stock	3.70	1985-1990
Service Delivery:		
Revenue Passenger Enplanements	1.40	1987-1992
Domestic Revenue Passenger Miles	2.80	1986-1992
Revenue Ton-Miles, Total Domestic Air Cargo		
Aircraft Operations at FAA	6.08	1985-1991
Towers:		
Air Carrier	1.72	1985-1991
General Aviation	0.18	1985-1991
Quality of Service:		
Delay:		
Percent Change in Avg Minutes Delay	2.1	1983-1990
Percent Delays Over 15 Minutes		
Attributed to Weather	3.0	1985-1990
Fatalities per Passenger Mile	NA	
Cost Effectiveness:		
Passenger Load Factor	0.11	1985-1991
Revenue per Passenger Mile	-3.16	1985-1991
(1987 dollars)		

TABLE 2: ANNUAL RATES OF GROWTH: HIGHWAY PERFORMANCE

Performance Indicators	Annual Growth Rate	Years
Physical Assets:		
Route-Miles	0.13	1985-1991
Lane-Miles	0.15	1983-1990
Net Capital Stock	2.00	1985-1990
Motor Vehicle Registrations	1.50	1985-1991
Service Delivery:		
Vehicle-Miles Traveled	3.40	1985-1991
Passenger-Miles Traveled[1]	1.60	1977-1990
Ton-Miles Traveled	5.10	1982-1991
Quality of Service:		
Percent Urban Peak-hour Traffic Occurring Under Congested Conditions	2.30	1984-1990
Percent Urban Interstate Pavement in Poor Condition	-0.60	1985-1991
Number of Fatalities per 100m VMT	-4.26	1985-1991
Cost Effectiveness:		
Expenditures/Net Capital Stock:		
Capital Outlays	2.80	1985-1990
Maintenance	-1.82	1985-1990
Expenditures/GDP:		
Capital Outlays	-0.89	1985-1991
Maintenance	-1.62	1985-1991
Expenditures/Vehicle-Miles of Travel:		
Capital Outlays	0.53	1985-1991
Maintenance	-2.45	1985-1991

1 The definition of number of passengers per vehicle has changed over time; therefore, vehicle miles of travel is likely a more useful measure of service delivery.

TABLE 3: ANNUAL RATES OF GROWTH: MASS TRANSIT PERFORMANCE

Performance Indicators	Annual Growth Rate	Years
Physical Assets:		
Net Capital Stock	5.2	1985-1990
Number of Employees	1.7	1983-1991
Number of Transit Systems	2.3	1984-1991
Number of Vehicles:		
Active Passenger	-0.5	1984-1991
Light Rail	8.7	1986-1991
Trolley Buses	6.2	1986-1991
Directional Route Miles:		
Heavy Rail Track	5.8	1981-1990
Light Rail Track	2.9	1981-1990
Service Delivery:		
Vehicle Miles Traveled (VMT)	3.08	1985-1991
Passenger Trips	0.01	1985-1991
Passenger Miles	0.53	1985-1991
Load Factor (Trips/VMT)	-2.47	1985-1991
Operating Cost (1987 dollars) per:		
VMT	-1.66	1985-1991
Passenger Mile	0.88	1985-1991
Passenger Trip	1.35	1985-1991
Quality of Service:		
Accidents per Million Vehicle Miles:		
Bus	-6.70	1984-1990
Light Rail	-9.40	1984-1990
Injuries per Million Passenger Miles:		
Bus	-6.10	1984-1990
Light Rail	-15.6	1984-1990
Fatalities per Billion Passenger Miles:		
Bus	1.50	1984-1990
Light Rail	-22.3	1984-1990
Frequency of Maintenance Road Calls	([1])	
Waiting Time, Transfer Rate, Standees	([1])	
Investment Efficiency/Externality:		
Revenue Vehicle Miles per Employee	2.35	1985-1991
Passenger Miles per Employee	-0.18	1985-1991
Passenger Miles per Dollar of Net Capital Stock	-4.50	1985-1990
Transit Bus Passenger Miles per Gallon	-2.50	1984-1990

1 Time series data not available.

TABLE 4: ANNUAL RATES OF GROWTH: WATER RESOURCES PERFORMANCE

Performance Indicators (Flood Control)	Annual Growth Rate	Years
Physical Assets:		
Navigation Net Capital Stock	-1.30	1985-1992
Number of Flood Control Reservoirs	0.54	1985-1991
Service Delivery:		
Flood Storage Capacity	0.24	1985-1991
Population of Protected Communities	Recent Data not Available	
Quality of Service:		
Flood Damages Averted[1]	$11 billion/yr	1985-1992
Flood Damages Sustained	$1.6 billion/yr	1985-1992
Flood-Related Deaths	93 per year	1985-1992
Cost Effectiveness:		
Ratio of Annual Flood Damages Averted to Amortized Capital Expenditures for Flood Control	Avg ratio of 9.0	1985-1991
Physical Assets:		
Number of Ports	0.00	1986-1990
Number of Terminals	1.00	1986-1990
Number of Berths	1.32	1986-1990

Performance Indicators: (Ports and Harbors)	Annual Growth Rate	Years
Service Delivery:		
Cargo Tons Handled by Ports:		
Coastal Ports	5.60	1985-1989
Great Lakes Ports	3.30	1985-1989
Quality of Service:	NA	
Cost Effectiveness:		
Unit Cost to Dredge Cubic Yard of Sediment (1987 dollars)	2.24	1985-1992

[1] Damages averted and sustained vary annually due to location, flood control structure, and rainfall. Due to the weather dependent variation of these measures, quality of service for this section is in terms of average annual values, as opposed to growth rates.

TABLE 5: ANNUAL RATES OF GROWTH: WASTEWATER TREATMENT PERFORMANCE

Performance Indicators	Annual Growth Rate	Years
Physical Assets:		
Number of Collection Systems	0.64	1982-1988
Number of Treatment Plants	0.17	1982-1988
Capacity of Treatment Plants (mgd)	1.09	1982-1988
Percentage of National Population Served	1.18	1982-1988
Net Capital Stock	2.12	1985-1990
Service Delivery:		
Volume of Wastewater Treated	1.12	1982-1988
Quality of Service:		
Ambient Water Quality[1]	NA	
Percent of Municipal Treatment Facilities in Significant Compliance with Effluent Limits[2]	8.5	1984-1990
Worker Safety:		
Injury Frequency Rate	-2.40	1982-1988
Injury Severity Rate (days lost per million man hours)	1.50	1982-1988
Cost Effectiveness:		
Operations and Maintenance Expenditures per Unit Volume Treated	4.85	1982-1988

[1] Although no detailed data exist on the effects of wastewater treatment to water quality improvement, trends suggest some improvement.

[2] Includes changes in NPDES rules.

TABLE 6: ANNUAL RATES OF GROWTH: WATER SUPPLY PERFORMANCE

Performance Indicators	Annual Growth Rate	Years
Physical Assets:		
Net Capital Stock	2.10	1985-1990
Miles of Distribution Systems	2.76	1983-1990
Treatment Plant Capacity	-2.98	1981-1990
Storage Distribution Capacity	-8.33	1981-1985
Service Delivery:		
Finished Water per Person Served	2.57	1984-1990
Quality of Service:		
Percent of Systems in Compliance with Drinking Water Standards	0.47	1985-1992
Incidence of Disease	([1])	
Water Leakage	([2])	
Water Main Breaks	([3])	
Cost Effectiveness:	NA	

1 Slight increase during the 1971-1992 period, but most experts largely attribute this to more active surveillance.

2 1980 and 1985 AWWA surveys report similar leakage rates in U.S. cities. According to 1992 AWWA survey, unaccounted for water was 15 percent of total production.

3 Survey data indicate no significant increase in water main breaks over the past 15 years (1978-1993).

TABLE 7: ANNUAL RATES OF GROWTH: SOLID WASTE PERFORMANCE

Performance Indicators	Annual Growth Rate	Years
Physical Assets:		
Number of:		
Landfills	-9.20	1988-1992
Curbside Recycling Programs	50.9	1988-1992
Compost Facilities	46.3	1988-1992
Waste-to-Energy Facilities	10.6	1985-1992
Municipal Waste Combustion Capacity (tons per day)	14.3	1985-1992
Net Capital Stock	10.15	1985-1990
Service Delivery:		
Municipal Solid Waste Generation and Management	3.5	1985-1992
Cost Effectiveness:[1]		
Landfill Tipping Fees (per ton)	9.4	1991-1992

[1] New RCRA Subtitle D requirements and 1990 Clean Air Act Amendments, designed to minimize environmental and health risks associated with solid waste disposal, go into effect in 1993 and 1994.

TABLE 8: ANNUAL RATES OF GROWTH: HAZARDOUS WASTE PERFORMANCE

Performance Indicators	Annual Growth Rate	Years
Physical Assets: Number of RCRA Hazardous Waste Generators	7.25	1987-1989
Number of Treatment, Storage, and Disposal (TSD) Facilities	-3.5	1987-1989
Service Delivery: Tons of RCRA Hazardous Waste Generated	-8.5	1987-1989
Quality of Service[1]		
Cost Effectiveness[2]		

1 National level data measuring the impact of hazardous waste cleanup and compliance on environmental and health risks are not available.

2 Data are not available to measure the cost-effectiveness of hazardous waste cleanup and compliance.

CONSOLIDATED PERFORMANCE REPORT ON THE NATION'S PUBLIC WORKS: AN UPDATE

CHAPTER I: A FRAMEWORK FOR MEASUREMENT AND MANAGEMENT OF PERFORMANCE IN PUBLIC WORKS SYSTEMS

INTRODUCTION AND OVERVIEW

Performance is a concept often difficult to define. However, whether one is talking about the way in which a business is managed or an automobile runs, performance is a lot like the Supreme Court's definition of pornography: you know it when you see it.

You also often know it when you don't see it. That is why performance is important. For if something doesn't perform well or at all, the consequences can be serious. Thus the factors which affect performance are of interest to policymakers, since if they can be understood, they may potentially be manipulated to lead to better outcomes and avoid failures.

Government has a special challenge in identifying and managing improvements in performance. Unlike a private enterprise producing goods or services for sale in the marketplace, government output is often difficult to measure, and the effects of a particular policy on a given problem can be esoteric. Moreover, even when a particular course of action is suggested, public agencies may have difficulty in pursuing such a course due to external constraints or institutional rigidities.

Despite these challenges, a performance drive has come to Washington, D.C. Starting with the National Performance Review, continuing with the Government Performance and Results Act of 1993 (both described later in this chapter), and driven by a general perception that the public sector is not working like it is supposed to, the desire to impose a results-orientation on government has taken firm root.

DEFINING PERFORMANCE

What exactly is performance and how is good performance achieved in a public sector setting? First, one must start by defining one or more **goals** or objectives which are expected or desired. If there is nothing to be accomplished, then by definition the performance of an organization has little interest or meaning.

Having defined a goal, there must then be some sense of knowing when and if the goal is being achieved. Critical to such a measure is the articulation of a **standard or benchmark of comparison** which allows an assessment of whether goals are being met.

Then there comes the actual attainment of the specified goals. Thus an **ability and means for taking actions** which can move events forward and result in changes in circumstances from whence one began must be identified. Such a means of action require **inputs** (resources), such as funding, employees, machines, and facilities, in order to create **outputs** (projects), such as the building of a bridge, dredging of a harbor, or the paving of an airport runway.

Achieving output is desirable, but not as an end in itself. As mentioned above, performance is always defined with respect to some goal, implying that the final **outcome** of a set of actions is what is desired. Outputs, such as waterway canals, are a means towards achieving outcomes such as enhanced mobility of goods and people.

PLANNING FOR PERFORMANCE

In actual practice, the achievement of performance, even in private organizations, can be quite difficult. Successful mobilization of inputs to create outputs which then influence outcomes takes time and effort and careful planning. The setting of goals and implementation of means can be organized into different stages loosely conforming to the temporal stages in the decisionmaking process. These stages could be described in the following way:

Planning/Budgeting:	Define mission Identify business functions Set long-term goals Identify constraints Identify organizational priorities Identify and select alternatives/strategies
Financing:	Identify and secure funds
Managing/Control:	Generate and validate performance measures Develop benchmarks Implement performance measurement system and collect data Implement strategies Keep organization functioning
Outcomes:	Monitor and assess results Measure goal achievement Repeat process, adjust goals, reassess and benchmark

Because decisions are so multifaceted, different strategies for achieving performance will often be necessary for different situations. Also, performance can be measured and managed over the whole decisionmaking cycle or only one specific stage of it: there is no "one-size-fits-all". Thus strategies for improving performance will vary. Some strategies can and must focus primarily on improving available information. Other strategies must focus on actions on the ground as well.

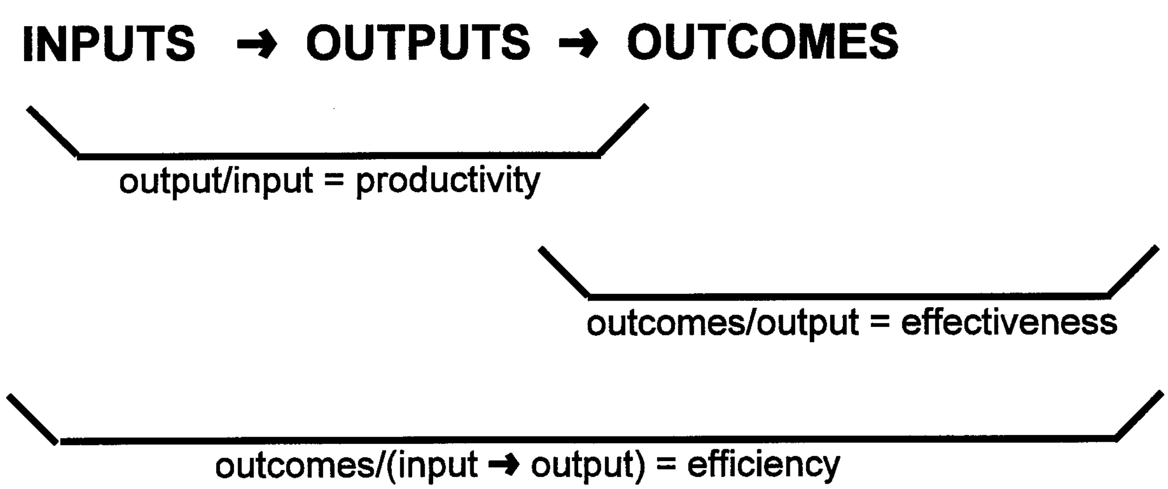
PERFORMANCE MEASUREMENT CONCEPTS

The simplest ways of measuring performance involve quantifying inputs and outputs. Input measures quantify the resources consumed by a program, while output measures emphasize the program's direct products. To aid in measuring and managing performance, a number of concepts are often applied. One important idea is **productivity**. Productivity simply measures the amount of output delivered for a given unit of input. The more output which a given amount of input can turn out, the greater the organization's productivity.

A broader idea than productivity is **effectiveness**. Effectiveness is doing the right things well. It measures how close an organization gets to achieving its stated goals, i.e. how much its inputs-to-outputs have resulted in changed outcomes. An organization may be productive but not very effective. For example, a transportation agency may implement its program very rapidly and at low-cost, but nevertheless, may be very ineffective in achieving its fundamental goal of increasing mobility for the general population.

The concept of **efficiency** combines the ideas of productivity and effectiveness. It measures cost effectiveness. While an effective organization may achieve 100% of its goals, an efficient organization will do so with expenditure of the fewest possible resources. Both effectiveness and efficiency are thus defined with respect to a given goal, respectively measuring the extent of the achievement relative to the goal and the skill with which that achievement was accomplished. Productivity, by contrast, is not explicitly defined with respect to a specific goal but simply measures the relative output produced by a given input. The various concepts described above are summarized in Figure 1:

Figure 1-1: Performance Concepts



QUANTIFICATION, MEASURABILITY AND COMPARABILITY

Measurement and analysis of performance poses some special challenges. The factors which go into achieving performance - inputs, outputs and outcomes - may be **unquantifiable**, that is, they may be described in words but not with numbers. Such factors may not only be uncountable but also **immeasurable**, that is, they cannot be described qualitatively.

Immeasurable factors are by nature resistant to performance analysis since they effectively cannot be seen or understood by the human beings who want to manipulate them. Measurable but unquantifiable factors can be seen by the analyst, but the different factors cannot necessarily be **compared** with one another, making the monitoring of performance possible but difficult to interpret. Measurable and quantifiable factors make the analyst's job easier, but still may not necessarily result in factors which can be compared to one another. To be able to compare different constellations of input, output and outcomes, one must quantify those constellations using the same metric. A typical metric is money.

Social conditions, such as the genuine education level of the populace, can often only be described qualitatively or quantified only indirectly (for example, test scores). Many environmental outcomes fall in this category though many are quantifiable but not comparable to one another (for example, biological oxygen demand (BOD) in a waterway versus various facets of air quality). At the other end of the spectrum are sales of different commodities which are both quantifiable and comparable since they are measured in dollars received for each unit on the open market.

PERFORMANCE IN THE PUBLIC SECTOR

In general, the private sector is considered more efficient than government because of the competitive nature of the markets it serves and because of its relative lack of political constraints. The overriding focus on the bottom line (i.e., profit) provides a measurable context for private sector operations. The thinking goes, if principles employed by more efficient organizations are applied to less efficient organizations, the result can only be more efficient operations.

However, government programs are fundamentally different than private enterprise. The public sector does not run a profit, nor does it generally strive to. It is often called upon to meet complicated social challenges such as environmental quality and fairness. Today most citizens would not accept a government agency which ran say, a road system which more than covered its costs but which imposed heavy burdens on the environment or quality of life of the surrounding community. Shareholders in a private enterprise which managed that same road probably would be more forgiving of managers in those circumstances, providing there was no government or legal action taken to force them to financially account for those burdens.

To say that managing for performance is more difficult in the public sector is certainly not to say that it should not be attempted. Indeed, governments at all levels have been experimenting with performance budgeting, management and other systems. Nonetheless, government's role and function in society is different than those of a market-based institution, and this must be taken into account when applying any private-sector model.

PUBLIC WORKS DELIVERY MECHANISMS

Strategies for performance may also differ according to the particular means chosen to achieve a specified end. Public works providers can serve as an example in this regard since there are a number of ways in which services can be delivered. Public works can be provided directly to constituents. Federal water resources investments are generally supplied in this way, an artefact of their development during the Great Depression. Examples include the waterways of the Corps of Engineers and the dams and reservoirs of the Bureau of Reclamation, which were built and continue to be operated by those two agencies.

Government may also provide infrastructure indirectly through grants or other financing to different levels of government and institutions to build and operate investments in public works facilities. The highway grants by the Federal Highway Administration within the Department of Transportation to State and local governments, is an example of the indirect provision of public works.

Finally, one can direct other institutions to provide services and enforce standards which those services must meet. This is a regulatory approach to public works provision and is best represented by the U.S. Environmental Protection Agency's enforcement of the Clean Water Act and other environmental laws which require treatment and mitigation of various environmental hazards.

In actual practice, federal agencies administer a mix of service delivery mechanisms, with a predominance towards one or the other. For example, while the Corps owns and operates the Inland Waterways System, it also regulates wetlands under Section 404 of the Clean Water Act. Similarly, the U.S. Environmental Protection Agency is primarily a regulatory agency, but does provide grants for wastewater treatment investments and other kinds of public works.

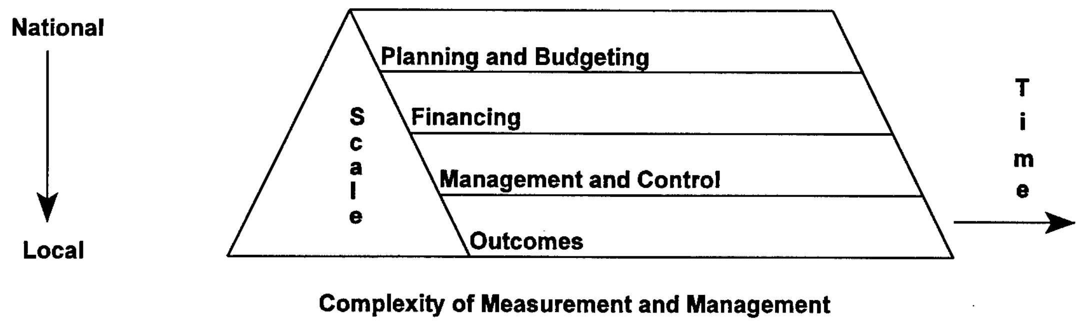
Generally, the more indirect the method of service provision, the more difficult performance is to measure and manage. It is easier to measure and manage results when an agency is providing a service directly than when it is only providing financing, and simply requiring others to provide that service. That is not to say that direct service provision is necessarily more effective than indirect methods, particularly if other providers are more efficient in their management and operations as is often the case. But the fact remains that making the link between initial inputs and final outcomes is more challenging where the distance between the two is great.

A PERFORMANCE FRAMEWORK FOR PUBLIC WORKS

As noted above, performance crosses many dimensions in terms of the nature and ownership of the organization itself, the level and stage of decisionmaking, the characteristics of outcome being achieved, and the method chosen to deliver it. Figure 1-2 summarizes these various dimensions.

Infrastructure thus provides a variety of services at national, state, and local (community) levels. Within this context, performance can be viewed as a multi-dimensional concept, addressing a range of objectives across these political and impact levels. A number of different measures, both qualitative and quantitative, are typically necessary to measure and optimize an organization's performance and, in many cases, some sort of analysis of trade-offs between competing objectives is necessary. The articulation of meaningful "real world" performance assessment frameworks has proved to be a difficult task, raising significant issues to policy analysts and decisionmakers alike.

Figure 1-2: A Framework for Performance



(Simplest) → (Most Complex)

OBJECTIVES: Market value maximization → Social/equity goals

OWNERSHIP: Private → Public

INPUTS/OUTPUTS: Physical → Human/Social/Ecological

DELIVERY METHOD: Direct → Indirect

SCALE: Project → Program → Society

THE POLICY CONTEXT FOR FEDERAL INFRASTRUCTURE PERFORMANCE

There has been much ferment lately in the name of optimizing government performance, which, in turn, has emerged from of an older debate over the improvement of government planning and budgeting procedures.

Government Performance

Reinventing Government. In 1992, David Osborne and Ted Gaebler wrote *Reinventing Government* which argued that traditional command-and-control techniques which the federal government had developed during the Great Depression were no longer appropriate to an ever more complicated world with an increasing multiplicity of centers of authority. It was time, the authors argued, to "reinvent" government to make it more effective in serving the public purposes which it was set up to accomplish.

The fundamental suggestion of Osborne and Gaebler's book is to "steer rather than row" which means that the government is no longer best suited to actually doing much of the work of solving society's problems itself but should devote itself to providing direction and incentives to others to take on those tasks. In this context, decentralization is generally considered more appropriate since those closest to a problem, such as state and local governments, are best suited to understanding and dealing with it. What the federal government can contribute is a system-wide view.

To make this construct work, performance measurement is essential since otherwise social problems and their solutions are not made clear and different levels of government cannot be held accountable for their actions. In an appendix to their book, Osborne and Gaebler develop guidelines for performance measurement emphasizing: (1) the involvement of all interested parties in developing the system; (2) constant refinement to measures as experience with them reveals their strengths and weaknesses; (3) a balance between too much information, which may cause decisionmakers to lose their focus and too few, which could obscure areas in need of improvement; (4) political neutrality and independence for those who generate performance information; and (5) the avoidance of perverse incentives which may defeat the purpose of performance measurement and make matters worse.

The National Performance Review. In 1993, Vice-President Al Gore led a review of federal operations which was based on many of the principles found in *Reinventing Government*. The final report of the National Performance Review (NPR) argues that the problem with federal operations was not that the people working in them were incompetent or mean-spirited, but that the design of federal bureaucracies has become outdated. The emphasis of most federal agencies is on pre-set standards for "cookbook" solutions to prescribed problems. Thus agencies are not particularly flexible to respond to rapidly changing circumstances. In addition, most agencies are monopolies in the services they provide and thus have little incentive to change their ways.

The solution, the NPR maintained, is essentially to emphasize final outcomes rather than mandate methods which might or might not achieve those outcomes. Greater authority should be given to employees to make decisions, customer service should become a central mission, an effort should be made to involve these customers in decisionmaking, and procedures should be simplified and scaled back. To make everything work, performance measurement should be instituted to provide greater accountability and to allow for better management of programs.

Oregon. One of the widest application of performance principles to the public sector has been at the State level. In 1991, Oregon enacted into law its *Oregon Benchmarks* program . Approximately 270 benchmarks have been developed, divided into two classes - priority standards dealing with acute issues such as drug abuse and health care access and core benchmarks for longer-term issues such as economic development.

The benchmarks are designed to measure outcomes such as pregnancy rates and commuting times. As such, the information they provide is intended to indicate to state policymakers where problems exist and how current programs may or may not be affecting policy outcomes.

But Oregon has gone beyond merely providing information to creating institutions which are supposed to ensure that the information provided is acted upon. The 1991 law which created the benchmarks also created the Oregon Progress Board, a bipartisan agency headed by the Governor which must report publicly on progress being made on each benchmark goal.

The program is new enough that its success has not been completely evaluated yet. Nonetheless, the Oregon effort has captured wide attention because of both its scope in terms of programs and policy areas covered and its broad political and public support. It is also the performance program which is most advanced in its implementation. Already Minnesota has launched a similar program and Maine, Hawaii, Florida, Texas and Ohio are in various stages of developing their own versions.

Government Performance and Results Act of 1993. Although its origins as legislation predated both *Reinventing Government* and the NPR, the Government Performance and Results Act of 1993 (GPRA) is the first piece of legislation passed into law which implements many of the performance principles contained in those two works.

GPRA's purpose, as stated in the law, is to systematically hold federal agencies accountable for achieving program results and improve the effectiveness of federal programs in accomplishing their goals, their delivery of services, and their internal management, as well as to improve Congressional decisionmaking. GPRA seeks to achieve these results by requiring that each agency develop and submit strategic plans and set performance goals, testing these approaches through a series of pilot programs whose results will be reported to OMB and the Congress. Ultimately all agencies are to have annual performance plans and performance reports as well as development of strategic plans.

GPRA not only requires the development of ever greater amounts of performance information, but it provides incentives to Federal managers to act on the implications of that information. Thus agencies may propose to waive administrative procedural requirements and controls, including those on staffing levels, compensation and prohibitions of funding transfers. If performance is maintained, these waivers of procedure can be made permanent. This is the embodiment of "steering rather than rowing."

Benefit-Cost Analysis. The federal government has long been required to conduct benefit-cost analysis on many of its undertakings. Federal guidance on this topic is provided in the Office of Management and Budget (OMB) Circular A-94 entitled *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* and dated October 29, 1992. In most instances (water resources agencies being a prominent exception addressed below), Federal agencies are required to follow the precepts of the Circular.

Benefit-cost analysis can be viewed as performance analysis of a particular type, as the stated purpose of A-94 makes clear: "The goal of this Circular is to promote efficient resource allocation through well-informed decisionmaking by the federal government." To ensure that this goal of efficiency is met, federal activities should meet the criteria that "net present value -- the discounted monetized value of expected net benefits (i.e. benefits minus costs)" be maximized.

To conduct a benefit-cost analysis is as much an art than a science and has been the subject of much discussion elsewhere. The Circular identifies the prerequisites of such an analysis, including the identification of alternatives to the action being analyzed and the benchmark against which that action is being compared; the identification and measurement of benefits and costs; and the clear exposition of assumptions used in the analysis.

Benefit-cost analysis is itself an abstraction of the details of specific actions or investments which expresses and analyzes those actions in terms of their progress in meeting their goals. Although benefit-cost analysis is often oriented towards economic efficiency goals (namely the maximization of measured output at lowest cost), it can, in theory, be applied to broader objectives such as maximizing social welfare and often is used in such a way. Being outcome-based, the precepts of benefit-cost analysis are perfectly compatible with the principles outlined in the NPR, GPRA and *Reinventing Government*. The main difference is in emphasis - benefit-cost analysis is centered more on the planning stages of public decisions, while the other initiatives focus on management and control stages as well.

Federal Water Resources Programs: The Principles and Guidelines. Federal water resource programs, such as those of the U.S. Army Corps of Engineers and U.S. Department of Interior, Bureau of Reclamation, are exempted from the requirements of Circular A-94. That is not to say that such programs are not required to conduct such an examination. In fact, water resource programs were required by the Flood Control Act of 1934 to examine "the benefits to whomever they accrue..." and thus developed a more systematic and detailed benefit-cost approach than generally exists in the rest of the federal government. This approach is known as the P&G after the *Principles and Guidelines for Federal Water Resource Investments*, put in its latest form by the Water Resources Council in 1983.

The P&G is a detailed decision guide to the evaluation and selection of alternatives for federal water resources investments. The P&G has four accounts which are used to classify the benefits and costs of alternatives. These are the National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE) accounts. The P&G recognizes that water resource programs are by their very nature "multiobjective" - that is they achieve many different and sometimes mutually exclusive goals. Thus there is allowance for analysis of these different goals, particularly economic efficiency, which the NED account is designed to consider, and environmental impacts, which the EQ account is designed for. The distribution of economic impacts across regions (RED) and the many other social impacts are usually not agency objectives in the direct way that NED and EQ are, and are thus usually not as explicitly used in weighing the benefits and costs of a particular project. However they are recognized as being important enough in decisionmaker's minds that they should be reported and considered.

The P&G is a useful model in development of any government-wide performance framework. It recognizes the need for a number of, and not just one performance measure, at the same time keeping such measures to a manageable minimum (there are many categories of benefits and costs which are not mentioned here which are folded into the four accounts). In addition, the need for explicit consideration of tradeoffs between competing objectives is formalized in the P&G. This sort of tradeoff is never easy of course, and the P&G has its limitations, but any performance monitoring system will have to grapple with the same issues that water resources agencies have been grappling with for 60 or more years. Their experience provides a useful precedent to current initiatives to increase pubic sector performance.

Infrastructure Performance

National Council on Public Works Improvement. In 1984, the U.S. Congress created the National Council on Public Works Improvement (NCPWI). The Council was a temporary body set up to look at the nation's infrastructure needs and policies which would help meet those needs. In 1988, it issued its report, *Fragile Foundations* which limited its study to public works in the areas of transportation (highways, streets, roads, bridges; airports and the nation's air traffic control system; and mass transit systems including light rails and buses); water supply (community water supply systems); wastewater management (municipal wastewater treatment facilities); water resources (flood control, inland navigation and coastal ports); and, hazardous and solid waste management (recycling, landfills, resource recovery and hazardous waste management facilities).

The NCPWI report recognized the multi-faceted nature of infrastructure performance and focused on five categories of performance measures, namely:

- physical assets
- product or service delivery
- quality of service to users
- cost-effectiveness
- external effects.

The first category could be said to be an measure of inputs. Those inputs are used to produce the program outputs which could be described by the next three categories. Although not referred to as such, the final category, external effects, could fall into the category of outcomes, though narrowly conceived (as the NCPWI report framed them), they could also be seen as expanded measures of output.

Thus, for example, locks and dams, physical assets of the U.S. Army Corps of Engineers, can be categorized as inputs into the Inland Waterways' outputs, namely services such as navigation for movement of waterborne commerce which can be additionally described in terms of its quality to users and its cost-effectiveness in operation. The outputs could include external effects such as savings in travel time which, in a broader sense, is one of the program's goals, namely improvement in the quality of life and the economic efficiency of the nation.

Financial Performance

The Chief Financial Officers Act of 1990. The initiatives mentioned above focus mainly on performance in the planning and management stages of government systems. The Chief Financial Officers Act of 1990 is a relatively recent law that brings a performance focus to the financing stage as well.

The law's stated purpose is to "bring more effective general and financial management practices to the federal government." The act provides for such improvement by creating in the Office of Management and Budget (OMB) a Deputy Director for Management and an Office of Federal Financial Management headed by a Controller, and by designating in each agency and Executive Department a Chief Financial Officer (CFO).

Like CFOs in the private sector, agency CFOs have the responsibility to oversee all agency financial management matters, reporting directly to the head of the agency, develop integrated financial management and accounting systems, and create financial reporting and internal controls which accord with standard accounting practices. The CFO must also develop a 5-year financial management plan for the agency.

The general thrust of the CFO act is accountability - not only must financial plans be developed, but there must be an individual responsible for executing them who has access to top decisionmakers. While there is a general management emphasis in the Act's language, its most basic thrust is to improve the government's management of funds themselves, minimizing waste and fraud, whatever the merits of the purposes to which those funds are devoted.

Service Delivery Alternatives

Executive Order 12866: "Regulatory Planning and Review". On September 30, 1993, President Clinton issued Executive Order (EO) No. 12866 entitled *Regulatory Planning and Review*. The EO, a revision of a previous Order on the same topic, is significant in that it deals specifically with that most indirect provision of government service, namely regulation. While the policies described above pertain to all forms of service provision, they are most readily applicable to, or in practice used for, direct provision and grant programs.

EO 12866 requires that all proposed regulatory actions which have an economic impact of greater than $100 million be subjected to a broad benefit-cost analysis, compared with the alternatives to regulation and implemented only if net benefits are maximized. Each agency is also required to develop a Regulatory Plan which lays out the goal, legal basis, statement of need and schedule of action for all proposed regulations. A centralized review process to monitor regulations is established, with OMB acting as the monitor and the Vice President leading an interagency working group to review regulatory issues. Regulations must be put into simple language and must be subject to consultations between agencies and state, local and tribal governments before being put into effect.

The main significance of the Order in a performance context is that it requires explicit consideration of nonregulatory alternatives, limiting the incentive on the regulator's part to issue regulations simply because all their costs are on someone else's budget. There is also a hearkening to steering rather than rowing in its requirements to consult and work with affected parties, particularly State, local and tribal governments. The regulatory review process similarly is designed to improve government performance by culling out regulations which may remain on the books but have long since outlived any usefulness.

Executive Order 12893: "Principles for Federal Infrastructure Investments". As the narrative above shows, much has happened in the area of government performance since the issuance of *Fragile Foundations* in 1988. Recognizing many of these advances, President Clinton issued Executive Order No. 12893, entitled *Principles for Federal Infrastructure Investments*, on January 26, 1994. The Order applies to Federal programs in transportation, water resources, energy and environmental protection.

The EO is innovative in a number of ways. First, it calls for consideration of operations and maintenance (O&M) spending as well as new capital investments in any analysis of infrastructure programs, recognizing the innate complementarity between the two. Second, the Order calls for an analysis of benefits and costs over the life-cycle of the project. Third, the Order calls for consideration of efficient management of existing assets as an explicit alternative to new investments. Fourth, the EO explicitly recognizes the importance of the method of service delivery, applying to both grants and direct provision. Finally, and perhaps most significantly, the Order calls for analysis of programs, and not just individual projects.

THE CURRENT STATE OF PERFORMANCE MEASUREMENT IN FEDERAL AGENCIES

Federal agencies of all types appear to do a great deal already to measure and monitor the performance of their programs. It is fair to ask what they do, how well they do it, and how what they do advances the effectiveness with which they fulfill their given missions.

In attempting to answer these questions, the U.S. General Accounting Office (GAO) issued a study in May 1992 entitled *Program Performance Measures: Federal Agency Collection and Use of Performance Data*. The GAO study defined program performance measurement as "the regular collection and reporting of a range of data" and categorized such data as covering:

- inputs, such as dollars, staff, and materials;
- workload or activity levels, such as the number of applications that are in process, usage rates, or inventory levels;
- outputs or final products, such as the number of children vaccinated, number of tax returns processed, or miles of road built;
- outcomes of products or services, such as the number of cases of childhood illnesses prevented or the percentage of taxes collected; and
- efficiency, such as productivity measures or measures of the unit costs for producing a service (e.g., the staff hours it takes to process a Social Security or the cost to build a mile of highway). (p.2)

These categories accord essentially with the input, output and outcome categories used in above. GAO surveyed 103 Federal agencies to ask them how many of them used these types of measures. To tie these measures into objectives, GAO also asked whether the agencies had long-range strategic plans.

The results of the survey indicated that most agencies used performance measures of some type, particularly for program inputs and outputs and financial health. Fewer measured quality of the their outputs, and fewer still tracked outcomes, although in all cases a majority of respondents answered GAO's questions affirmatively. About two-thirds of the agencies had a single long-term plan.

However, further analysis of the data, and more detailed examinations of selected agencies indicated that the actual use of these performance measures in decisionmaking was fairly limited. Most agencies reported their data only internally, rather than to the Congress, OMB or the public. Even in these cases, the data were mainly for informational purposes and not for use in management, planning or policy. While some agencies did use information for accountability (such as the Federal Transit Administration's use of performance information to track compliance with grant conditions) or to manage operations (as the National Archives and Records Administration did to increase the speed with which requests from the Revolutionary War Military Service Records were processed), few agencies used the information they collected to "manage for results", i.e. use the data to develop and implement strategies for achieving agency missions or goals.

These results were largely confirmed and expanded upon in a 1993 study by the U.S. Congressional Budget Office (CBO) entitled *Using Performance Measures in the Federal Budget Process*. The study surveyed state and local governments as well as the federal agencies and found that outcome measurement and management was scarce all around, largely because of the difficulty of executing it.

The CBO study makes a number of points regarding the implementation of performance measurement at the Federal level. First, performance measurement has some inherent limits in its ability to effect change. Top managers and decisionmakers must be committed to acting on information that they receive, and even if this commitment is present often there will be little that these managers can do since so many actors often influence the final outcome.

Second, performance measures do not make politically difficult tradeoffs any easier to make. Better informed decisions are not necessarily easy ones. Finally, despite the limited potential of performance measures, they do have enough utility that their use should be expanded and experimented with. The key is to choose the right pace of implementation - not so fast that unintended consequences and sloppy follow-through doom the enterprise, but not so slow that the measures seem less effective than they really are.

A POLICY AGENDA FOR THE FUTURE

New efforts at describing, measuring, evaluating, and improving performance are taking place at all levels of government. A general level of consensus appears to be that any framework for evaluating performance ought to move beyond measures of inputs and outputs, and should focus on programmatic outcomes and measures of productivity, efficiency, and effectiveness.

<u>The Federal Infrastructure Strategy</u>. Many of the performance principles described above have been reiterated or refined in a process facilitated by the U.S. Army Corps of Engineers' Institute for Water Resources known as the Federal Infrastructure Strategy (FIS) program. The program has focused on the roles of the various levels of government and the private sector in devising practical approaches for improving infrastructure performance, ensuring more efficient investments, and protecting the environment.

The process was designed to be "bottom-up" and to bring together agencies which implement infrastructure policies and programs along with parties affected by and interested in those policies. At the Corps request, the U.S. Advisory Commission on Intergovernmental Relations (ACIR), an independent Presidential commission with members from all levels of government in both executive and legislative branches, facilitated this intergovernmental consultation.

Two phases of interagency coordination were completed. The process included over 30 Federal agencies and units of Congress, along with more than 80 other organizations representing state and local governments, public works providers, and related research, policy advocacy, user and professional groups. The coordination culminated in a *National Conference on High Performance Infrastructure* sponsored by ACIR and the Corps in July 1993, and the subsequent approval by the interagency consensus recommendations by the ACIR at the Commission's February 14, 1994 meeting.

These recommendations were contained in a joint ACIR/Corps publication entitled *High Performance Public Works: A New Federal Infrastructure Investment Strategy for America*. The document lays out a set of performance goals for federal infrastructure, namely high quality investments which yield maximum net benefits; cost-effective maintenance of existing facilities; sound and equitable regulation; and affordable facilities with affordably priced services.

To achieve these goals, the report proposes a detailed "action agenda" which suggests roles for the President and the Executive Branch, the Congress, and the federal agencies to play in advancing the cause of well-performing public works. Some of these roles, such as an Executive Order on infrastructure, have since been implemented (i.e., EO 12893). Other recommendations, such as establishing a public works investment section in the President's budget, or a mandate relief bill which would require costing of federal regulatory mandates are either working their way through Congress (as in the mandates case), being discussed, or are under development by various entities (as in the former case by the U.S. Office of Management and Budget and the National Performance Review). Some recommendations still await consideration, among them reorganization and streamlining of Congressional decisionmaking procedures on infrastructure and environmental policy, budget and appropriations processes, an interagency infrastructure policy coordinating mechanism, and more flexible, performance-based infrastructure block grants.

Other FIS study elements have focused on issues ranging from estimating the costs of deferred maintenance on large infrastructure systems (conducted for the Corps by the Urban Institute); the impact of Federal infrastructure mandates on local public works management practices (conducted by the National Academy of Public Administration and the American Public Works Association); policies to improve the transfer of technology from the federal to the private sector (conducted by the Civil Engineering Research Foundation); and a study to identify, quantify and understand the microeconomic and macroeconomic impacts of federal infrastructure investments (conducted for the Corps and the Federal Highway Administration by Apogee Research, Inc., Dr. Charles Hulten of the University of Maryland at College Park, Dr. Ishaq Nadiri of New York University and the National Bureau of Economic Research, and Dr. David Aschauer of Bates College.

MEASURING AND IMPROVING INFRASTRUCTURE PERFORMANCE: THE NATIONAL RESEARCH COUNCIL

Besides the studies identified above, the FIS program has approximately 25 other interagency components looking at specific aspects of federal public works policy. The component most directly concerned with performance is a study by the National Research Council (NRC) of the National Academy of Sciences to look at the measurement and improvement of infrastructure performance.

The Board on Infrastructure and the Constructed Environment (BICE) of the NRC has issued its draft report entitled *Measuring and Improving Infrastructure Performance*. This report develops its own framework for how infrastructure policy goals should be determined, converted into strategies, and assessed in terms of their success or failure in achieving those goals.

In particular, the study starts with the premise that a system-wide view of infrastructure be taken by all parties involved, i.e., that measurement of performance of a particular segment of a specific infrastructure mode (e.g., a 10-mile stretch of road) is not sufficient. The way a given project or program affects the operation of the network of which it is a part is the perspective which policymakers should take.

Given this perspective, the process used to determine infrastructure goals and then to define, measure, and manage system performance should be as inclusive and comprehensive as possible, involving all relevant stakeholders. If this process is managed correctly, goals will be clarified, conflict among goals minimized, and strategies for executing goals given the maximum chance for successful implementation.

With goals set, measures of performance should be developed, taking a system-wide perspective and accounting for all stakeholder views. The report recommends three critical dimensions of performance — effectiveness, reliability, and cost — and suggests that quantifiable measures be developed wherever possible.

Along these lines, the NRC study has suggested some factors to be considered in future performance evaluation frameworks. These include: reliability and flexibility; schedule, disruption, and performance of systems; valuation of resources; and willingness to pay.

CONCLUSION

If there is one theme that emerges from this discussion, it is the notion of system. Projects are parts of programs, and, taken together, programs constitute an overall and evolving infrastructure system which is integral to the flow of goods and services and the improvement of the nation's economic productivity, its environment, and its quality of life. Incrementally, the various policy advances over the past decade have moved investment analysis somewhat closer toward a system-wide evaluation stance. This movement is continuing.

Currently, however, the federal infrastructure system continues to be managed through a set of individual and sometimes disparate programs whose investment practices and strategies, while related, remain separate and occasionally competing with one another. As the chapters which follow will show, federal public works programs cannot often be directly compared to one another since their data are not always collected and displayed in a manner which allows for meaningful comparison. Serious data gaps also exist. Measurement and understanding of how outcomes are affected by agency inputs and outputs is particularly weak. Improving the comparability of agency data and getting a better handle on outcomes, although extremely difficult in some instances, is beginning to improve. The GPRA performance pilots will play a critical role in better linking inputs/outputs to outcomes for federal infrastructure programs. Given the magnitude of the task it is wise that initiatives like the GPRA have opted for a pilot approach rather than a top-down mandate.

To realize how far there is to go, it helps to understand how much has already been accomplished. This chapter has provided a general context of the current developments in public works policy. The next chapter turns to specific programs in transportation, water and waste management to review where those programs are in terms of performance measurement and to understand where they are headed.

CHAPTER II: CURRENT PERFORMANCE PRACTICE IN FEDERAL TRANSPORTATION, WATER RESOURCES AND WASTE MANAGEMENT PROGRAMS.

PERFORMANCE IN WASTE MANAGEMENT, WATER AND TRANSPORTATION: THE STUDY

In the last chapter, a framework for understanding the dimensions of performance was introduced. Figure 1-2 summarized that framework.

Performance can be measured and managed across some or all of these dimensions, depending on the need at hand. Recent policy initiatives, described in the last chapter, have focused on expanding the reach of performance management over these dimensions and on improving the methods of understanding and controlling the links between what goes into a program and the outcomes that it results in.

This chapter will review some of the current performance management practices in areas of transportration, water and waste management. The discussion will begin with the consideration of some of the implicit and explicit goals of the programs: what might they be? Are they well-defined? What basis do they provide for defining performance measurements and strategies?

Given the goals of the program, the question will be asked as to what programmatic means have been chosen to achieve those goals, both in terms of the strategy and services provided and the methods of delivering those services. A broad review of performance data and its uses in each program will be provided. The discussion will conclude by considering each overall program area in terms of the broader discussion about performance at the federal level.

The discussions of each program area contain the following subsections:

- **Program Goals**: describing some of the goals and objectives of each of the programs, as spelled out in enabling legislation or other documents; this review is not meant to be definitive or comprehensive but indicate one approach to laying out program objectives for developing performance benchmarks.

- **Program Outputs**: describing the outputs the programs deliver to achieve those goals;

- **Delivery Methods**: describing the methods used by each program to deliver those outputs (i.e. direct service provision, grants, or regulation);

- **Policy Context**: describing the relationship of current program performance to the larger policy actions surrounding public sector performance.

- **Data Collected and its Uses**: describing some of the types of performance information which is routinely collected at the federal or other level of government, as well as the primary use of the information collected (i.e. planning/budgeting, financing, management/control or outcomes);

The Federal infrastructure programs which are discussed are the transportation sector, including the programs of aviation, highways and mass transit; water resources, which includes flood control and inland navigation; public water supply; and in the environmental sector, the programs of wastewater treatment, hazardous waste and solid waste management.

TRANSPORTATION

Transportation in the United States has become increasingly intermodal, with rail, road, air and water transportation becoming more interdependent, particularly at certain nodes of the transportation system such as ports and harbors. Recognizing the intermodal aspect of the transportation system, the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 allowed Federal planning and management regimes to more flexibly shift resources across different modes. The "Declaration of Policy" section of the Act states:

> It is the policy of the United States to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy, and will move people and goods in an energy efficient manner.
>
> The National Intermodal Transportation System shall consist of all forms of transportation in a unified, interconnected manner...to reduce energy consumption and air pollution while promoting economic development and supporting the Nation's preeminent position in international commerce.

Thus ISTEA not only emphasizes intermodal tradeoffs and its relationship to enhanced mobility and economic productivity, but also speaks of two additional requirements to be met in achieving that mobility, namely environment-friendliness and energy efficiency.

Aviation

Program Goals. The "modern" federal role in aviation programs can perhaps be said to have begun with passage of the Airport and Airway Development Act (PL 91-258) in 1970. This bill repealed the Federal Airport Act of 1946 and authorized a new long-range program for expansion and improvement of the U.S. airport and airways system. The program was to be financed largely by new taxes on users of the system, with revenues being paid into a new Airport and Airway trust fund.[11]

Among the objectives of the Act were:

"Title I, Sec. 2. DECLARATION OF POLICY - The Congress hereby finds and declares ... that the Nation's airport and airway system is inadequate to meet the current and projected growth in aviation, and ... that the substantial expansion and improvement of the airport and airway system is required to meet the demands of interstate commerce, the postal service, and the national defense."

"Sec. 14. AIRPORT AND AIRWAY DEVELOPMENT PROGRAM - (a) General Authority. - In order to bring about, in conformity with the national airport system plan, the establishment of a nationwide system of public airports adequate to meet the present and future needs of civil aeronautics, the Secretary is authorized to make grants for airport development..."

Thus the Act, at a minimum, specified that the goal of a national airport system is to meet the demands of interstate commerce, the postal service, and national defense.

Program Outputs. The Nation's aviation system provides a number of services, especially increased mobility of goods and people using the most safe, reliable and efficient air delivery mechanisms possible. The components of this system are manifold and include the aircraft themselves, airports which those craft use, and the air traffic control system which keeps those craft getting into and out of those airports quickly and safely.

Delivery Methods. The federal role in the aviation system is relatively small, but critical. The only direct service provided by the federal government is the air traffic control system itself. Indirect services are provided in the form of construction, safety, expansion, noise reduction and planning grants for airports. Finally, there is important regulatory oversight over airport safety and the operation of aircraft. Of course financing for the Federal share of the system is at least partly provided by the federal taxes collected as part of the Airport and Airway Trust Fund.

Policy Context. Much of the national aviation system is privately owned and operated, and even that portion which is controlled by the federal government, namely the air traffic control system, relies heavily on user-fees and user taxes. Thus there has been recent interest in modifying the government control of the air traffic system, either by "corporatizing" it (i.e. by spinning it off into a separate quasi-public corporation which would be free of many of the restrictions which apply to public sector activities) or by privatizing it completely.

The main stumbling block against these efforts thus far has been a concern about the safety of the system. There is a perception that a completely privately run aviation system might be less safe for fliers because of a desire to maximize profits or pressure exerted by the financially weak position of many carriers might lead to cutting corners on such safety-enhancing measures as better employee training, rigorous equipment maintenance and reasonable scheduling for pilots and other key personnel.

Data Collected and its Uses. The federal aviation sector appears to be rich in information which has many potential uses for all stages of the decisionmaking cycle Table 2-1 presents selected representative measures while Table 2-2 presents aviation performance data currently available. Federal planning and budgeting for air travel appears to be quite strong. With the sensitivity towards safety issues, and the central role which the federally-operated air traffic system plays in safety, there is a great deal of follow-through in decisionmaking for that outcome. However, deficit reduction pressures, and the great variety of service-providers, often leave the federal government with little ability to act on the

TABLE 2-1: SELECTED DATA CATEGORIES FOR FEDERAL AVIATION PERFORMANCE
Airports
Number of airports
Characteristics of airports (ownership, operation, size, management)
Characteristics of airport components (landing facilities, runways etc.)
Number of accidents
Airport accessibility (i.e. distance of population from airport)
Aircraft, Airlines and Flights
Number of air carriers
Characteristics of air carriers (e.g. organization, market share, finances, number of employees etc.)
Number of aircraft and type
Revenue-passenger miles (RPM)
Revenue-passenger emplanements (RPN)
Revenue-ton mile (RTM)
Cargo type carried
Takeoffs and landings
Travel delays (number, length, cause)
Flight stages (time in gate hold, taxi-out, airborne, taxi-in)
Point of origin of travel and point of destination
Length of overall flight
Passenger Load factor
Air Traffic Control
Value of air traffic control assets
Number of control towers
Services provided (e.g. weather forecasts)
Number of employees

information they have. Indeed, to the extent challenges exist in the federal aviation system, the problem is not with a lack of information, but with constraints to follow-through on its implications.

Quite a few measures of these services are currently tracked by the federal government as well as the inputs which are required to generate those outputs. Information collected includes: the number of airports and their characteristics (e.g. landing facilities, length of runways), the type and number of aircraft which are operated, the ownership and finances of air carriers, and air control system assets (e.g. the number of towers, their locations and the number of employees working there).

From this basic data, some derivative measures are obtained to gain more insight into the system's effectiveness in delivering safe and reliable air transportation. For example, air carrier revenue can be divided by the number of passenger-miles flown (itself a ratio of passengers to total miles flown) to obtain revenue passenger miles (RPM) as a measure of air carrier efficiency. Fatality rates are another example

TABLE 2-2: PERFORMANCE DATA CURRENTLY AVAILABLE - AVIATION		
PERFORMANCE INDICATOR	**DATA SOURCE**	**YEARS**
Physical Assets:		
Number of Airports	FAA Office of Public Affairs.	1968-1992
Number of Public and Private Facilities	FAA Office of Public Affairs.	1969-1992
Commercial Fleet Size	FAA Aviation Forecasts, various years.	1986-1992
Net Depreciated Capital Assets	Apogee Research, Inc.	1932-1990
Product Delivery:		
Revenue Passenger Enplanements	FAA Aviation Forecasts, various years.	1964-1992
Revenue Passenger Miles	FAA Aviation Forecasts, various years.	1960-1992
Revenue Cargo Miles	Boeing, World Cargo Forecast, 1992.	1970-1991
Aircraft Operations at FAA Towers	FAA Aviation Forecasts, various years.	1960-1992
Quality of Service:		
Delay: By Stage of Flight / By Cause	Aviation System Capacity Plan.	1982-1990
Fatalities per Passenger Mile	Apogee Research Inc. from FAA Aviation Forecasts and National Transportation Statistics.	1991
Airport Accessibility	National Plan of Integrated Airport Systems: 1986-1995.	1985
Cost Effectiveness:		
Passenger Load Factor	FAA Aviation Forecasts, various years.	1960-1991
Revenue per Passenger Mile	FAA Aviation Forecasts, various years.	1964-1991
Airline Operating Profit (%)	ATA, The Annual Report of the U.S. Scheduled Airline Industry.	1960-1992
Airline Net Profit	ATA, The Annual Report of the U.S. Scheduled Airline Industry.	1982-1992

of a derived number which equals the number of deaths which occur per 100 million passenger-miles traveled and which measures the overall safety of the system.

Because of the great decentralization in the system, the use of performance data in the Federal decisionmaking process varies. The use of data for planning and budgeting is perhaps the predominant Federal use of information, primarily because so much of the aviation system is run by state and local governments and the private sector. Because the Federal government actually owns and operates the air traffic control system, performance data are especially of use in managing and controlling that system in particular. The existence of the Airway and Airport Trust Fund means that some extra information is available regarding program financing especially with regards to air traffic control. However, because of the build-up of a substantial surplus in the AATF account, there is some feeling that this information is not being acted upon to ensure optimal financing of the Federal aviation role.

Highways

Program Goals. The outlines of the current federal-aid highway system were drawn with the passage of the Highway Act of 1956 (PL 84-627) which was comprised of Federal-Aid Highway Act of 1956 (Title I) and Highway-Revenue Act of 1956 (Title II). The Act authorized the biggest road-building program in U.S. History - $31 billion in federal-state funds over a 13-year period, and the biggest authorization for the National System of Interstate Highways, initiated in 1944. The Act also firmly established the use of highway user fees and taxes, particularly the gasoline tax, for financing national highway improvements through a Highway Trust Fund.[12]

The stated purpose of the two Acts, and the justification offered for Federal involvement in what had been more of a purely State and local affair, was to build a network of highways which would enhance the nation's ability to mobilize for national defense. The Act's preamble states:

"(a) ACCELERATION OF PROGRAM. - It is hereby declared to be in the national interest to accelerate the construction of the Federal-aid highway systems, including the Interstate System, since many of such highways, or portions thereof, are in fact inadequate to meet the needs of local and interstate commerce and the national and civil defense.

(b) COMPLETION OF INTERSTATE SYSTEM. - It is further declared that one of the most important objectives of this Act is the prompt completion of the Interstate System. (Title I, Sec. 116)."

Of course, since the Interstate Highway System is now essentially complete, the Highway Act of 1956 can be said to have accomplished its immediate objective. The Act also indirectly spells out additional goals for highways in general and the Interstate System in particular, namely the needs of local and interstate commerce and the national and civil defense.

Program Outputs. Like aviation, one of the primary services which Federal highway programs deliver is increased mobility for people and goods. The difference, of course, is in the mode of transportation focused on, namely road rather than air. The building and maintenance of roads is now the primary output of the national highway system. The equipment used on these roads, namely vehicles, is regulated by the Federal government.

Delivery Methods. The Federal highways program provides infrastructure services primarily indirectly through grants to State and local governments for highway construction, operations and maintenance. The Federal Highway Administration also regulates highways in terms of standards for operations and maintenance, and in many of its environmental ramifications (a role it shares jointly with the U.S. Army Corps of Engineers in regards to wetlands and with the U.S. Environmental Protection Agency more generally).

Otherwise, the national highway system is primarily a state and local affair. For example, state and local governments are the actual owners and operators of the various types of roads (subject to applicable regulations and grant conditions) and also oversee many other aspects of the highway operators, such as registration of motor vehicle drivers. Of course most of the traffic which runs on those roads is privately operated.

Policy Context. In concept, the federal highway system is a model of "steering rather than rowing," where the central government provides signals and incentives to other actors to achieve common goals. In actual practice, the multiplicity of actors and the rigidities and time-lags inherent in Congressional decisionmaking can create difficulties. In order to pass the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, many compromises had to be made, compromises which advanced the reform of national transportation funding and management but also left room for improvement in areas such as funding formulas for distributing monies across States. In addition, highway projects in one state are not necessarily evaluated using the same criteria in another state, although these criteria may be similar. Putting evaluations of system increments and decrements on an equal footing is a challenge which remains and one which is broadly addressed by Executive Order 12893.

Also, the optimization of program finance remains a significant issue. Like aviation, the Federal highway system is funded by a dedicated trust fund, financed largely by a tax on gasoline. Deficit reduction pressures have, in the past, led to running a surplus on the fund mainly because that surplus would partly offset the deficit run on the unified budget. In addition, as clean air initiatives lead to pressure to reduce the amount of miles traveled, the revenue potential of the gasoline tax is expected to decline at some point being outstripped by funding needs. Finding and implementing a new revenue source, either through new types of taxes or through tinkering with existing trust fund taxes (such as the oft-mentioned proposal to tax trucks more highly to account for their heavier impacts of road surfaces), is likely to be very difficult in the current political climate.

Finally, the highway system, like most infrastructure modes, is facing the increasing importance of environmental objectives in their programs. Traditionally, highway performance has been evaluated in terms of its ability to move people and goods, a fairly tangible output. Now highways must also minimize and sometimes even enhance the natural and social setting in which they are built. These objectives are harder to measure and harder to achieve and have raised a significant challenge to program administrators. Programs like the Congestion Mitigation and Air Quality program (CMAQ) and the changes in ISTEA which grant new flexibility to move funds from highways to alternative modes such as mass transit are attempts to deal with this issue.

These various facts are recognized both in ISTEA and the various management systems which it has spawned within the FHwA. ISTEA changes many of the grant conditions which existed prior to its passage in an attempt to create incentives for State and local governments to maintain the capital they already have and to take greater opportunity of participation by the private sector.

Data Collected and its Uses. Like aviation, there is a considerable amount of information available regarding system inputs and outputs, especially the miles and condition of roads and bridges, system capacity and congestion, and characteristics of the driving age population. (See Tables 2-3 and 2-4).

There are some significant gaps however, and not all the information is necessarily straightforward to interpret. For example, functional and structural obsolescence data, can and sometimes have been misinterpreted as measures of true need when in fact their meaning is much more narrow, referring to pre-set standards of function and structural integrity. Information on travel-times and trip purpose are, of necessity, based on statistical samples and have some uncertainty surrounding them. Finally, with the deregulation of the trucking industry, much information is now unavailable for that sector.

Mass Transit

Program Goals. The landmark act in the mass transit arena was the Urban Mass Transportation Act of 1964 (PL 88-365) which stated that the federal government should extend financial assistance to urban mass transportation systems because "the predominant part" of the nation's population was located in rapidly expanding metropolitan and other urban areas which often crossed the boundaries of state and local jurisdictions, and because the welfare of these areas, the satisfactory movement of people and goods, and "the effectiveness of housing, urban renewal, highway and other federally aided programs" was being jeopardized by "the deterioration or inadequate provision" of urban transportation services, "the intensification of traffic congestion, and the lack of coordinated transportation and other development planning on a comprehensive and continuing basis."

The Act authorized the Administrator of the Housing and Home Finance Agency to make federal grants and loans to states and localities for acquiring, constructing and improving facilities and equipment for mass transportation systems owned, operated, leased or otherwise used by a public transportation authority.[13] A later reorganization by President Lyndon Johnson moved mass transit programs into the Department of Transportation.[14]

Program Outputs. Like aviation and highways, mass transit is a mode of transportation, and hence has the primary mission of increasing mobility. However, mass transit is often seen as addressing significant environmental and equity concerns as well. Riders of mass transit tend to be more concentrated among the poor and the elderly than in other modes, and the very fact that more people are generally moved in a given trip on light rail, subway or bus than those taken by automobile implies less energy usage and hence less pollution created per trip. In addition, mass transit functions best in areas of high population density. To the extent that mass transit may itself encourage such settlement patterns, some believe that it lessens the need for transportation services and hence any environmental damage which is caused by the use of those services.

Delivery Methods. As with aviation and highways, the federal government primarily provides mass transit services indirectly through State and local governments and independent operating authorities. Grants for capital spending and operations and maintenance are provided and the Federal government

TABLE 2-3: SELECTED DATA CATEGORIES FOR FEDERAL HIGHWAY PERFORMANCE
Facilities
Intensity of use (e.g. vehicle-miles, passenger-miles, ton-miles
Type of use (e.g. logging roads etc.)
Capacity (e.g. lane-miles)
Net depreciated capital assets
Financing source and administration (private, toll-road etc.)
Function (Interstate, primary, secondary, urban etc.)
Road condition (Pavement Serviceability Rating (PSR))
Functional or structural obsolescence
Number, condition and type of bridges
Vehicles and Traffic
Number of registered vehicles
Point-to-point travel times
Peak-hour traffic flows
Vehicle-miles traveled (VMT)
Passenger-miles traveled
Ton-miles traveled
Trip purpose
Trip time (by time of day and week)
Average trip length
Number of accidents/fatalities
Fatality rates (distributed by functional class of road)
Costs of congestion
Number and characteristics of registered drivers
Number of vehicles per driver

plays a major role in the start-up of new subway and mass transit systems. Operations and ownership of mass transit systems and assets rests primarily with non-Federal governmental authorities. Unlike aviation and highways, relatively few private parties operate transit systems, and those that do usually receive significant public subsidies from area governments.

Policy Context. Because of its reliance on grants, one big issue in mass transit performance has been the incentives contained in those grants. Much attention has been focused on local maintenance of current investments. As with other transportation grant programs, past biases had been towards new construction with little federal support for O&M afterwards. During the 1970's and 1980's, tighter controls were placed on money for new capital with a greater emphasis on cost-sharing by State and local interests.

Another issue which has loomed large is the selection of "new starts" and other transit projects. In 1993, the Chairman of the House Transportation Appropriations Subcommittee of the Public Works and Transportation Committee proposed what were referred to as guidelines to be used in sorting through

TABLE 2-4: PERFORMANCE DATA CURRENTLY AVAILABLE - HIGHWAYS		
PERFORMANCE INDICATOR	**DATA SOURCE**	**YEARS**
Physical Assets:		
Route-Miles	Highway Statistics, various years.	1960-1991
Lane-Miles	Status of the Nation's Highways, Bridges and Mass Transit: Conditions and Performance.	1983-1990
Net Depreciated Capital Assets	Apogee Research, Inc.	1932-1990
Motor Vehicles	Highway Statistics, various years.	1960-1990
Product Delivery:		
Vehicle-Miles of Travel	Highway Statistics, various years.	1960-1991
Passenger-Miles of Travel	National Transportation Statistics, various years.	1979-1990
Ton-Miles of Travel	National Transportation Statistics, various years.	1966-1990
Quality of Service:		
Congestion	Status of the Nation's Highways, Bridges and Mass Transit: Conditions and Performance.	1975-1990
Pavement Conditions	Status of the Nation's Highways, Bridges and Mass Transit: Conditions and Performance.	1983-1991
Percent of Roads Paved	National Highway Statistics: Selected Facts and Figures.	1950-1991
Number of Registered Drivers	Highway Statistics.	1960-1991
Number of Fatalities	Highway Statistics.	1960-1991
Fatality Rates	Highway Statistics.	1960-1991
Cost Effectiveness:		
Spending/Assets	Apogee Research, Inc.	1960-1990
Spending/GDP	Apogee Research, Inc.	1960-1991
Spending/Vehicle-Miles of Travel	Apogee Research Inc.	1960-1991

project proposals. Although not applicable to mass transit alone, the guidelines highlighted a concern that has been expressed that decisions to fund some mass transit proposals were based on projections of ridership that, in hindsight, were found to be far beyond the traffic that actually occurred once the project was built. (Similar concerns have been expressed about other publicly funded projects, including water resources development.) Further analysis of these effects and the way in which mass transit achieves its key objectives of mobility, equity and environmental protection appears to be a pressing need, particularly with the large expenditures needed for capital-intensive transit projects.

Intermodalism is another important wrinkle on this issue. In the past, the performance of various modes has been assessed in isolation of one mode from another. However, of course, the modes are interrelated in that one can be substituted for another. Failure to account for so-called "mode switching" can understate or overstate the effects of investments in a particular mode. This element is especially important in mass transit where environmental objectives are achieved mainly by switching users from highways. Whatever performance system is developed, it must be intermodal, a fact recognized by the packaging together of the highways and mass transit needs surveys, previously conducted and provided separately.

Data Collected and its Uses. Like other modes of transportation, the federal mass transit system tracks many of the typical measures of transportation efficiency and effectiveness such as route-miles, congestion and capacity, revenue-hours (a unit of transit service produced as a vehicle operated in revenue service for one hour or one mile), and real operating cost per vehicle mile traveled (VMT), or passenger mile, or passenger trip. (See Tables 2-5 and 2-6). Inputs into the system are gauged (such as number of vehicles, number and type of stations and characteristics of operating authorities) as are the quantity and quality of many of the outputs (such as passenger trips taken and fatality rates).

In addition, the characteristics of transit riders and their access to transit modes is especially important given the fact for some segments of the population it is the only available mode of transport.

TABLE 2-5: SELECTED DATA CATEGORIES FOR FEDERAL MASS TRANSIT PERFORMANCE
Share of overall transportation by type of transit mode (light rail, heavy rail, buses, etc.)
Labor productivity (e.g. vehicle miles per employee or real operating expenses per employee)
Number of passenger trips
Transit operating expenses (labor, services, materials and supplies, etc.)
Transit revenues (e.g. farebox, government subsidies etc.)
Capital stock (ownership, condition, age, etc.)
Peal hour travel
Directional route-miles
Congestion
Ridership profiles (location, income, etc.)
Number of system employees
Load factors
Passenger safety
Vehicle reliability and cleanliness
Accident rates
Frequency of maintenance
Waits for rides (length, intervals etc.)

TABLE 2-6: PERFORMANCE DATA CURRENTLY AVAILABLE - MASS TRANSIT		
PERFORMANCE INDICATOR	**DATA SOURCE**	**YEARS**
Physical Assets:		
Net Depreciated Capital Assets	Apogee Research, Inc.	1932-1990
Number of Systems, by Size	Federal Transit Administration, National Transit Summaries and Trends for the 1990 Section 15 Reporting Year.	1990
Number of Vehicles	American Public Transit Association, 19xx Transit Fact Book.	1960-1991
Fleet Age	Federal Transit Administration, Section 15 data, various years.	1981, 1987-1990
Track Miles, Other Fixed Assets	Federal Transit Administration, Section 15 data, various years.	1981, 1990
Rail System Conditions	U.S. DOT, Rail Modernization Study, 1987.	1984
Product Delivery:		
Number of Employees	American Public Transit Association, 19xx Transit Fact Book.	1970-1991
Passenger Miles Traveled	American Public Transit Association, 19xx Transit Fact Book.	1977-1991
Vehicle Miles	American Public Transit Association, 19xx Transit Fact Book.	1972-1991
Vehicle Revenue Hours	Federal Transit Administration, Section 15 data, various years.	1984, 1990
Costs per Vehicle Mile	American Public Transit Association, 19xx Transit Fact Book.	1977, 1991
Quality of Service:		
Accidents, Injuries and Fatalities per Passenger Mile	American Public Transit Association, 19xx Transit Fact Book.	1984, 1990
Frequency of Maintenance Road Calls	Federal Transit Administration, Section 15 data, various years.	1981, 1984, 1990
Waiting Time, Transfer Rate, Standees	Bureau of the Census, Summary of Travel Trends: 1990 National Personal Transportation Survey, 1992.	1990

TABLE 2-6: PERFORMANCE DATA CURRENTLY AVAILABLE - MASS TRANSIT (continued)		
PERFORMANCE INDICATOR	**DATA SOURCE**	**YEARS**
Externalities:		
Energy Use per Passenger Mile	Federal Transit Administration, Section 15 data, various years.	1984, 1990
Cost Effectiveness:		
Revenue Vehicle Miles per Employee	U.S. Department of Transportation 1987 Status Report, American Public Transit Association, 1992 Transit Fact Book.	1970-1991
Passenger Miles per Employee	American Public Transit Association, 19xx Transit Fact Book.	1970-1991
Passenger Miles per Dollar of Net Capital Assets	Apogee Research, from Government Finances and APTA data.	1977-1989

WATER RESOURCES AND WATER SUPPLY

Water Resources

Program Goals. The landmark act in federal water resource policy is the Flood Control Act of 1936 which asserted for the first time that the federal government would take the lead responsibility for controlling major floods in river basins throughout much of the nation. Major responsibilities for flood control were assigned to the U.S. Corps of Engineers and the Department of Agriculture. The 1936 Act is also noted for requiring benefit-cost analysis of water projects and requiring that project benefits should exceed project costs in order for project approval. Early major reauthorizations and amendments came in 1938, 1941 and 1944. In particular, the 1944 Flood Control Act authorized the Corps to include in its projects not only flood control and navigation features, but also hydroelectric, irrigation and recreation features, thus establishing multiobjective project planning.

The Natural Resources Conservation Service (NRCS), established within the Department of Agriculture as the Soil Conservation Service, can trace its water resources development authorities through the Flood Control Acts of 1936 and 1944, and the Watershed Protection and Flood Protection Act of 1954. The NRCS's focus has traditionally been on small watersheds, generally limited to upstream tributary river basins of less than 250,000 acres. The program primarily addresses the watershed interrelationships between land cover, soil erosion, and flooding.

Two other major federal water resources development agencies, the Bureau of Reclamation and the Tennessee Valley Authority (TVA), predate the expansion of the federal water resources role in 1936. The Bureau was brought into existence under the Reclamation Act of 1902 and subsequent reclamation laws, including the Reclamation Project Act of 1939. The original purpose of the Reclamation Act was to reclaim land in the arid west, by providing water for municipal and industrial, irrigation and related uses. The overall aim was to encourage the settlement of the West. The 1939 Act irrigation and related uses. The overall aim was to encourage the settlement of the West. The 1939 Act also authorized the Bureau to consider multiple purposes, specifically provision for municipal and industrial water supply, irrigation, flood control, navigation, and hydroelectric power production.

TVA was created in 1933 specifically to foster regional development. The agency was given the power to carry out navigation and flood control work on the Tennessee River and its tributaries and to build power facilities in the region.[15]

These separate agency activities were gradually drawn into a common analytic framework known as the Principle and Standards (P&S), later succeeded by the Principles and Guidelines (P&G) for federal water resource projects. The P&G is a detailed decision guide to the evaluation and selection of alternatives for Federal water resources investments. The P&G has four accounts which are used to classify the benefits and costs of alternatives. These are the National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE) accounts. The P&G recognizes that water resource programs are by their very nature "multiobjective" - that is they achieve many different and sometimes mutually exclusive goals. Thus there is allowance for analysis of these different goals, particularly economic efficiency, which the NED account is designed to consider, and environmental impacts, which the EQ account is designed to capture.

Program Outputs. Of the three federal water resource agencies which operate and maintain a significant capital stock - the U.S. Army Corps of Engineers, the U.S. Department of Interior, Bureau of Reclamation and the Tennessee Valley Authority - only the Corps program is national in scope. (The TVA limits its activities to the Tennessee Valley while the Bureau is statutorily restricted to 17 Western states).

The Corps program consists largely of structures and services to control and limit riverine and coastal storm damage, and to facilitate national and international waterborne commerce. These programs - flood control, shore protection, and navigation - account for the greater part of the Corps civil works activities. In addition, the Corps also is involved in, among other things, multi-purpose projects involving: hydropower production, municipal and industrial water supply, recreation, fish and wildlife improvement, environmental mitigation and restoration; disaster preparedness and relief; and environmental regulation of wetlands. The TVA and Bureau programs are more heavily concentrated in power production, irrigation and water supply, while the NRCS program is primarily aimed at soil and agricultural objectives for small watersheds.

Delivery Methods. The federal government builds, maintains and manages physical structures designed to facilitate navigation, and protect against floods. Thus, for example, through the Corps of Engineers, the federal government has invested in the development of a system of locks, canals, and dams which make up the inland waterways navigation system. In this sense, the federal water resources program is unique because of its heavy reliance on the direct provision of services, rather than indirect provision through grants or regulation. The flood control program also makes use of nonstructural methods of service delivery such as the purchase of properties within a floodplain as well as the structural methods (like levees) mentioned above.

The federal water resources program does represent a partnership with State and local governments in that new investments must have local sponsors and those sponsors must provide cost-sharing on projects. In the case of the Inland Waterways system, users provide significant cost sharing for the construction and rehabilitation of facilities through the Inland Waterways Trust Fund.

In addition, there is a significant regulatory program within the Corps which governs discharges into waters of the U.S. and thus regulates development in wetlands; parties contemplating activities that involve a discharge into wetland areas must get a "Section 404" permit from the Corps of Engineers to undertake those activities.

Policy Context. Of the many issues facing water resource programs today, four stand out: the increasing age of the system; the level of cost-sharing; the appropriate balance between structural and nonstructural methods of achieving policy goals; and the role of environmental objectives in the overall multiobjective water resources enterprise.

Regarding the first issue, much of the Corps flood control and navigation system, and for that matter the TVA and Bureau of Reclamation facilities, were put in place some time ago. Relatively few new projects have been proposed or begun in the last decade. That means that the age of federal facilities has been increasing. For example, many of the flood control reservoirs in operation today are over 50 years old as are many of the locks and dams on the inland waterways system. Because of the increased age of the water resources capital stock, maintenance is consuming more and more of the water resources budget. Over one-half of the Corps civil works budget is now consumed by operations and maintenance expenses.

The increased need to maintain rather than build has required a shift in emphasis on the part of agency managers. The challenge has become both to squeeze as much service out of old facilities as possible (rather than build new ones), and to accurately analyze the trade-offs between maintenance expenditures and new capital investments. Traditionally, analytical procedures in support of the P&G have been applied and developed in the context of new projects; in the past, when capital investment made up the lion's share of the program, that was not a constraining problem. But now, with the shift towards upkeep of existing investments, payoffs to maintenance are being increasingly scrutinized and measured. Thus, the Corps of Engineers has a long-standing O&M program improvement effort underway to ensure the efficiency and effectiveness of O&M spending.

Cost-sharing has also been an important issue, particularly since the landmark Water Resources and Development Act of 1986 (WRDA 86) which increased non-federal cost-sharing and required a more active planning role for project sponsors. The percentage of local funds that must be put forward before a project can commence has increased since the 1936 Act. Future reforms may further examine cost sharing levels and the fundamental question of the appropriate federal role in water resources development. In particular, privatization or defederalization of all or part of the system becomes an increasingly viable option in many cases as federal resources become more scarce.

The Mississippi Flood of 1993 brought to the fore another issue, namely the question of balance between structural and nonstructural methods of achieving water resource objectives. The "Galloway Report" argues that the historical development in the Mississippi floodplain increased the damages caused by that flood and that the increased development was in part a response to the well-developed structural approach of levees and dykes which lulled floodplain residents into a false sense of security. The report suggested greater emphasis on nonstructural policies to reduce flood damages such as acquiring floodprone properties and relocating residents and businesses away from the floodplain, and reducing implicit subsidies to settlement in the floodplain such as subsidizing the cost of federal flood insurance.

Finally, environmental objectives have received increased attention in water resources programs as they have in most other Federal infrastructure programs. Environmental protection is now a primary mission of the Corps, in accordance with Section 306 of WRDA 1990. Section 307(a) of WRDA 1990 establishes "no net loss of wetlands and an increase in the quality and quantity of the nation's wetlands" as goals of the water resources development program. Further, current Corps Civil Works budget guidance identifies the restoration of ecosystems and their associated ecological resources as a priority project purpose.

While the P&G does have an Environmental Quality (or "EQ") account, the measurement of environmental outputs remains a difficult undertaking. This difficulty, some have argued, implies that measurable economic outputs receive more emphasis when projects are analyzed. Be that as it may, increasing effort has been devoted to measuring environmental impacts of proposed projects, such as those being accomplished under Section 1135 of WRDA 1986, and particularly in connection with the Corps Evaluation of Environmental Investments Research Program (EEIRP).

Data Collected and its Uses. A wide range of Federal water resource data are collected and much of it can be used to develop improved performance measures (See Tables 2-7 and 2-8). Much of this information measures outputs such as facility characteristics and operating expenses. However, because of the long-standing tradition of benefit-cost analysis in water resource programs, there is also some information on outcome measures such as the dollar value of prevention of flood damages. While useful, this type of information remains sensitive to the assumptions underlying and application of the individual project analyses.

Public Water Supply

Program Goals. Public water supply has traditionally been and largely remains the province of state and local governments and private utilities with one exception: water quality. The federal government began to regulate water quality with The Water Quality Act of 1965 laid down nationwide standards of purity for all interstate waters, while the Clean Waters Restoration Act of 1966 provided substantial amounts of federal money to help communities defray the costs of meeting the standards imposed in 1965. Meanwhile, the 1965 Water Resources Planning Act encouraged federal-state cooperation in development of water resources of river basins lying within the jurisdiction of several states.[16]

The Water Quality Improvement Act of 1970 (PL 91-224) continued this new federal role in setting water quality standards. The bill authorized the federal government to clean up disastrous oil spills which seriously jeopardized the nation's waters and beaches, with the polluter paying the costs. The bill also placed new controls on sewage coming from vessels which fouled many of the nation's marinas, harbors and ports. Finally, the bill ordered criteria to be developed to cover pesticides in streams, rivers and other waters.[17]

TABLE 2-7: SELECTED DATA CATEGORIES FOR FEDERAL WATER RESOURCES PERFORMANCE
Hydropower:
Percent time meeting scheduled planned outages
Percent of unplanned outages (reliability)
Loss of megawatt hours
Cost per megawatt generated
Hours in service versus total available service hours
Percent of time meeting dispatch agreements
Percent of time voltage and frequency meet power system criteria
Revenue per megawatt generated
O&M dollars per megawatt of installed generation
Installed capacity versus available capacity
Navigation:
Tons carried by destination
Ton-miles of commodities
Service area (Inland Waterways, Coastal Ports)
Number and characteristics of lock chambers and lock sites (e.g. location, age, size of chamber, processing time)
Miles and characteristics of waterway (e.g. capacity, channel depths and widths)
Cargo traffic handled
Private investment in floating stock - towboat fleet, barges, etc.
Commodities carried - value and type
Percent of time that lock is available
O&M dollars per lockage
O&M dollars per commodity tonnage/ton-mile
Lock utilization and availability rates
Losses due to lock delays (real dollars)
Delay per tow, average delay times, total delay time
Processing time (total time spent at each lock)
Downtime/failure rates by cause (e.g. weather, equipment failure, accidents etc.)

More major bills followed. First there was the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) passed over Nixon's veto. This bill added strict limits on what could be discharged into waterways and set a national goal of eliminating all pollutant discharges into U.S. waters by 1985, and an interim goal of making the waters safe for shellfish, fish, wildlife and people by July 1, 1983. Federal grants to states for the construction of waste treatment plants were also approved. A permitting system was set up to enforce quality limits.[18] This regulatory structure was revised and expanded with the passage of the Safe Drinking Water Act (PL 93-523) passed in 1977 and the Clean Water Act of 1977.[19] A number of major reauthorizations of this legislation has followed.

Program Outputs. The primary output of federal water supply programs has largely been in the form of setting standards for water quality. Some water supply capacity is available from federal multipurpose water supply facilities, but this accounts for only a small portion of overall water supply

TABLE 2-8: PERFORMANCE DATA CURRENTLY AVAILABLE - WATER RESOURCES		
PERFORMANCE INDICATOR (Overall)	**DATA SOURCE**	**YEARS**
Physical Assets:		
Net Depreciated Capital Assets	U.S. Army Corps of Engineers, Infrastructure in the 21st Century Economy: An Interim Report, February 1994.	
U.S. Army Corps of Engineers: Navigation		1936-1992
U.S. Army Corps of Engineers: Flood Control		1936-1992
State and Local Government: Water Transport and Terminals		1932-1990

PERFORMANCE INDICATOR (Flood Damage Reduction)	DATA SOURCE	YEARS
Physical Assets:		
Number of Flood Control Reservoirs	U.S. Army Corps of Engineers, 1991 Fiscal Year Annual Report of the Secretary of the Army for Civil Works Activities, Volume II.	1960-1991
Product Delivery:		
Flood Storage	U.S. Army Corps of Engineers, 1991 Fiscal Year Annual Report of the Secretary of the Army for Civil Works Activities, Volume II.	1963-1991
Quality of Service:		
Flood Damages Averted	U.S. Army Corps of Engineers, 1991 Fiscal Year Annual Report of the Secretary of the Army for Civil Works Activities, Volume II.	1960-1992
Damages Sustained	U.S. Army Corps of Engineers, U.S. Army Corps of Engineers Annual Flood Damage Report to Congress for Fiscal Year 1992, Engineering Division, February 1993.	1977-1992
Flood-Related Deaths	U.S. Army Corps of Engineers, U.S. Army Corps of Engineers Annual Flood Damage Report to Congress for Fiscal Year 1992, Engineering Division, February 1993.	1983-1992
Flood Control Dam Safety	U.S. Army Corps of Engineers, 1991 Fiscal Year Annual Report of the Secretary of the Army for Civil Works Activities, Volume II.	1991

TABLE 2-8: PERFORMANCE DATA CURRENTLY AVAILABLE - WATER RESOURCES (continued)		
PERFORMANCE INDICATOR (Flood Damage Reduction)	**DATA SOURCE**	**YEARS**
Cost Effectiveness:		
Ratio of Annual Flood Damages Averted to Amortized Capital Expenditures for Flood Control	Apogee Research, Inc., from U.S. Army Corps of Engineers, U.S. Army Corps of Engineers Annual Flood Damage Report to Congress for Fiscal Year 1992, Engineering Division, February 1993, and Institute for Water Resources expenditures database.	1981-1991

PERFORMANCE INDICATOR (Inland Waterways System)	DATA SOURCE	YEARS
Physical Assets:		
Number of Locks and Dams	U.S. Army Corps of Engineers, 1991 Fiscal Year Annual Report of the Secretary of the Army for Civil Works Activities, Volume II.	1991
Number of Terminals	U.S. Army Corps of Engineers, The 1992 Inland Waterway Review, Institute for Water Resources, October 1992.	1990
Number of River Ports	U.S. Army Corps of Engineers, The 1992 Inland Waterway Review, Institute for Water Resources, October 1992.	1987
Product Delivery:		
Total Tonnage Carried	U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Part V, National Summaries, Water Resources Support Center, various years.	1960-1992
Ton-Miles	U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Part V, National Summaries, Water Resources Support Center, various years.	1960-1989
Percentage of Intercity Tons Carried	ENO Transportation Foundation, Inc., Transportation in America, 1992.	1960-1991
Percentage of Ton-Miles Carried	ENO Transportation Foundation, Inc., Transportation in America, 1992.	1960-1991

TABLE 2-8: PERFORMANCE DATA CURRENTLY AVAILABLE - WATER RESOURCES (continued)		
PERFORMANCE INDICATOR (Inland Waterways System)	**DATA SOURCE**	**YEARS**
Quality of Service:		
Delays	U.S. Army Corps of Engineers, The 1992 Inland Waterway Review, Institute for Water Resources, October 1992.	1990
Processing Time	U.S. Army Corps of Engineers, The 1992 Inland Waterway Review, Institute for Water Resources, October 1992.	1990
Downtime	U.S. Army Corps of Engineers, The 1992 Inland Waterway Review, Institute for Water Resources, October 1992.	1990
Utilization	U.S. Army Corps of Engineers, The 1992 Inland Waterway Review, Institute for Water Resources, October 1992.	1990
Cost Effectiveness:		
Cost per Ton Mile	U.S. Army Corps of Engineers, The 1992 Inland Waterway Review, Institute for Water Resources, October 1992	1977, 1982, 1990
Inland Waterway Freight Bill	ENO Transportation Foundation, Inc., Transportation in America, 1992.	1960, 1965, 1970, 1975, 1980-1991

capacity. In addition, the federal government has undertaken a number of national water supply assessments (the last being in 1972), but generally these plans have not been followed up with federal policy actions and no national studies have been undertaken in the past 25 years.

Delivery Methods. As noted above, the federal water supply program is almost entirely regulatory in its focus. The federal government sets standards for water quality and enforces those standards through permits and sanctions for violation. Finally, there is some federal financing of water quality needs in small communities and a fairly small role in water supply R&D. In that sense, the water quality outputs of the federal water supply role are near completely indirect.

Policy Context. Water quality in the United States has improved dramatically since the passage of the major environmental bills of the 1960s and 1970s. However, the major gains in quality, due mainly to control of point sources of pollution, are now mainly over. The new challenge is to control nonpoint sources such as agricultural pollutant sources like insecticide users and stormwater flows (i.e. combined sewer overflows or CSO's). These nonpoint sources are not easy to regulate and there is some

TABLE 2-8: PERFORMANCE DATA CURRENTLY AVAILABLE - WATER RESOURCES (continued)		
PERFORMANCE INDICATOR (Ports and Harbors)	**DATA SOURCE**	**YEARS**
Physical Assets:		
Number of Ports	U.S. Department of Transportation, A Report to Congress on the Status of the Public Ports of the United States, Maritime Administration, October 1992.	1982, 1986
Number of Terminals	U.S. Department of Transportation, A Report to Congress on the Status of the Public Ports of the United States, Maritime Administration, October 1992.	1982, 1986, 1990
Number of Berths	U.S. Department of Transportation, A Report to Congress on the Status of the Public Ports of the United States, Maritime Administration, October 1992.	1982, 1986, 1990
Product Delivery:		
Cargo Tons Handled by Ports	U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Part V, National Summaries, Water Resources Support Center, various years.	1960-1989
Cost Effectiveness:		
Unit Cost to Dredge Cubic Yard of Sediment	U.S. Army Corps of Engineers, Water Resources Support Center, Navigation Division.	1963-1992

question as to how effective the permit system can control their behavior. For example, publicly owned treatment works (POTW's) are subject to permit requirements and must maintain the quality of discharges from their plants even though that quality may be heavily affected by the outflows from many smaller, unregulated dischargers in the watershed.

The problem of POTW's raises the larger problem of unfunded mandates which is what many States and localities are claiming are contained in major environmental laws. Not only is it expensive to meet water quality requirements, it is often inefficient to meet them in the ways that federal laws often prescribe, or so these parties claim. Many non-federal jurisdictions have argued for more flexibility in meeting water quality standards and more risk-assessment of those standards. In theory this request is the essence of performance management - focusing on final goals and allowing maximum flexibility to maximize those goals in as cost-effective a manner as possible. In practice, however, risk-assessment is rarely noncontroversial and there is a concern that greater flexibility may lead to greater flouting of the law.

Data Collected and its Uses. Some data on water supply are available, much of it dealing with water quality characteristics rather than quantity flows (See Tables 2-9 and 2-10). Much of the quality data is output and program administration-oriented, describing how well permittees, for example, comply with permit requirements rather than examining the change in actual water quality brought about by the law and its enforcement. At the local level, much of the nationally consistent data are kept by a trade association, the American Water Works Association (AWWA).

THE ENVIRONMENT

Federal environmental policy has, in effect, many faces to it. On the one hand, there are many individual environmental laws, such as the Clean Water Act (CWA) and the Resource Conservation and Recovery Act (RCRA), each of which contain their own goals, objectives and programmatic details. Some of these laws are reviewed below.

At the same time, all federal environmental policies are meant to be coordinated under the rubric of the National Environmental Policy Act (NEPA) which was passed in 1970. NEPA states its goals up-front:

> "...it is the continuing responsibility of the federal government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate federal plans, functions, programs, and resources to the end that the Nation may:

(1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

(2) assure all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;

(3) attain the widest range of beneficial uses of the environment without degradation, risk to the health or safety, or other undesirable and unintended consequences;

(4) preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice;

(5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

(6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources." (NEPA, Sec. 101)

These are broad and relatively nonspecific goals. NEPA spells out an equally broad strategy for achieving those goals, namely a systematic analysis of environmental impacts of proposed projects and consideration of possible alternative actions and coordination of environmental policies across agencies. NEPA established the Council on Environmental Quality (CEQ) as an ombudsman for ensuring that the provisions of the act were carried out.

TABLE 2-9: SELECTED DATA CATEGORIES FOR FEDERAL WATER SUPPLY PERFORMANCE
Physical Assets/Product Delivery
Number of water systems and ownership type
Value of assets per system
Population served by system
Distribution storage (storage used and excess)
Uses of water (e.g. agricultural, industrial etc.)
Production per time period (e.g. gallons per person per year)
Water produced but unsold or unaccounted for
Leakage rates
Number of water main breaks
Quality of Service
Compliance with standards (time period of noncompliance; frequency of violations; number of violations)
Outbreaks of disease (Number of outbreaks, people affected, fatalities)
Treatment technologies and processes employed
Treatment plant capacity
Cost Effectiveness
Pricing policies
Revenues per gallon (distributed by size of population served)
Operating expenses per gallon
Average residential bill

Loosely speaking, NEPA provides some of the elements of a performance framework for environmental policy: goals are stated, parts of a strategy for achieving those goals are outlined and a requirement to conduct analysis of individual actions implementing that strategy is set forth.

However, in retrospect, NEPA is viewed by some policy analysts as being incomplete in that it does not spell out its goals and strategy in any detail and does not specify what information should be collected, or how it should be used to make decisions. In addition, the devil, as one says, is in the details, and satisfactory implementation of NEPA and other environmental laws has been difficult to determine at times.

Implementation of environmental policy varies greatly between each specific program area, and no general discussion of NEPA can address the performance-related subtleties of each infrastructure area. However, it is important to keep in mind that, conceptually, every federal environmental program implicitly has a broader set of goals and objectives prescribed for it by NEPA, namely avoiding health and other risks to human populations, and providing a balance between resource use and the natural environment.

TABLE 2-10: PERFORMANCE DATA CURRENTLY AVAILABLE - WATER SUPPLY		
PERFORMANCE INDICATOR	**DATA SOURCE**	**YEARS**
Physical Assets:		
Number of Systems	EPA, Office of Drinking Water and Ground Water, The National Public Water Supervision Program: FY XX Compliance Report.	1987, 1992
Net Depreciated Capital Assets	Apogee Research, Inc.	1932-1990
Miles of Distribution Systems	Apogee Research in-house estimate from U.S. Geological Survey and General Accounting Office reports.	1987, 1992
Treatment and Distribution Capacity	American Water Works Association, Operating Survey Data, various years.	1981,1984, 1985, 1990
Product Delivery:	American Water Works Association, survey data 1984, 1990.	1984, 1990
Quality of Service:		
Compliance with Drinking Water Standards	EPA, Office of Drinking Water and Ground Water, The National Public Water Supervision Program: FY XX Compliance Report.	1992
Incidence of Disease	Center for Disease Control Surveillance Summaries, Morbidity and Mortality Weekly Report, various years.	1990
Unaccounted-for-Water	American Water Works Association, survey data 1981, 1992.	1981, 1992
Water Leakage	American Water Works Association, 1985 case studies.	1985
Water Main Breaks	American Water Works Association, 1985 case studies.	1985
Cost Effectiveness:	American Water Works Association, survey data 1984, 1992.	1984, 1992

Solid Waste

Program Goals. There are a number of laws which have established current national policy on solid waste matters, most of them focusing on that portion of solid waste which could be deemed "hazardous." One of the key laws is the Resource Conservation and Recovery Act (RCRA); (other laws which govern hazardous waste more exclusively are discussed in the next section).

Although RCRA contains sections entitled "Findings" and "Objectives", as its name suggests, the bill is more of a statement of a strategy than an outline of goals. Among the objectives of the act are to provide "technical and financial assistance to State and local governments...for the development of solid waste management plans...which will promote improved solid waste management techniques"; provide "training grants"; prohibit "future open dumping on the land"; assure "hazardous waste management practices are conducted in a manner which protects human health and the environment" and so forth. Most of these objectives are actually means towards the more general end of reducing risks and costs imposed by the generation of solid waste.

Program Outputs. The strategy which federal and other solid waste programs has pursued has hewn fairly closely to the strategy outlined in RCRA. Put briefly, that strategy has been three-fold: first, to reduce waste streams at the source where they are first produced; then to increase recycling and reuse of waste streams that do occur; and finally to dispose of what cannot be recycled or reused in as safe and cost-effective manner as possible.

Delivery Methods. As with most federal programs, decentralization is the norm in solid waste management. Local governments have the primary responsibility for collecting and disposing of solid waste, although often these governments contract out to private carriers to do the job. States largely regulate this function as well as provide financing in some instances. The federal government largely sets standards for the whole system, regulates disposal activities, manages its own waste directly, and provides some financial help through tax and other subsidies.

Policy Context. The decentralization in the national solid waste management system and its regulatory emphasis presents a performance conundrum. Conceptually, decentralization should enable greater "steering" rather than "rowing" and allow for management solutions which can vary locally and thus best meet the problem at hand. On the other hand, decentralization also lengthens the span of control and tends to loosen accountability. One of the key issues facing this system is the appropriate use of a regulatory method of delivering services. For the advantages of a decentralized system to be realized, regulations should avoid being overly prescriptive in telling those being regulated in how to do things. Environmental policymakers now believe that, in many instances, regulations are too specific and need to be expressed more in terms of outcomes achieved rather than methods used to achieve outcomes. There are some constraints to making such a shift however, since the laws themselves often prescribe specific standards.

In addition, a policy debate has been going on over the past few years as to whether there may not be better alternatives to regulation as a way of achieving solid waste goals. At the least general agreement has been reached that regulated parties be allowed more flexibility in adhering to standards where such standards are set forth and that the financial burdens of federal "mandates" be considered if not partly or wholly paid for. And alternatives such as grants, revolving loan funds, and other incentive programs have been considered in this and other environmental areas.

Looming large in this discussion are the issues of risk and cost. However effective the current system has been in producing outputs such as greater recycling and reuse (and as Chapter IX indicates, there has been much success in that area), a performance-based management system is ultimately concerned with the social payoffs to such stratagems. In this case, the payoff is a reduction in overall risk and lowering of overall social cost imposed by solid waste generation and disposal, achieved through a direct and indirect expenditure of resources which is less than the benefits garnered by the program. Hence there has also been a push to use more risk and benefit-cost analysis in solid waste and other environmental programs.

In any program, risk and cost reductions can be difficult to measure and this can be a particularly daunting challenge in environmental programs where ecosystem dynamics are very complex and the cause and effect between an action taken and an ultimate outcome can be very difficult to trace much less understand. This presents a real problem for performance analysts and managers trying to track the efficiency and effectiveness of their programs. One concern expressed is that performance-based systems are biased towards measurable outcomes and thus will tend to bias decisionmakers against programs whose impact on outcomes is difficult to measure and understand.

In general, this concern applies mainly to the naive application of performance systems, an application which should be guarded against. And in some sense, lack of a clear understanding of how a particular policy works is not so much a defense of that policy as an impetus to do more to understand its workings, a task which a good performance monitoring system can aid rather than hinder.

Solid waste is probably less like other environmental programs in terms of measurability of outputs and outcomes. Waste streams are physical quantities and many of their effects, such as disposal cost, can be traced fairly easily. In this sense program outputs - e.g. waste stream reduction - are closely linked to some desired program outcomes - e.g. lowered disposal costs. What is particularly difficult to trace is risk reduction, an issue which looms especially large in the hazardous waste arena.

Data Collected and its Uses. There is a fair amount of data available on the solid waste industry, much of it applicable more to the state and local than the Federal level (see Tables 2-11 and 2-12).

Suffice it to say that most of the data collected measure either program inputs (such as number of recovery facilities) or outputs (such as collection rates). Outcome measurements, other than recycling and recovery rates which could be considered an initial if not ultimate program goal, are relatively rare. Much of this data appears to be used accordingly, namely to manage inputs and outputs. Not unique to this program, outcome management has not yet arrived in full bloom on the solid waste area.

Hazardous Waste

Program Goals. A number of laws pay special attention to the treatment and disposal of hazardous waste. RCRA, an act which deals with both solid and hazardous waste, was described in the last section. Other relevant laws include the Toxic Substances Control Act (TSCA), the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) otherwise known as "Superfund" and amendments made under the Superfund Amendments and Reauthorization Act (SARA). In addition, as with solid waste, other environmental laws governing clean water and clean air also contain provisions pertinent to hazardous waste.

TABLE 2-11: SELECTED DATA CATEGORIES FOR SOLID WASTE PERFORMANCE
Physical Assets
Number of Material Recovery Facilities (MRFs) (type, ownership, type treated)
Number of landfills (size, capacity, tons of waste treated)
Number of waste-to-energy plants (tons processed, power generated, volume of waste in and out)
Number of incinerators
Quality of Service/Cost Effectiveness
Management costs per ton
Collection rates
Number of collectors (by types of collection, e.g. curbside)
Cost of collection
Labor utilization in collection
Households served
Prices for recycled commodities
Costs of landfill
Tipping fees at landfills (by region, average number closing)
Product Delivery
Municipal solid waste (MSW) generated (by type of waste, location of generator, weight)
Recovery processes for MSW (e.g. recycling or composting)

In its "Findings, policy, and intent" section, the text of TSCA states that "it is the policy of the United States that:

(1) adequate data should be developed with respect to the effect of chemical substances and mixtures on health and the environment and that the development of such data should be the responsibility of those who manufacture and those who process such chemical substances and mixtures;

(2) adequate authority should exist to regulate chemical substances and mixtures which present an unreasonable risk of injury to health or the environment, and to take action with respect to chemical substances and mixtures which are imminent hazards; and

(3) authority over chemical substances and mixtures should be exercised in such a manner as not to impede unduly or create unnecessary economic barriers to technological innovation while fulfilling the primary purpose of this Act to assure that such innovation and commerce in such chemical substances and mixtures do not present an unreasonable risk to injury to health or the environment.

TABLE 2-12: PERFORMANCE DATA CURRENTLY AVAILABLE - SOLID WASTE		
PERFORMANCE INDICATOR	**DATA SOURCE**	**YEARS**
Physical Assets:		
Number of Landfills, Combustors, Compost Facilities, and Curbside Recycling Programs	"Nationwide Survey: The State of Garbage," BioCycle: Journal of Composting and Recycling (1989-1993).	1988-1992
Net Depreciated Capital Assets	Apogee Research, Inc.	1932-1990
Number of Waste-to-Energy Facilities	Integrated Waste Services Association, "Status of Municipal Waste Combustion in the United States: 1992 Update," reprinted from Waste Age, (November 1992); and unpublished data from Kidder Peabody Inc.	1975-1992
Product Delivery:		
Municipal Solid Waste Generation and Management Category, National Data	U.S. EPA, "Characterization of Municipal Solid Waste in the United States: 1992 Update" (July 1992).	1960-2000
Municipal Solid Waste Generation and Management Category, State Data	"Nationwide Survey: The State of Garbage," BioCycle: Journal of Composting and Recycling (1989-1993).	1988-1992
Landfill Capacity	National Solid Waste Management Association (NSWMA), "Landfill Capacity in North America, 1991 Update" (May 1992).	1986-1991
Combustion Capacity	NSWMA, "A Comprehensive Report on the Status of Municipal Waste Combustion," reprinted from Waste Age, (November 1990).	1975-1992
Quality of Service\Cost Effectiveness:		
Refuse Collection Cost Per Ton	New York City Department of Sanitation, A Comprehensive Solid Waste Management Plan for New York City and Draft Generic Environmental Impact Statement (March 1992).	1991
Per Ton Disposal Cost	"Nationwide Survey: The State of Garbage," BioCycle: Journal of Composting and Recycling (1989-1993).	1988-1992
	NSWMA, "1990 Landfill Tipping Fee Survey," (1991).	1988-1990

CERCLA states four objectives, namely to provide the enforcement agency the authority to respond to releases of hazardous wastes from "inactive" hazardous waste sites which endanger public health and the environment; to establish a Hazardous Substance Superfund; to establish regulations controlling inactive hazardous waste sites; and to provide liability for releases of hazardous wastes from such inactive sites.

As with RCRA, these objectives and purposes read more like an implementation outline than a vision of programmatic goals.

Program Outputs. As with solid waste generally, hazardous waste management has shifted towards an emphasis on reducing waste streams at their source where possible. An additional dimension which enters into solid waste is the large number of existing hazardous waste sites which often cannot simply be left alone, particularly, for example, where leachate is entering a local water supply.

Delivery Methods. The federal role in hazardous waste management is largely regulatory, in regulating disposals and clean-ups, and providing some financing for clean-ups through the Leaking Underground Storage Trust Fund (LUST) and the liability provisions of Superfund. The federal government also manages hazardous waste generated by its own activities, particularly nuclear wastes generated by the Department of Energy (DOE) and the Department of Defense (DoD), where total authorized clean-up and management costs were close to $10 billion in FY93. The federal government also plays a role in collecting and disseminating information about toxic substances through the 1986 Emergency Planning and Community Right-to-Know Act (EPRCA) which set up the Toxic Chemical Release Inventory (TRI) system. Under TRI, facilities are required to publicly report their releases of toxic chemicals to air, water and land for each substance used, manufactured, or processed above certain weight thresholds. Actual clean-up work at non-federal sites is largely the provence of state and local governments who usually turn to private contractors to do actual clean-ups and restorations.

Overall, the national hazardous waste system is fairly decentralized, with the federal government taking a leading regulatory role and, in this case, a more active presence in providing financing directly, or indirectly organizing private resources to provide that financing (as it has done with its restructuring of the liability system for hazardous waste sites). Even with respect to the federal government's own hazardous wastes, there is decentralization across agencies and little or no uniformity in how those wastes are managed.

Policy Context. In hazardous waste, risk looms especially large, both in terms of identifying which sites are hazardous, and clarifying which course of action gains the greatest risk-reduction at least-cost. Experience with Superfund has led most policymakers to believe that sometimes doing nothing may be the best policy and that, in other cases, complete restoration is either not possible or far too costly to make sense.

However, choosing appropriate strategies for appropriate sites remains difficult. In particular, regulation is often overly prescriptive, requiring clean-up and restoration options which do not make economic or environmental sense. The incentives for nonoptimal policies are exacerbated by the financing system established for Superfund where the liability rules established by the Act encourage going after the "deepest pockets" regardless of where true responsibility for the original mess lies.

Moving towards outcome-based regulation and more equitable and efficient financing schemes for hazardous waste remediation and clean-up seems to be the recommended course. However, coming up with accurate risk assessments, credible to all parties involved, remains a difficult problem. Here, too, there is a difficulty of ensuring that adequate financing is available to take necessary clean-up actions. At the federal level especially, managing clean-up actions already under way and keeping costs under control is a continuing challenge.

Data Collected and Its Uses. Beyond specific case-specific information, there are relatively few measures of hazardous waste's impact on society. Tables 2-13 and 2-14 contain information on types of measures and the kinds of data which are presently available.

TABLE 2-13: SELECTED DATA CATEGORIES FOR FEDERAL HAZARDOUS WASTE PERFORMANCE
Federal programmatic expenditures (e.g. Superfund)
Waste concentrations
Specifications and definitions of hazardous materials (e.g. RCRA standards)
Remediation costs
Number of treatment, storage and disposal facilities (TSD's) (by location, waste volume treated and stored, types of treatment, materials treated, industry served).
Waste streams generated (by volume, industry, waste type)
Violations of law and civil and criminal penalties paid
Capital investments by source
Number of Superfund sites
Number of people living within a given radius of a Superfund site
Removals from Superfund sites (e.g. cubic yards of solid waste of gallons of liquid waste)

Much of the available information pertains to expenditures, facilities, existing Superfund sites, waste flows, and capital investments for handling hazardous waste. The bias is thus towards programmatic inputs, and, to a lesser degree, outputs of the program.

As of yet, hazardous waste is not a performance-driven program per se. The measures which have been collected indicate management problems in both Superfund and federal facility clean-ups and this have provided grist for the mill of program redesign. However, while there is general agreement on the need for changes in these programs, there is relatively little consensus on measures to be taken which would ameliorate some of these problems.

Wastewater Treatment

Program Goals. One of the key laws governing water quality and wastewater management is the Clean Water Act (CWA). This act states that its objective is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The Act further states that its policy is to "prevent, reduce and eliminate pollution, to plan the development and use...of land and water

TABLE 2-14: PERFORMANCE DATA CURRENTLY AVAILABLE - HAZARDOUS WASTE		
PERFORMANCE INDICATOR	**DATA SOURCE**	**YEARS**
Physical Assets:		
Number of RCRA Hazardous Waste Generators and Treatment, Storage, and Disposal Facilities	U.S. EPA, "National Biennial RCRA Hazardous Waste Report" (February 1993).	1987-1989
Product Delivery:		
RCRA Hazardous Waste Generation and Management	U.S. EPA, "National Biennial RCRA Hazardous Waste Report" (February 1993).	1989
Superfund: Number of Sites, Cleanups Initiated and Completed	U.S. EPA, "1st Quarter FY 1993, Superfund Management Report" (December 1992).	1981-1993
LUST: Number of Tanks, Cleanups Initiated and Completed	U.S. EPA, "LUST Trust Fund Second Quarter Report, Fiscal Year 1993" (1993).	1987-1993
U.S. Department of Energy	U.S. Department of Energy, Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1994-1998, (January 1993).	Progress to Date
U.S. Department of Defense	Executive Office of the President, Council on Environmental Quality, Environmental Quality, 23rd Annual Report, (January 1993).	Progress to Date
Quality of Service:		
RCRA Hazardous Waste Compliance and Enforcement	Executive Office of the President, Council on Environmental Quality, Environmental Quality, 23rd Annual Report, (January 1993).	1992
Superfund	U.S. EPA, "Superfund: Reporting on Cleanup Activities Through Environmental Indicators, FY 1991 Update," (September 1991).	Progress to Date
Federal Agencies	Executive Office of the President, Office of Management and Budget, Budget of the United States, FY 1991-1993.	1991-1993

TABLE 2-14: HAZARDOUS WASTE (continued)		
PERFORMANCE INDICATOR	**DATA SOURCE**	**YEARS**
Cost Effectiveness:		
Economic and Employment Impacts of Environmental Compliance and Cleanup	Apogee Research Inc., "The Effects on Industry of Environmental Protection Regulations," draft report prepared for U.S. EPA, (December 1991).	1972-1991

resources." To achieve these objectives, the Act spells out a number of goals, namely, "that the discharge of pollutants into the navigable waters be eliminated by 1985;...that discharge of toxic pollutants in toxic amounts be prohibited;" and other more specific strategies such as providing financial assistance to construct publicly owned treatment works, do research and development into clean water technologies and control nonpoint sources of pollution.

The general goals expressed in the CWA are prescriptive in terms of program outputs such as elimination of discharges of various types by a specific time. In this sense, the CWA is similar to most environmental laws in that it does not focus on outcomes (such as water quality which maximizes social benefit) but on means to achieve social outcomes (such as control of nonpoint pollution and reduction of toxic discharges).

Program Outputs. The general thrust of the national wastewater management system has been to reduce overall effluents and increased the level of treatment which these effluents are subjected to. Although relatively few facilities have been built since 1987, federal policy has called for the building of more treatment facilities with less primary treatment and more secondary and greater-than-secondary treatment called for.

Delivery Methods. The federal role in wastewater treatment consists mainly of setting guidelines and regulations for maintaining water quality and developing national policy for treatment technologies. This regulatory role is backed up by financing in the form of construction grants and increasingly leveraged through State Revolving Loan Funds (SRF's) established with an initial injection of federal seed money but ultimately self-financed by payments and repayments from the SRF-financed projects themselves. With the SRF's in place, states play a more active role in financing facilities and also in enforcing compliance with regulations, both their own and those of the federal government. Local governments, as is often the case, generally provide wastewater treatment directly through the management and ownership of treatment plants. Overall the system has a regulatory bent, is highly decentralized, but is more heavily subsidized by state and local governments than solid and hazardous waste management.

Policy Context. The main focus of wastewater programs is on point discharge sources, namely those dischargers which are large, immobile and easy to locate, as opposed to nonpoint sources, such as farms and automobiles, which tend to be small, numerous, highly mobile and thus hard to locate at any particular time.

Unfortunately, water quality may be most adversely affected by these nonpoint sources. Thus the program outputs may not be especially closely related to the desired program goals. Identifying and tracking nonpoint polluters is difficult and making those sources change their behavior is even more problematic. Regulation is recognized as being a particularly ineffective and inefficient way of managing nonpoint sources. Alternatives such as effluent fees are conceptually more effective, but can be difficult to design.

Data Collected and its Uses. Wastewater program data are heavily focused on compliance and output measures such as percentage of effluents subjected to primary and secondary treatment (see Tables 2-15 and 2-16). In that sense, the federal wastewater program is like most other federal environmental programs with its focus on enforcement of existing standards rather than monitoring and managing of outcomes.

TABLE 2-15: SELECTED DATA CATEGORIES FOR FEDERAL WASTEWATER PERFORMANCE
Number of treatment facilities
Compliance with national standards (e.g. effluent limits)
Size and type of service provided by plant (e.g. level of treatment as in primary, secondary etc.)
Public expenditures by type (e.g. new capital and O&M)
Miles of sewer in service and number of households served
Number of sewer systems
Net depreciated capital stock
Population served by sewer systems
Reserve capacity available
Plant worker safety (e.g. injury frequency rate)
Volume of wastewater treated
Achievement of material goals (i.e., fishable, swimmable water)
Worker Safety

TABLE 2-16: PERFORMANCE DATA CURRENTLY AVAILABLE - WASTEWATER TREATMENT		
PERFORMANCE INDICATOR	**DATA SOURCE**	**YEARS**
Physical Assets:		
Number of Sewer Systems	EPA, 19xx Needs Survey Report to Congress: Assessment of Needed Publicly Owned Wastewater Treatment Facilities in the United States, various years. (Biennial report first published in 1976).	1976-1988
Number of Treatment Facilities	EPA, 19xx Needs Survey Report to Congress: Assessment of Needed Publicly Owned Wastewater Treatment Facilities in the United States, various years.	1976-1988
Population Served	EPA, 19xx Needs Survey Report to Congress: Assessment of Needed Publicly Owned Wastewater Treatment Facilities in the United States, various years.	1978-1988
Net Depreciated Capital Stock	Apogee Research, Inc.	1932-1990
Product Delivery:		
Volume of Wastewater Treated	EPA, Biennial Needs Survey, various years.	1976-1988
Reserve Capacity	EPA, Biennial Needs Survey, various years.	1978-1988
Quality of Service:		
Ambient Water Quality	EPA, National Water Quality Inventory: 1990 Report to Congress (1992).	1992
Compliance with Effluent Limits	EPA, Office of Drinking Water and Ground Water, National Water Quality Inventory: 1990 Report to Congress (1992).	1984-1990
Worker Safety	Annual "Safety Survey" published by the Journal of the Water Pollution Control Federation.	1967-1988
Cost Effectiveness:	Apogee Research, Inc.	1984, 1992

CONSOLIDATED PERFORMANCE REPORT ON THE NATION'S PUBLIC WORKS: AN UPDATE

CHAPTER III: AVIATION

OVERVIEW OF AVIATION

The aviation system is comprised of three separate but interrelated sectors: aircraft operators, airports, and air traffic control. Aircraft operators include major international carriers, with several billion dollars in annual revenues, smaller regional carriers that may only run a short-haul service, and small general aviation aircraft owners. Airport facilities vary in size, traffic volume, and type of aircraft served, from major hubs serving hundreds of thousands of aircraft yearly and as many as 60 million passengers a year to small general aviation fields that may serve only a few hundred aircraft each year. The third component is the air traffic control system, whose responsibility is to provide safe conditions for the operation of aircraft and airports.

The late 1980s and early 1990s have been difficult years for the aviation industry. In 1987, the major challenge facing the aviation community was building capacity to meet the rapidly increasing demand for air travel. However, the slow growth of the economy over subsequent years has substantially changed financial conditions within the aviation industry and may affect the industry's ability to meet future demands.

Despite the slow-down in the growth of air service demand, the federal Aviation Administration (FAA) still forecasts a significant rise in future traffic. In 1992, there were just over 1 billion passengers served on domestic flights and international flights connecting through the United States. The forecasts for the year 2000 is 700 million enplanements, expected to rise to 800 million enplanements by the year 2004.[20] This represents a 40 percent increase in demand in just seven years.

Performance of the air traffic control system is more difficult to assess. While air traffic control has responded well to changes in demand for services and commercial air carrier safety has continually improved, modernization is needed. This issue is currently being addressed through the Aviation System Capacity Plan, but continues to face implementation problems

Because the overall goal of the air transportation system is the safe and efficient movement of people from one city to the next, the performance of each sector is evaluated both individually and together to understand the performance of the entire system. This chapter examines how well these three sectors work together.

OVERALL PERFORMANCE OF AVIATION FACILITIES

The most visible part of the system, airports, are financed by a combination of the private sector and every level of government. Aircraft and airlines, from the larger commercial air carriers to the small general aviation aircraft that are owned and operated by individuals and corporations, are almost entirely privately funded and operated. The air traffic control system, on the other hand, is almost entirely owned and operated by the federal government. These unique combinations of financing, ownership, and operation have resulted in a system of diverse demands on public sector participation.

Airports

The U.S. has 17,846 airports, more than the rest of the world combined (Figure 3-1).[21] Most serve small planes (included in the category "general aviation") exclusively and 12,301 are not available for use by the general public. The 5,545 that are open to the public include all airports used by the commercial aviation industry and most of the largest general aviation airports.

Most commercial airports are publicly owned and operated. The vast majority, about 95 percent, are operated by the local government or a special planning district. The remaining five percent are controlled by state governments. Typically, large commercial airports operate as self-sufficient enterprises with most capital funds provided through tax-exempt bonds and operating costs financed by landing fees and other direct user charges.

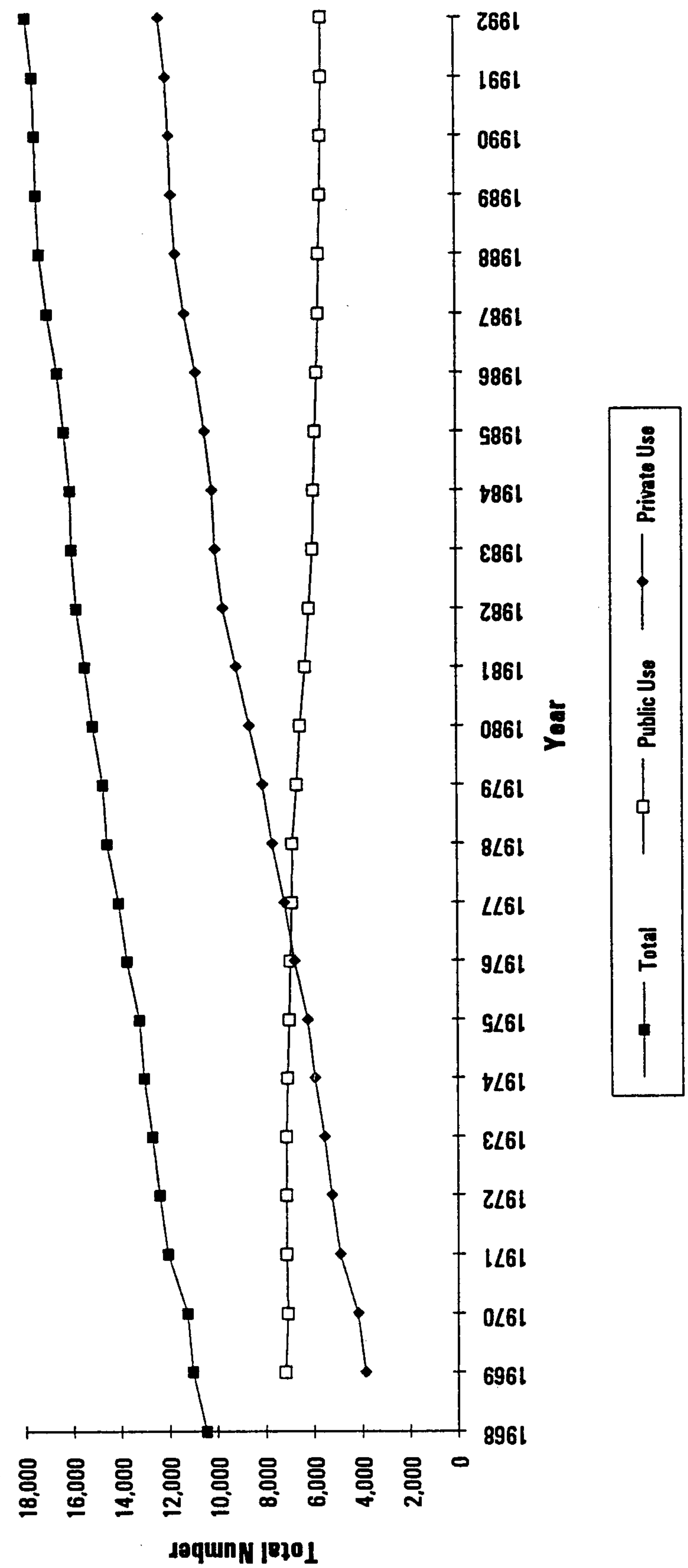
Commercial air travel is concentrated at a few large commercial airports with 90 percent of national passenger enplanements occurring at the 100 largest airports. It should be noted, however, that these large airports serve mostly air carriers that operate larger than average aircraft so that the group of airports with the highest levels of enplanements are not always the same as those with the highest number of aircraft take-offs and landings. In addition, these commercial airports serve the general aviation flyer as well. In fact, general aviation traffic exceeds commercial airline traffic at almost every airport smaller than a large FAA hub and at many large hubs, as well. This trend is becoming more pronounced as larger commercial airports begin to experience more severe delays and encourage general aviation traffic to use smaller, less congested airports.

Most of the nation's airports are not used by commercial air carriers, but are smaller facilities used by planes owned by individuals and corporations exclusively. One third of these airports are publicly owned (including military base airports) and more than three-fourths are privately owned.[22] As with commercial airports, most traffic is handled by a relatively small number of general aviation airports. Indeed, in terms of the number of takeoffs and landings, some of these airports are among the busiest in the nation. For example, the general aviation airport in Santa Ana was the fifth busiest airport in the country in 1990.[23] In addition, many larger general aviation airports located near commercial airports have been designated by the FAA as relievers. Because they are meant to serve general aviation aircraft as alternatives to the more congested commercial airports they receive special consideration in federal aid programs.

Aircraft and Airlines

Unlike airports and the air traffic control system, aircraft and airlines are almost exclusively owned and operated by private firms or individuals. These include several distinct types: large commercial aircraft capable of carrying 600 or more passengers over long distances, that are the mainstay of the large national and international <u>air carriers</u>; smaller commercial aircraft used by <u>commuter airlines and air taxis</u> to carry up to 60 passengers between smaller airports and larger primary airports, and <u>general aviation</u> planes that typically handle less than ten passengers and are owned by individuals and private firms.

Figure 3-1: Number of U.S. Airports



Source: FAA Offce of Public Affairs.

The vast majority of aircraft are small planes owned by individuals and corporations. Of these general aviation planes, 88.3 percent are piston aircraft and only 4.7 percent are jet or turbo prop.[24] In terms of the most visible output of the aviation industry -- the intercity movement of people -- one percent of the fleet owned by commercial airlines accounts for 97 percent of all aviation passenger-miles. This imbalance is possible because commercial airliners are much larger and because they are used much more intensively than general aviation aircraft.

The airline industry has undergone dramatic organizational and economic changes, mostly triggered by the end of federal industry regulation in 1978. These changes have continued since the previous report and include:

- A revolution in how airlines compete, with an increased emphasis on price and a change in the cost structure of every major air carrier.

- A wave of mergers that could ultimately reduce the level of competition. This potential has increased with the number of major airlines filing for bankruptcy.

- A switch to the hub and spoke system in the early 1980s, with the effect of concentrating traffic at certain airports, adding to congestion in some areas and reducing traffic in others. However, in recent years, Southwest Airlines reintroduced direct point-to-point service and achieved the highest profitability in the domestic airline business.

Air Traffic Control

The air traffic control system is owned and operated by the FAA and represents the most direct and significant federal influence on aviation. The FAA also operates a sizable research and development program geared to improving the air traffic control system.

The FAA operates a series of facilities including 401 airport control towers located in the busiest airports, 22 enroute centers to manage the flow of aircraft between airports, and 172 flight service stations that provide weather and related information to general aviation pilots.[25] Air traffic controllers located in the enroute centers and airport towers monitor and direct all aircraft in the vicinity of airports with airport traffic control towers. A key part of this system is a network of radar, computers, and other equipment designed to monitor aircraft movements.

IMPROVING PERFORMANCE REPORTING IN THE FUTURE

Unlike most categories of public works, many aspects of aviation are well-documented. Trends in airport and airline activities and performance are readily available to nearly any degree of detail. Alternatively, very little information is available on how the public is served by the current air traffic control system. From a public policy perspective it is important that this information, including detailed airline and airport data and air-traffic control data, be organized to allow comparisons for benefit-cost analysis. Of course, this does not apply as directly to the airline industry because its performance is most easily measured by its profitability. However, exploring the relationship of airline profitability to public sector activities may reveal useful policy information.

Thus, one general observation can be made regarding aviation system data: information management needs to be streamlined. There is considerable information on air carriers and large airports and too little information on smaller facilities. Further, the air traffic control system tracks information which could prove particularly useful for performance analysis, but because the FAA needs only a small portion of this information for system operations, most is not compiled and ultimately lost. A coordinated approach to collecting and using this information could, in addition to assisting in tracking system-wide performance, enhance system planning at all levels of government.

Data needed to support financial or operational performance measures include detailed financial statements, operational data (by type of operation), physical characteristics of each airport, and the number of employees. Optimally, for example, complete information on the types of operations by period of the year, coupled with detailed information on the number of runways and/or employees as well as financial information would allow one to develop an objective, comparative performance index.

OVERVIEW OF AVIATION MANAGEMENT

Government Roles

Federal Government. The federal role in air transportation is concentrated in air traffic control, regulation and capital grants. Air traffic control comprises the majority of federal direct expenditures, and of this, more than 75 percent is used to pay air traffic controllers' salaries. The reasoning behind this role is that the operation and maintenance of local airports is the responsibility of the local government, but because it is more difficult for the local government to provide an integrated air service system, the federal government must fill this position. The same reasoning justifies extensive federal regulation of aviation.

Federal grants are generally earmarked for air traffic control improvements, airport safety and noise reduction or airport planning efforts. The majority are provided to commercial airports with the balance going to large general aviation airports that help relieve congestion at commercial airports. User taxes finance capital spending and FAA operating expenditures.

State and Local Government. State governments have a very limited role in the air transportation system, providing system planning and some small grants. Although the state's financial contributions are considerably smaller than that of the federal government, because they focus their contributions on smaller general aviation facilities, they can afford assistance to a large number of airports.

State governments operate five percent of the nation's airports. The remaining 95 percent are planned, built and operated by local governments. Generally, these airports are operated as financially independent organizations by special districts, and receive most of their financing through user fees and bond issues.

Private Sector. The private sector dominates a vital part of the aviation industry through its ownership and operation of commercial airlines. Also, because extensive airport improvements are often financed through increased user fees, private airlines shoulder a large financial responsibility for these improvements. In addition, most general aviation aircraft are owned by corporations and individuals.

Financial Trends

The federal government, primarily because of its responsibility for the air traffic control system, and local governments, because of their operational control of major commercial airports, are the two principal participants in aviation finance. States provide minimal financial assistance and the private sector's contribution is for investment that is not comparable to public "infrastructure."

User fees dominate public aviation funding for every level of government and for airports as well as air traffic control. This is a key strength of the U.S. aviation system since it helps ensure that adequate market demand exists before construction is put in place. As with other public areas, reliance on user fees functions best when there is a clear commercial market for aviation services. Indeed, the solid access that the larger airports have had to the financial markets results from this ability to be self-supporting. For the smaller commercial airports and most general aviation airports, however, the ability to finance major capital improvements through the bond market is limited, and greater reliance must be placed on state, local, and federal grants and on retained earnings.

Federal Government. federal excise taxes have been paid into the Airport and Airways Trust Fund and dedicated to aviation improvements since 1970. Disagreements between the FTA and Congress and between Congressional authorizing and appropriating committees over spending levels and use of funds for FAA operating costs have resulted in the build-up of a large surplus ($15.2 billion at the end of fiscal year 1992) in the federal trust fund. However, estimates for fiscal year 1993 show the end of year surplus falling to $13.1 billion.[26]

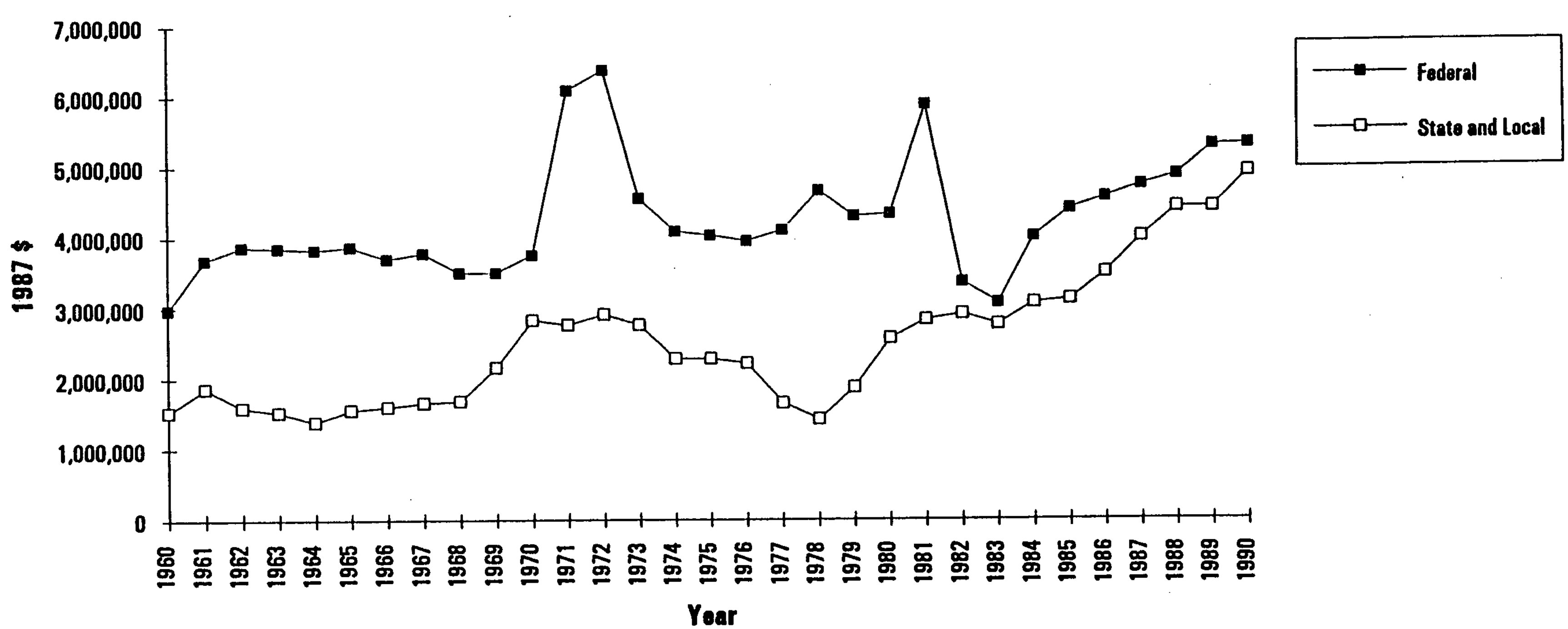
Federal spending on aviation, largely supported by a series of excise taxes, has remained steady. Total real federal spending was $4.5 billion in 1986 and $5.3 billion in 1990 (Figure 3-2). Though a relatively small component of total federal spending on aviation, real capital expenditures have increased from their low of $132 million in 1982 to $618 million in 1990 (Figure 3-3).

State and Local. Although local government investment in the overall aviation system is second to that of the federal government (Figure 3-2), they are the largest investors in airports, as reflected in total capital expenditures (Figure 3-3). For example, state and local capital expenditures from 1987 to 1990 have, on average, been five times greater than federal capital expenditures. In 1990, real federal capital expenditures were $618 million and the state and local governments spent $3.197 billion. However, just as the building of Dallas/Fort Worth airport inflated local expenditures in the mid-1970s, construction of the new Denver airport has significantly increased outlays in the late 1980s. State government expenditures remain a small part of total aviation expenditures.

PERFORMANCE OF AVIATION FACILITIES

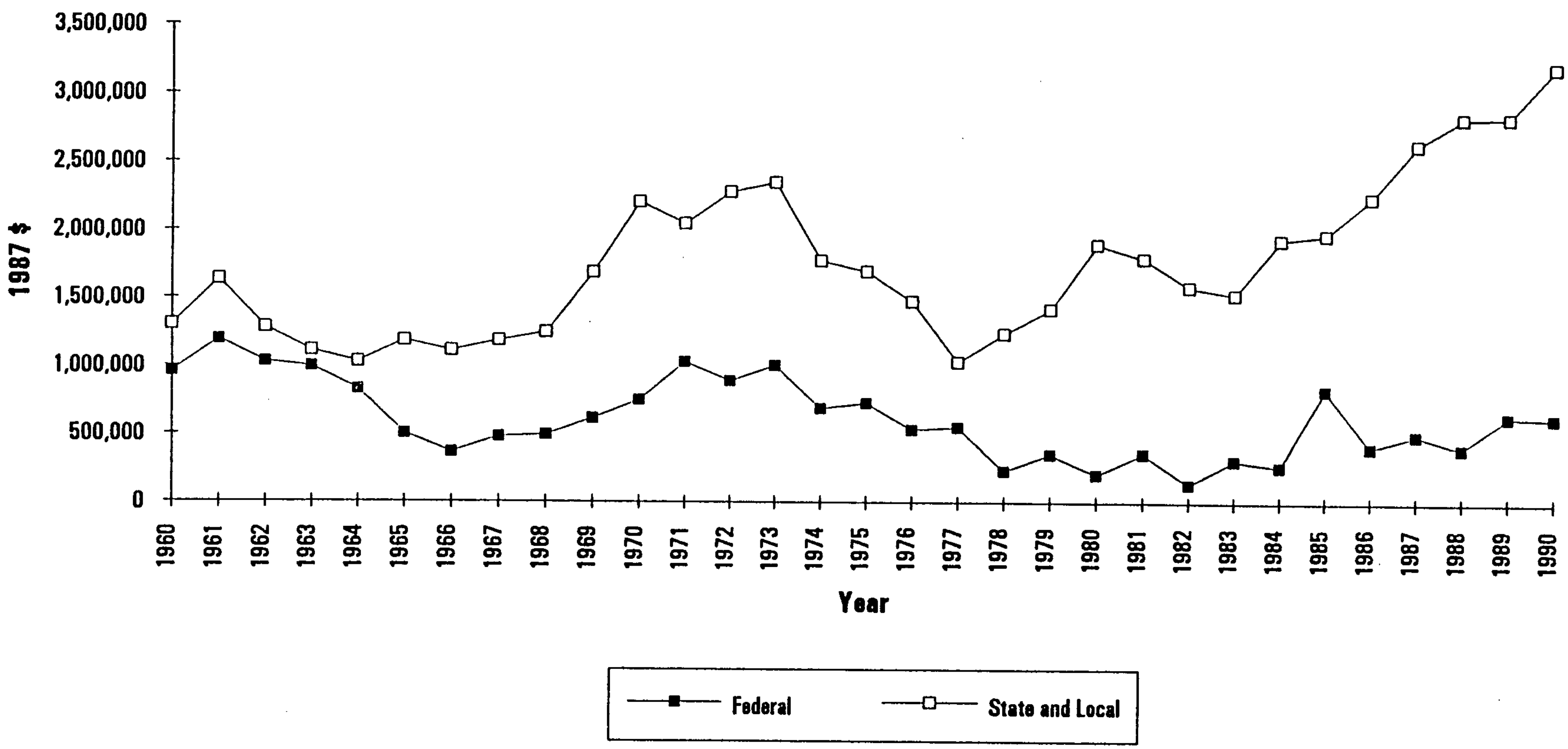
This section describes a wide variety of performance measures, often from the perspective of each of aviation's three main components: airports, aircraft and airlines and air traffic control. Because of their interdependency, however, each measure also reflects the successes and failures of the other to exogenous factors. For example, increased delay may be due to insufficient airport capacity, poor scheduling by the airlines or inadequate air traffic facilities. In addition, delays are often due to inclement weather conditions.

Figure 3-2: Total Spending on Aviation By Level of Government



Source: Bureau of the Census, Government Finances Data Series.

Figure 3-3: Capital Spending By Level of Government



Source: Bureau of the Census, Government Finances Data Series.

Separately, the three components should be evaluated according to their particular goals. However, from a public policy perspective, it is more important that the three components successfully deliver safe, efficient and reasonably priced inter-city transportation. As a result, this section will describe overall system performance and try to evaluate the success of the components as a secondary task. As with the other modes, performance will be measured according to four categories: physical assets, service delivery, quality of service, and cost effectiveness.

Physical Assets

Physical assets in airports are quantified based on the growth rate in airport facilities and net capital stock. While these two data series reflect different relations of capital to performance, the data indicate similar trends. Airline assets are measured according to changes in fleet size and air traffic control is evaluated more qualitatively.

Airports. Although simplistic, one measure of aviation system physical assets is growth in the number of airports. Since the late 1960s, the total number of airports has grown by an average of 2 percent per year to 17,846 in 1992 (Figure 3-1). However, the rate of growth has begun to decline -- in the last five years the number of airports has grown by an annual rate of only 1.4 percent. This decreased growth rate is attributed to a decrease in the number of public use airports. Because of increasing insurance costs, many private airport owners are restricting access to their airfields.

In addition to the absolute increase in number of airports, the quality of facilities at these airports has also improved. In 1968, only 3,353 landing facilities were equipped with paved runways. By 1985, 6,721 airports were paved, and in 1992, this number had risen to 7,936. Furthermore, runway lengths have been increasing. This is important because many of the larger aircraft require runway-lengths greater than 11,000 feet to operate safely. Since 1986, the number of airports with runways greater than 10,000 feet has increased from 152 to 213 in 1992.[27] This increase is impressive when one considers the investment requirements for such high-quality runways.

Airlines and Aircraft. The commercial airline industry responded to increased air service demand by rapidly expanding its fleet. In 1986, the US fleet of large jet aircraft was comprised of 3,168 aircraft. By 1991, the fleet had grown by 34 percent to 4,252 aircraft (6 percent annual rate). In the wake of the 1991 recession and severe operating losses, the industry then retired many of its older stage two aircraft and the estimated fleet size for 1992 fell to 4,206. However, the fleet of wide body aircraft continued to rise by 29 percent since 1986.

The fleet of regional aircraft has also increased from 1,538 aircraft in 1986 to 1,960 in 1992, an increase of 27 percent. More dramatically, the fleet mix has developed to favor larger aircraft. In 1986, 77 percent of the regional fleet was comprised of aircraft with less than 20 seats. In 1992, only 65 percent of aircraft in the regional fleet were configured with less than 20 seats.

The number of general aviation aircraft has remained constant for the last few years. This comes after a dramatic decline in the early 1980s. The previous decline is attributable to significant increases in fuel costs. The repeal of the luxury tax may spark a rebound in aircraft ownership.

Air Traffic. It is more difficult to measure physical assets of the air traffic control system because capacity is more related to technology than to the number of facilities. An exception, however, is the number of air traffic controllers, which has risen steadily over the last few years. In 1981, the year of the Professional Air Traffic Controllers strike, the total controller work force was 6,575 persons. In 1992, there were 12,117 controllers and estimates for 1993 are 17,871.[28] It should be noted that because of the 1981 air traffic control strike, there was an immediate decrease in the capacity of the air traffic control system. Now that those individuals hired after the strike have gained experience, the air traffic control system has improved as it can handle more aircraft take-offs and landings.

Capital Stock. Figure 3-4 presents net capital stock for air transportation, based upon capital investment by all levels of government, and state and local governments. Both series have risen steadily from 1960 through 1990. The deviation in the smooth trend during the mid-1970s corresponds to construction and completion of the Dallas/Fort Worth Airport. The all-government net stock rose from $9.7 billion in 1960 to $33.6 billion in 1975, an average annual growth of 8.6 percent. Growth leveled off after this time, averaging 1.7 percent per year from 1975 to 1985. Since that time growth has increased, as total net stock rose from $39.6 in 1985 to $47.5 in 1990, an average of 3.7 percent per year. This increase is the direct result of the push to meet capacity at a growing number of congested airports. Furthermore, this growth can be expected to continue; the 1991-1992 Aviation System Capacity Plan estimates $6.4 billion is planned for runway construction alone.[29]

The net capital stock figures indicate that the growth in capital stock is beginning to keep pace with the growth in revenue passenger miles (RPMs).[30] From 1981 to 1987, RPMs per dollar of net capital stock rose from 6.7 to 9.5, an average increase of 6.0 percent per year (Figure 3-5).[31] From 1987 to 1990, the rate of increase slowed to 0.7 percent annually, as the 1990 rate reached only 9.7 RPMs per dollar of net capital asset. This can be partially attributed to the relative slowdown in the growth of air demand in the late 1980s. In addition, when one considers the incredible growth in air cargo during the 1980s, the capital stock utilization rate has probably continued to rise.

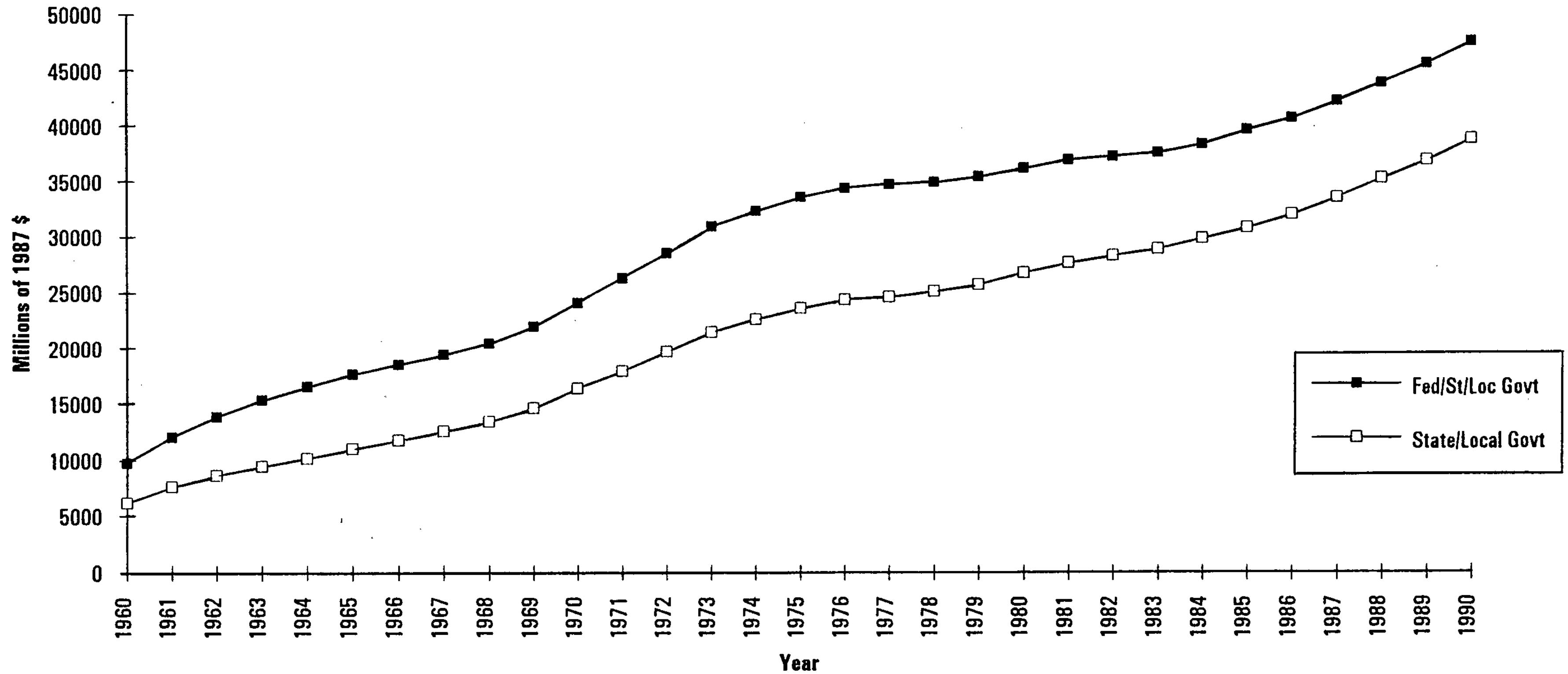
Service Delivery

Data on airline performance and service levels are perhaps the best indicators available of exactly how well the aviation system operates and of the quality of service that is provided. All airlines are required to file financial, operational, and service data with the U.S. Department of Transportation. These filings serve as the basis for financial performance measures, enplanements, passenger miles, and seat-miles.

Aviation output has two major components: service provided to commercial passengers and cargo; and service provided to pilots (air carrier and general aviation) via the air traffic control system. The first component most directly measures performance of the airports and airlines, whereas the second measures performance of the air traffic control system.

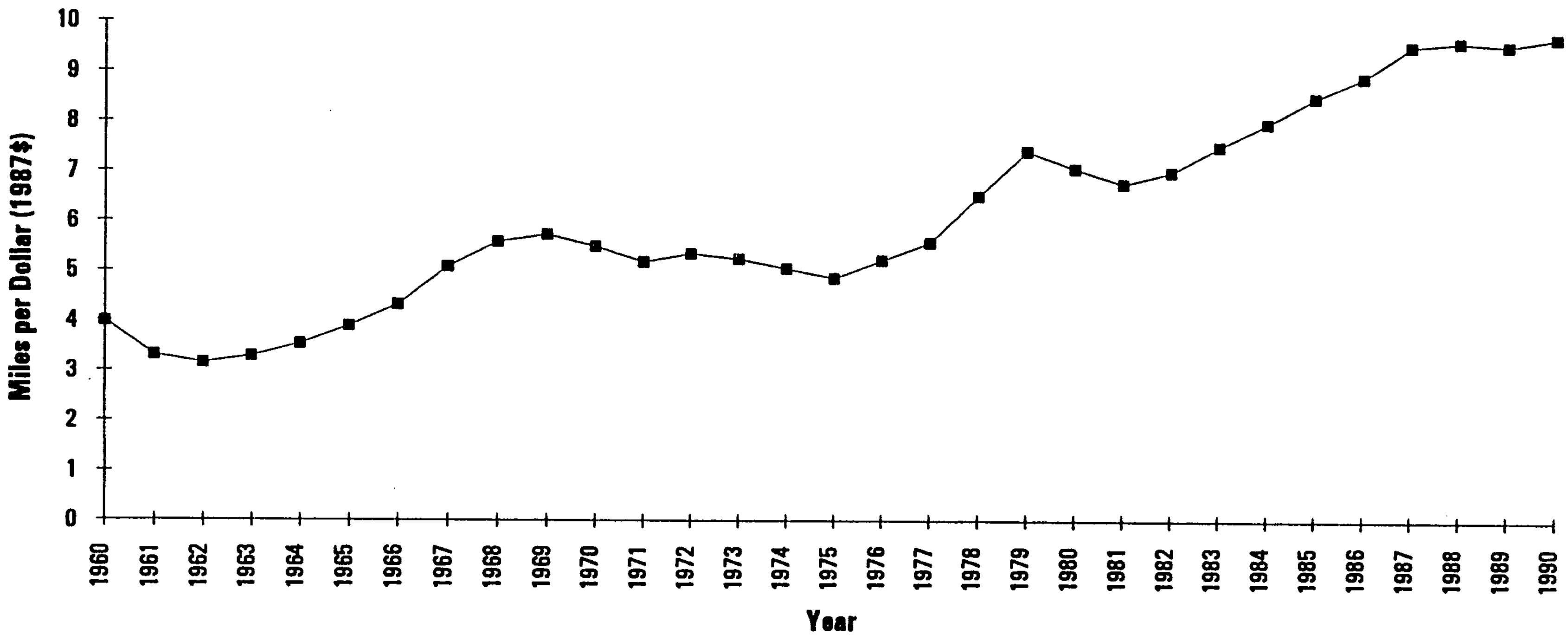
Service to Passengers. Revenue passenger enplanements serve as an overall indicator of service on the part of airlines, airports, and air traffic control (Figure 3-6).[32] Since 1960, the level of enplanements grew continually through 1979 from 100 million to nearly 320 million. The air traffic controllers' strike, however, severely limited capacity in the system, reducing enplanements to a point from which it would not fully recover until four years later. In the period 1981, when the effect of the strike was greatest, to 1987, revenue passenger enplanements grew at 8.5 percent annually. However, since 1987, because of slower economic growth and the Persian Gulf War, enplanement growth slowed to only 1.4 percent annually. In fact, total enplanements decreased in 1991 for the first time since 1981.

Figure 3-4: Air Transportation Net Capital Stock



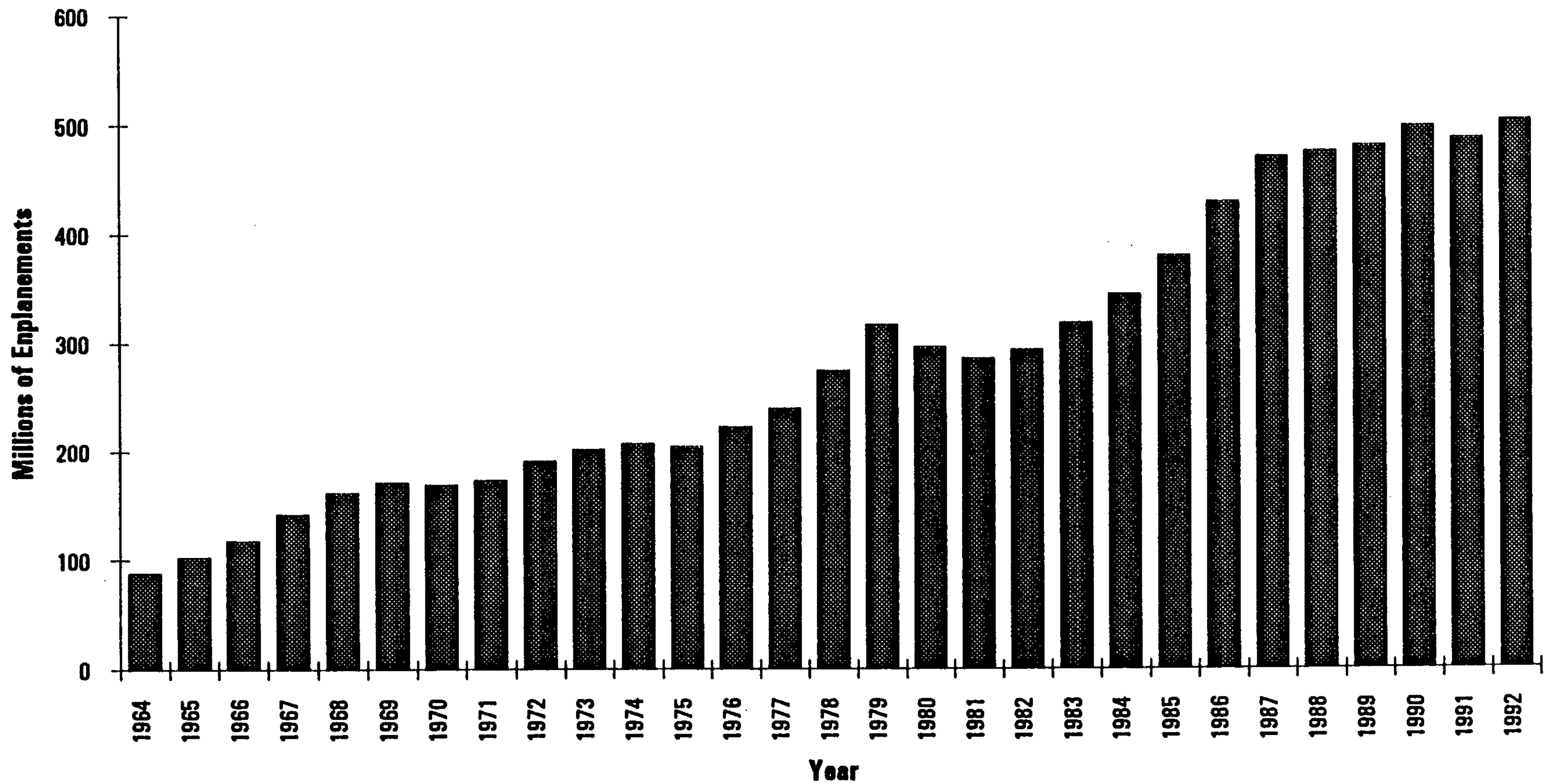
Source: Apogee Research, from Census Government Finances data

Figure 3-5: Revenue Passenger Miles per Dollar of Net Capital Stock



Source: Apogee Research, Inc.

Figure 3-6: Revenue Passenger Enplanements



Source: FAA Aviation Forecasts.

Total enplanements in 1992 rose to 503 million, a 3.5 percent increase over 1991. This growth is attributed to summer fare wars in 1992.[33]

Revenue passenger miles (RPMs), commonly cited as a measure of available service-related mileage, summarize the relationship of system use and total service provided by that use. An important comparison provided by this measure is the trend in domestic versus international growth (Figure 3-7). Since 1986, an interesting reversal of trends has occurred. From 1979 to 1986 the average annual growth in RPMs was 5.2 percent for domestic travel and 2.8 percent for international traffic. However, since 1986 the rate for domestic RPMs has fallen to 2.8 percent while for international travel, it has climbed to 12.3 percent. Part of this disparity can be explained by the growth in average trip length for international travel by 500 miles to over 3,000 miles per trip. In comparison, average trip length for domestic travel has increased by only 100 miles to just over 1000 miles per trip.[34]

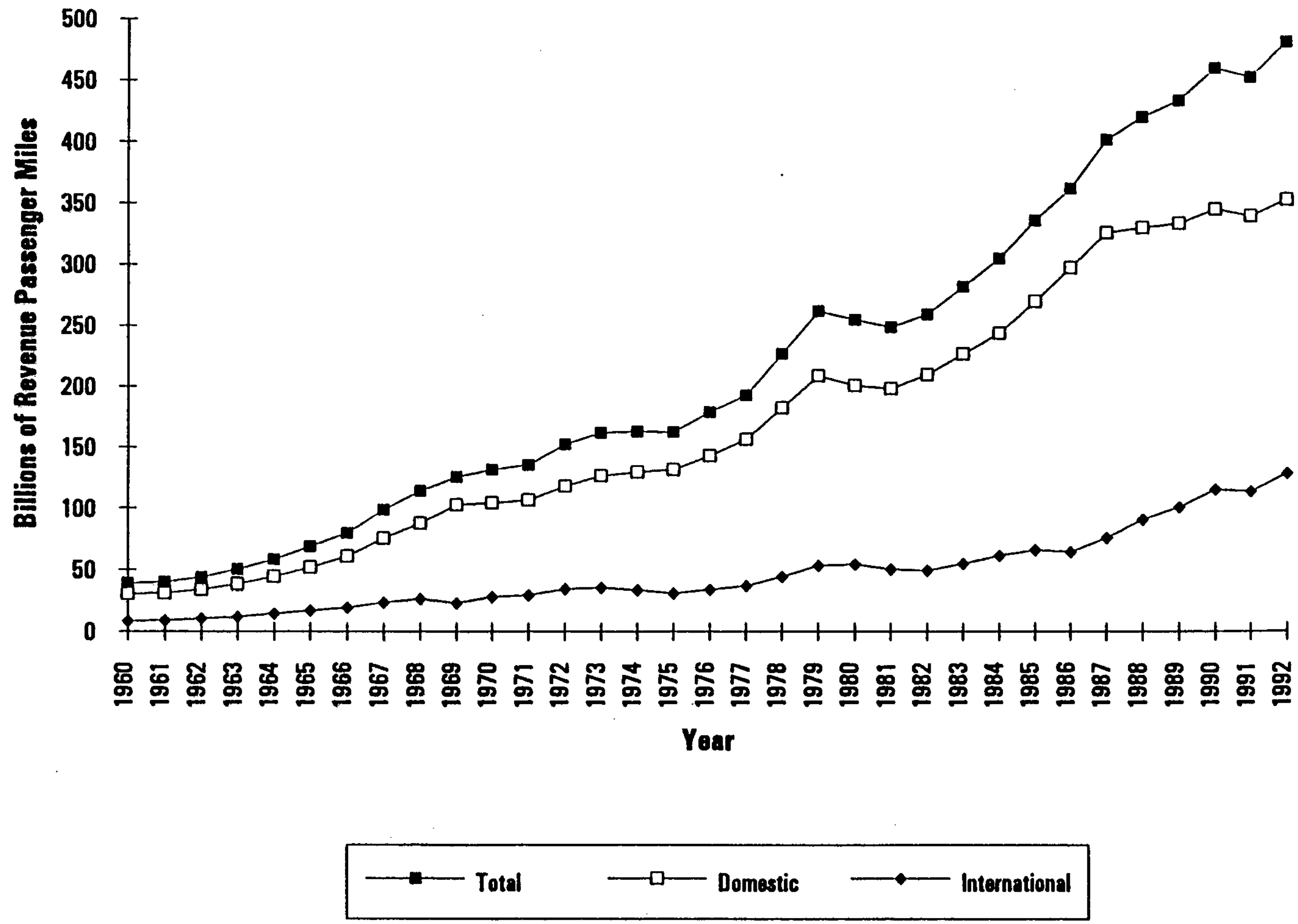
Cargo Service. The air cargo industry has grown considerably and changed dramatically since the early 1970s. Growth in cargo tons carried by US carriers since 1970 has been at an average annual rate of 3.9 percent (Figure 3-8). More importantly, this growth can be separated into the slow growth 1970s, 0.7 percent annual growth, and the high growth 1980s, 9.6 percent. The primary reason for this growth has been the introduction of the air express sector in the early 1980s which expanded during the decade at an average annual rate of 26.8 percent, from 445 million revenue ton miles (RTM) in 1980 to 6,067 million RTMs in 1991 (Figure 3-9).[35]

Growth of the air express market is largely due to deregulation of the air cargo industry in 1977. At this time, a number of air forwarders and surface operators began air freight service emphasizing speed and delivery. This new service not only displaced some traditional air carriers but also created new markets in much the same way that the Interstate Highway System changed the surface shipping industry. By offering next day service, express carriers altered the organization of business and facilitated "just-in-time" inventory systems. These "new markets" now account for 53 percent of express carrier business.[36]

Although international air cargo (Figure 3-10) has not experienced the same growth in the air express industry, its growth has averaged 7.3 percent since 1980 as compared to 12 percent for domestic air cargo. This high growth is directly attributable to increases in Asian and Latin American trade.

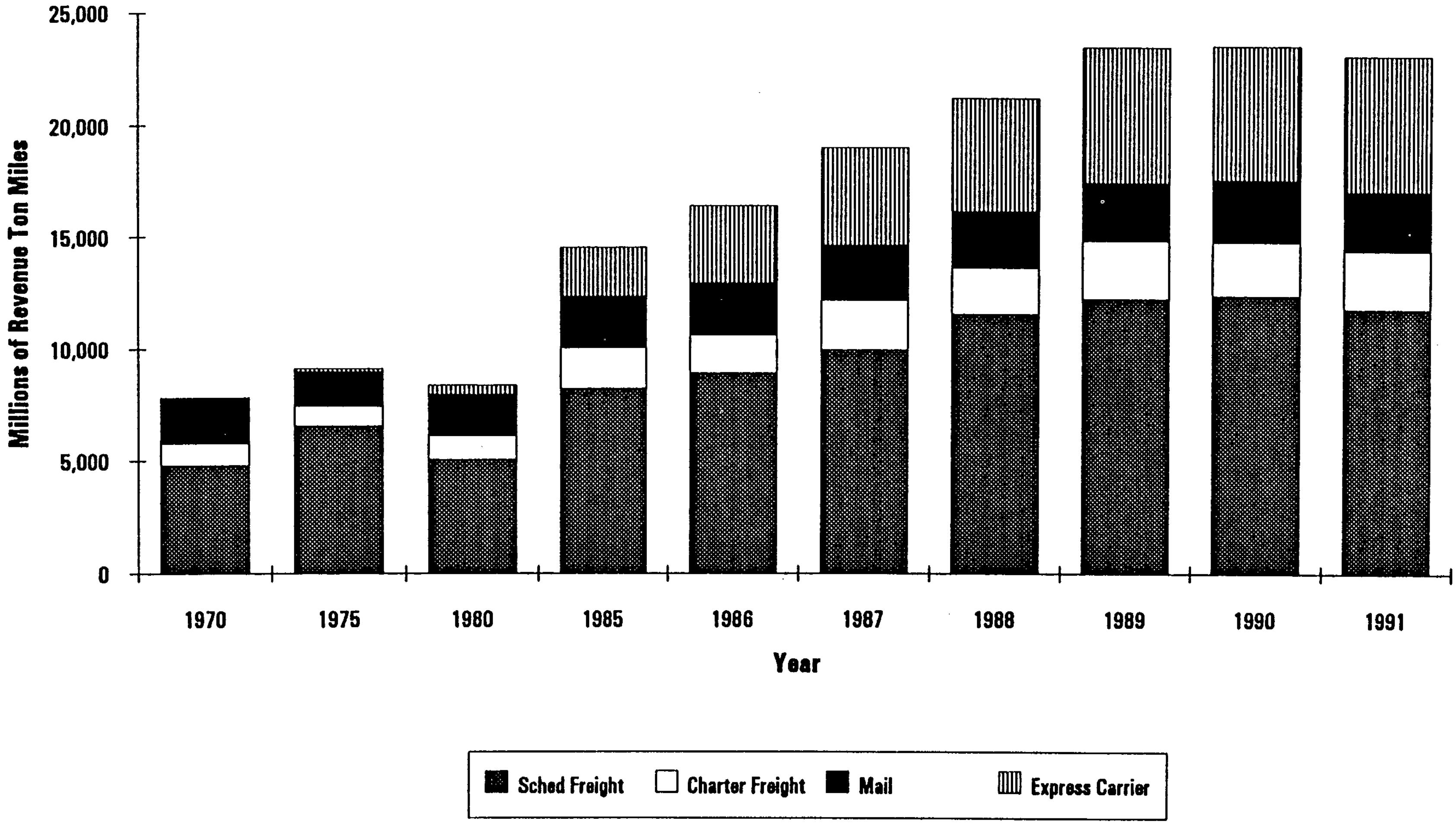
Service to Airlines and Pilots. Data on the number and type of operations (defined as take-offs and landings) at FAA-controlled towers show that the demands on the system have changed in nature since deregulation. Figure 3-11 and Figure 3-12 show that general aviation traffic at FAA towered airports reached a peak in 1979 at about 52 million operations. In the same year, air carrier operations were 10.5 million. Thus, as a percentage of total operations, including military and other traffic, general aviation operations accounted for 75 percent of the total and air carrier operations represent 20 percent. This mix has changed, with general aviation operations falling in the early 1980s and remaining flat since. In 1992, there were 37 million general aviation operations, around 60 percent of the total. At the same time, air carrier operations have grown steadily to around 12.5 million operations or 20 percent of the total. Most of the other growth in operations is attributable to regional and commuter aircraft.[37]

Figure 3-7: Trends in Revenue Passenger Miles



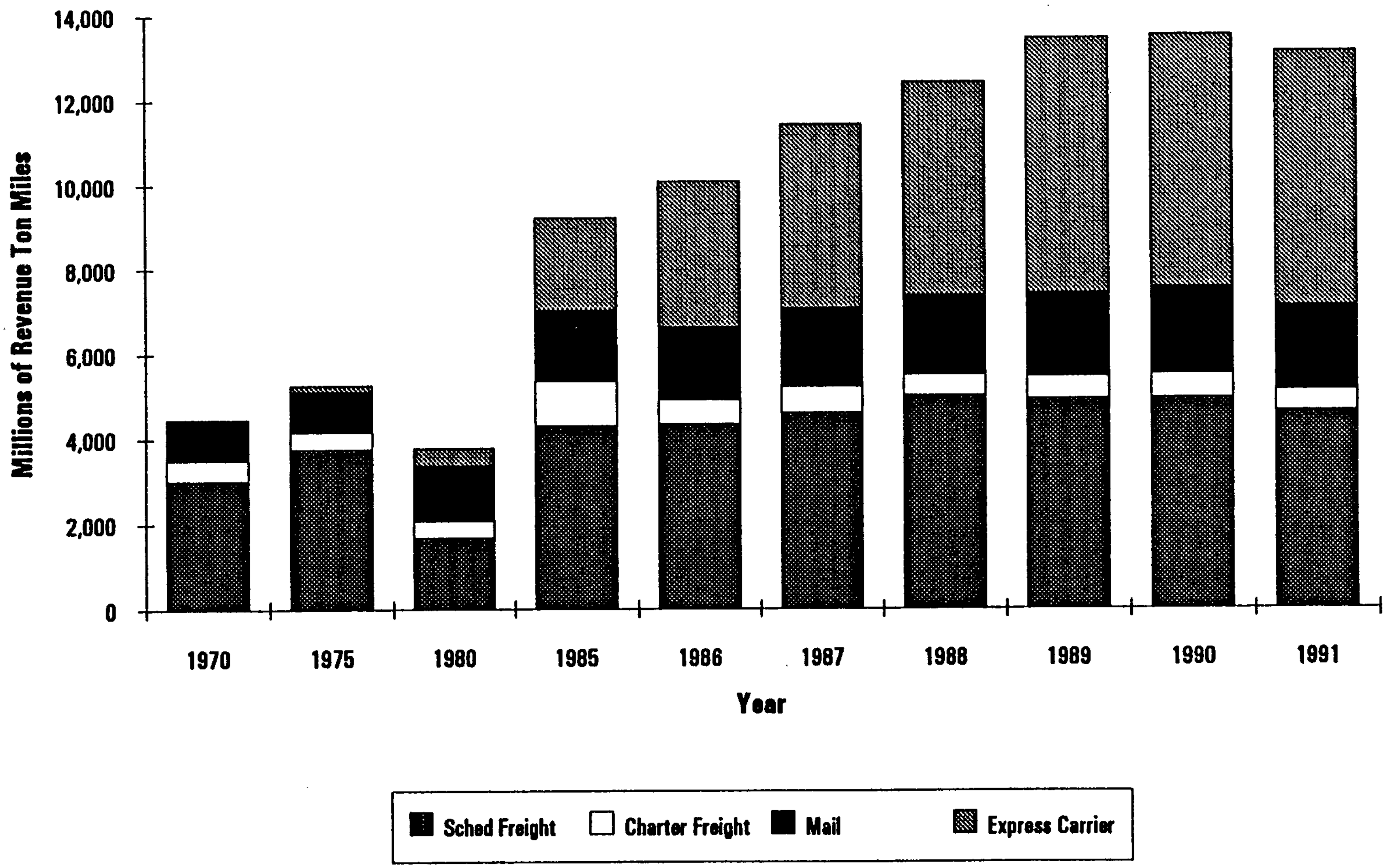
Source: FAA Aviation Forecasts.

Figure 3-8: Total Cargo by US Airlines



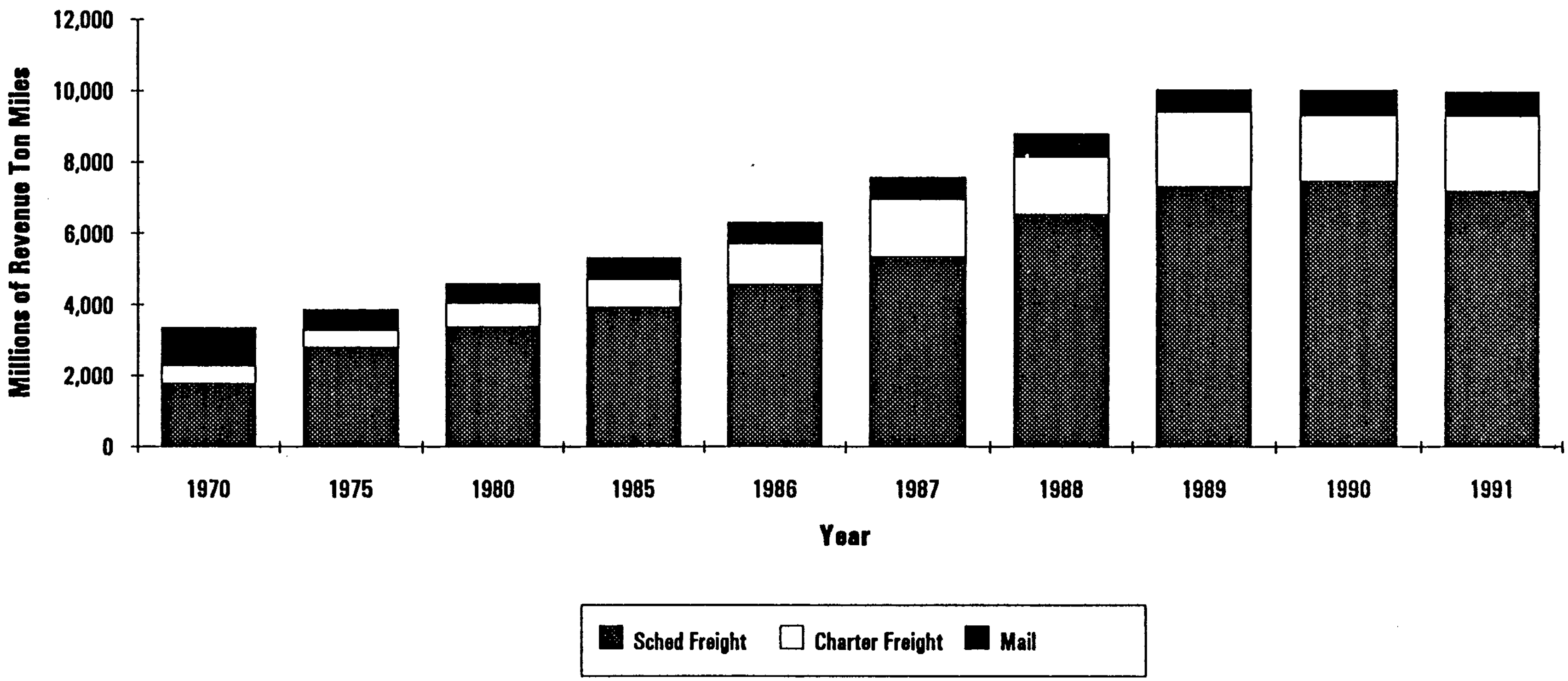
Source: Boeing World Air Cargo Forecast, 1992.

Figure 3-9: Domestic Air Cargo by US Carriers



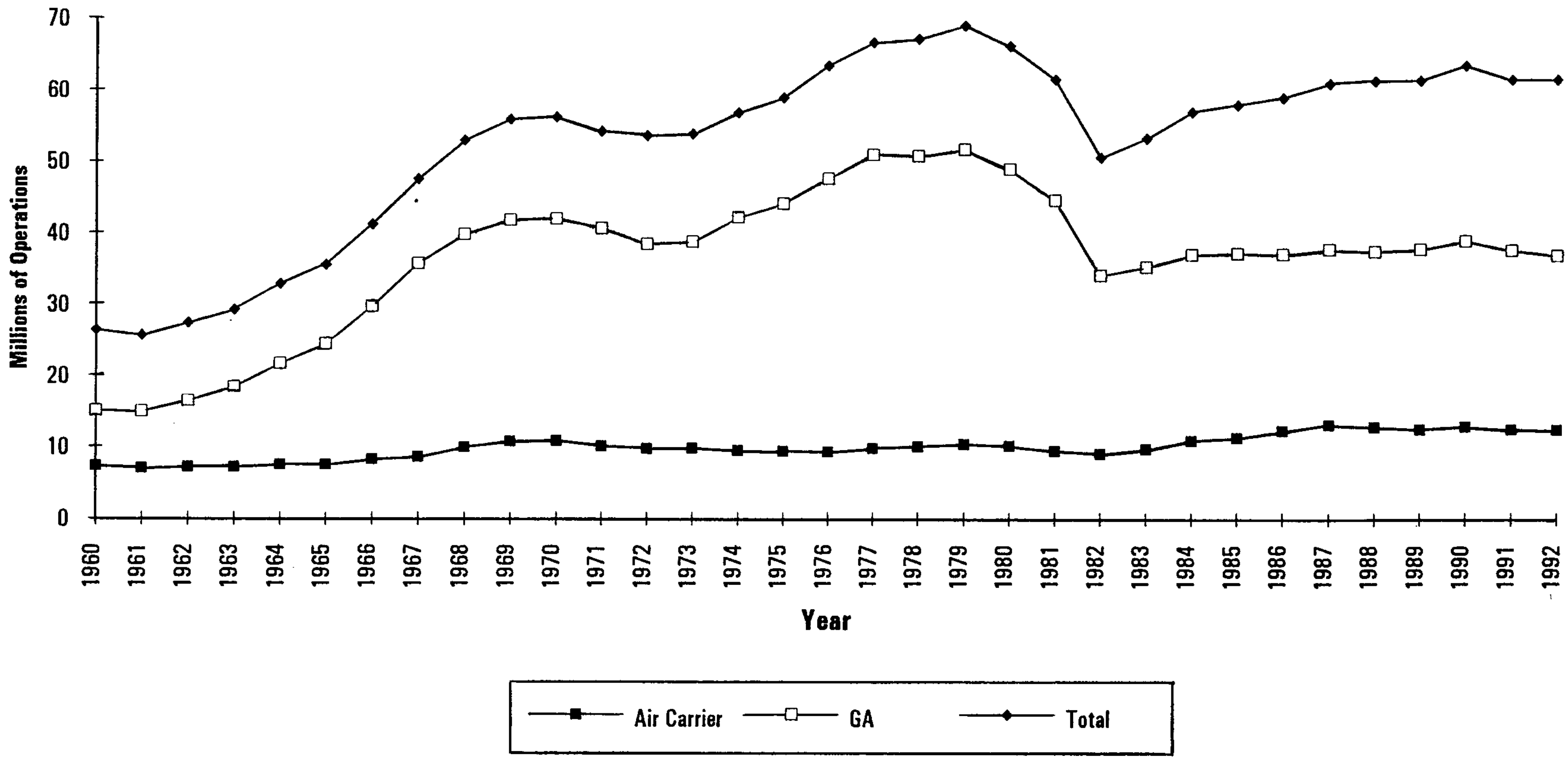
Source: Boeing World Air Cargo Forecast.

Figure 3-10: International Cargo by US Carriers



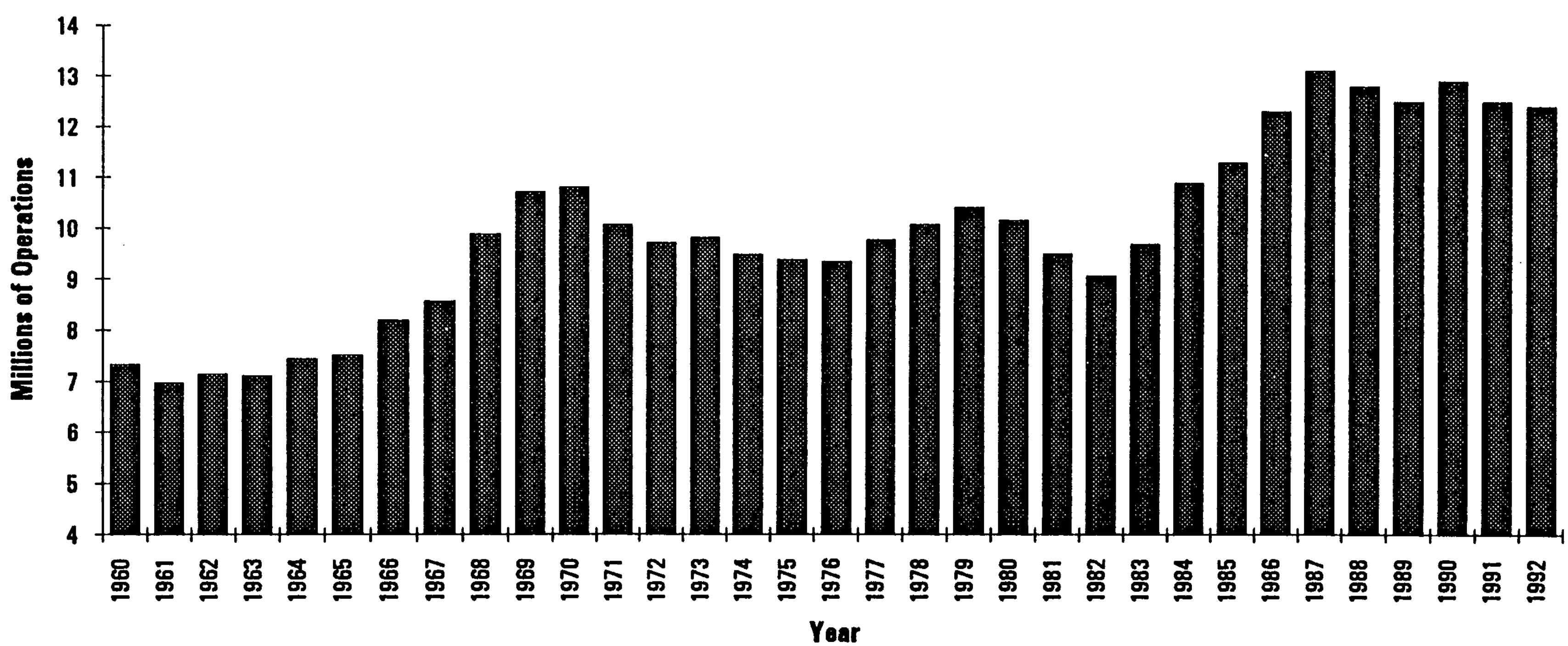
Source: Boeing World Air Cargo Forecast.

Figure 3-11: Operations at Airports With FAA Towers



Source: FAA Aviation Forecasts.

Figure 3-12: Air Carrier Operations



Source: FAA Aviation Forecasts.

Quality of Service

Passenger delays and safety are perhaps the two most important measures of quality of service -- delays because they translate directly into losses in economic efficiency and productivity, and safety because it has high economic and social costs. In addition, because the availability of service is a key determinant in the value and scope of the service provided, airport accessibility is an important measure of quality.

Delays. For most travelers, delays are possibly the most annoying aspect of air travel. Used by the FAA as a key measure of system performance, delays are tracked on a daily basis by airport and region in two systems: the first is the air traffic control system, which tracks all arrival and departure delays over 15 minutes; the second system tracks all delays including gate, taxi-way, and airborne delays over one minute.

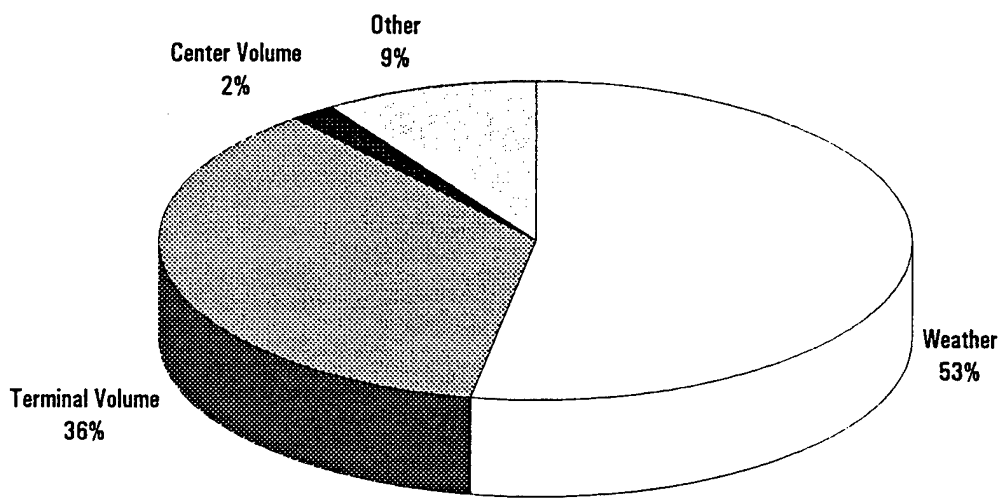
Because the FAA's air traffic control office uses delays as a mechanism for monitoring performance, it currently counts a delay only when arrival or departure is held up by 15 minutes or more.[38] Even though one flight may contain six or more individual segments, a flight's total delay may exceed 15 minutes, but still not be counted as an air traffic control delay. Further, delays are counted according to their immediate cause (weather, airport congestion, equipment failure etc.) and assigned to the airport that was the ultimate cause since weather problems in one city may create a cascade of problems in cities a thousand miles away. This system provides a more effective means of monitoring control-related delays.

From 1976 to 1980, the FAA estimated that weather-related delays accounted for 75 to 85 percent of all delays. However, since changing the method of calculating delays in 1982, the number of flight delays attributable to weather decreased. In 1985, it was estimated that 68 percent of all delays over 15 minutes were caused by weather with most of the balance attributable to terminal and center volume. Since 1985 this distribution has changed: after reaching a high of 70 percent in 1988, the percentage of delays attributable to weather declined to 53 percent in 1990 (Figure 3-13). Terminal volume now causes 36 percent of delays over 15 minutes, up from 12 percent in 1985.[39]

Because delays experienced by most travelers are much longer and of greater frequency than those included in the air traffic control estimates, a second delay tracking system is maintained. This system counts the average delays for different flight stages, including gate hold, taxi-out, airborne, and taxi-in. Figure 3-14 shows that growth in average delay has been steady, rising from 12.9 minutes in 1983 to 14.9 minutes in 1990.[40] Most of this growth can be attributed to increased delays in the taxi-out phase. However, growth in delay time has occurred despite only modest increases in operations over the last few years.

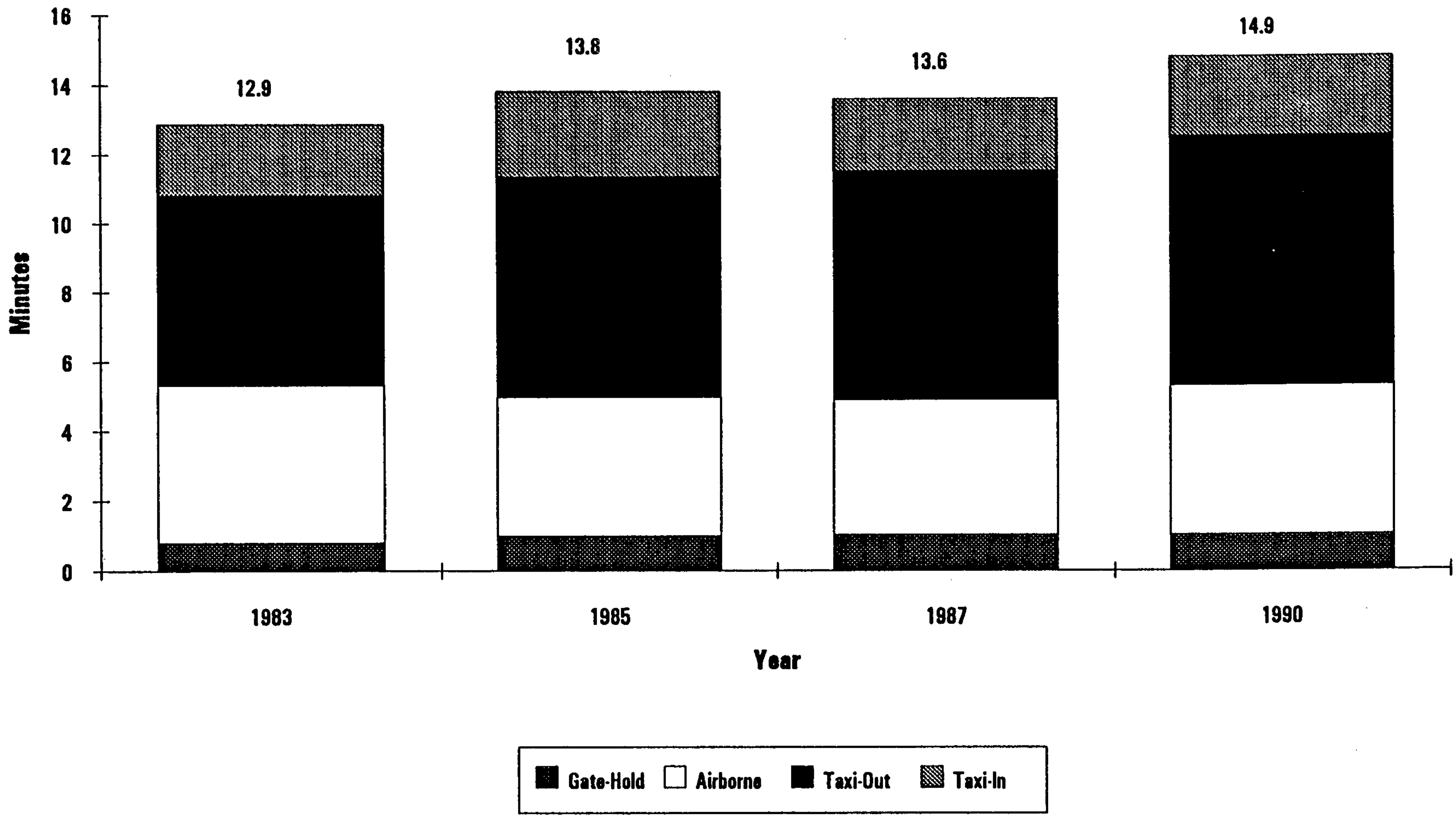
The FAA keeps additional records of 22 airports that account for a majority of total system delays. The percent of operations delayed at these airports has increased from 8 percent in 1987 to 10.3 percent in 1990. This highly skewed distribution indicates that policy options designed to cope with delays should consider the special problems of these airports. One important observation, for example, is that changing the number of general aviation flights undertaken at these airports could assist in the reduction of delays.

Figure 3-13: Airplane Delay, by Cause, 1990



Source: Aviation System Capacity Plan.

Figure 3-14: Delay By Stage of Flight



Source: Aviation System Capacity Plan.

Safety. Aviation safety is a key motivating factor behind federal involvement in aviation as shown by many Congressional hearings. This is partly due to the dramatic nature of many aviation accidents. In fact, when accident rates are adjusted for passenger-miles of travel, commercial aviation's safety record exceeds that of almost every other mode of transport. For example, the 1991 fatality rate per 100 million passenger miles for highways was 1.33 and only 0.03 for air carriers. The record for general aviation is less commendable, but has been improving in the last few years; currently the rate is 6.06 deaths per 100 million passenger miles.[41]

Safety at public airports is maintained at a rate higher than that of privately-owned airports through a closely monitored selection, design and operations and maintenance process. According to a recent analysis, most accidents on or near airports are attributable to pilot errors, such as failure to perform adequate pre-flight inspection, inadequate planning, or failure to achieve and maintain adequate air speed. In fact, airports are rarely cited as the cause of accidents and, when they are, it is usually in conjunction with weather-related conditions, such as snow or ice.

Because of the dramatic nature of aviation accidents and the potential for large numbers of deaths for each accident, greater public effort is directed toward aviation safety than for other modes of transport. However, given current techniques for tracking accident data in aviation, the low level of commercial aircraft accidents, and the inability to tie safety investment to capital investment, a study of federal spending on aviation safety is not likely to offer additional insights.[42]

Airport Accessibility. Airport access is perhaps one of the lesser-researched areas of the aviation system. Data are available for only two aspects of access, and these data are available only for limited time periods. They include population within reasonable distance to airports and the impact of ground transportation congestion on delays. In 1985, the FAA performed a study to analyze the coverage of airports included in the National Plan of Integrated Airports (NPIAS). This study showed 97.3 percent of the total U.S. population is within 20 miles of a NPIAS airport. The FAA is currently revising this study, and preliminary results indicate no significant change in the results.[43]

Cost Effectiveness

Cost effectiveness must be measured relative to program or system objectives. Aside from profits, private sector aviation investment is generally intended to result in service level benefits. Public sector investment, on the other hand, is generally intended to enhance safety (air traffic control) and provide for an effective national air transportation system (targeted capital investment). This section focuses primarily on airports and airlines, since data on the air traffic control system is extremely limited and the available data are not precise enough to estimate benefits.

In general, performance data indicate that private sector service levels, while improving, are highly sensitive to public sector actions, most notably the air traffic controllers' strike. Public sector goals, conversely, are much less sensitive to service levels. The interdependency of the public and private sectors in airline and airport investment make it difficult to draw conclusions on the extent to which each sector achieved their objectives independent of the other. Although sector specific effectiveness measures can be derived, it is more appropriate to analyze these measures in tandem as a gauge of overall cost effectiveness.

Airports and Airlines. Private sector effectiveness is measurable both as a function of airplane utilization rates (load factors), and on the basis of revenues per unit of service provided (revenues per passenger-mile). Trends in load factors indicate a high degree of sensitivity in private sector effectiveness to federal regulation. Trends in revenues per passenger-mile, on the other hand, indicate improved operating efficiencies and greater competition.

The passenger load factor is an estimate of commercial air capacity utilization based on a comparison of available seat-miles to passenger revenue-miles. Figure 3-15 indicates that the utilization rates of aircraft, both domestically and internationally, have risen dramatically since reaching a low in the early 1970s. There is a direct correlation between the end of federal regulation in 1978 and the rise in load factors; higher competition demanded more efficient use of available capacity and cost effectiveness improved markedly since that period. However, after reaching a post deregulation high in 1989 of 62.7 percent, load factors have declined to 61.8 percent in 1991, reflecting recent overexpansion of capacity by the airline industry.[44]

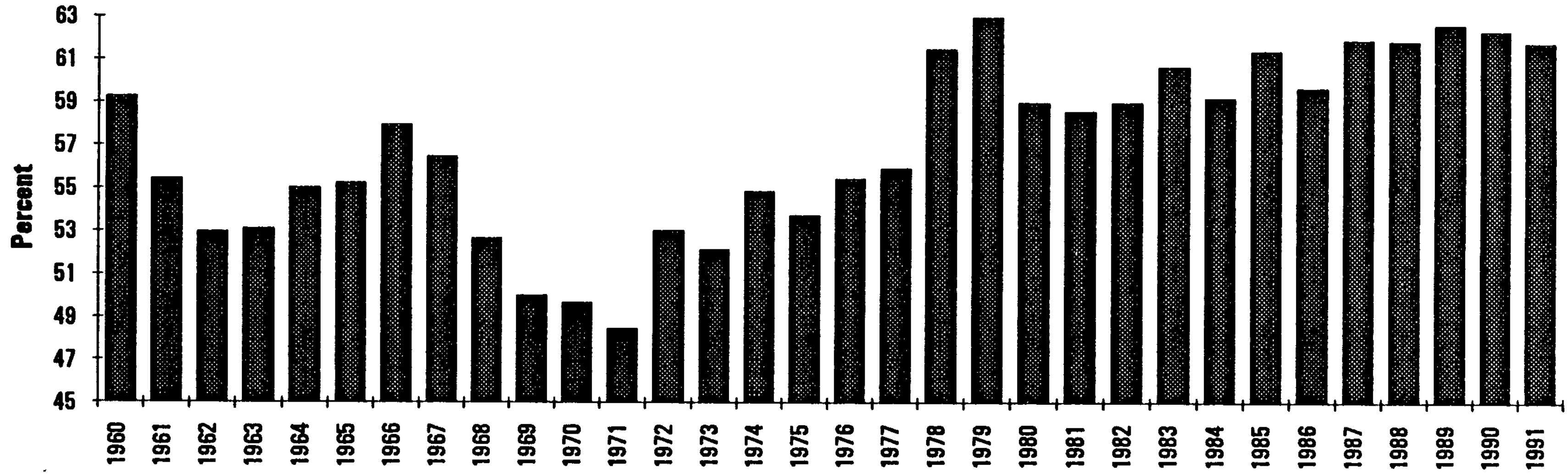
In addition to passenger load factors, one widely-used measure of airline financial performance is revenue per passenger-mile, a measure based on gross industry revenue and revenue passenger enplanements. As shown in Figure 3-16, revenues per passenger-mile in constant dollars have declined steadily.[45] In part, this decline is a result of increased operating efficiencies made possible through improved technology and service. After 1978, however, this number also reflects higher degrees of competition and increased operating costs that resulted from increases in fuel prices.

However, since 1985, real revenue per passenger mile has declined by 3.7 percent annually, from 12.75 cents in 1985 to 10.18 cents in 1991. The downward trend appears to have slowed after 1987, possibly indicating that efficiencies forced on the industry by deregulation have been exhausted. This could also be the result of several mergers among the major carriers that has reduced competition within the industry.

Since the airline industry is privately controlled, the main indicator of its cost effectiveness is profit margin. The influence of increased competition and fuel costs showed up on the bottom line immediately following deregulation. Operating profit margins fell dramatically following deregulation, and peaked again in the mid 1980s (Figure 3-17). Even more notable than operating losses are overall net losses of the last several years. From 1990 to 1992, the airline industry lost almost $8 billion (1987 dollars) and short term prospects are not favorable (Figure 3-18).[46] These losses reflect both decreased demand for air service due to the recession and the Persian Gulf War, as well as the increased debt burden caused by industry overexpansion.

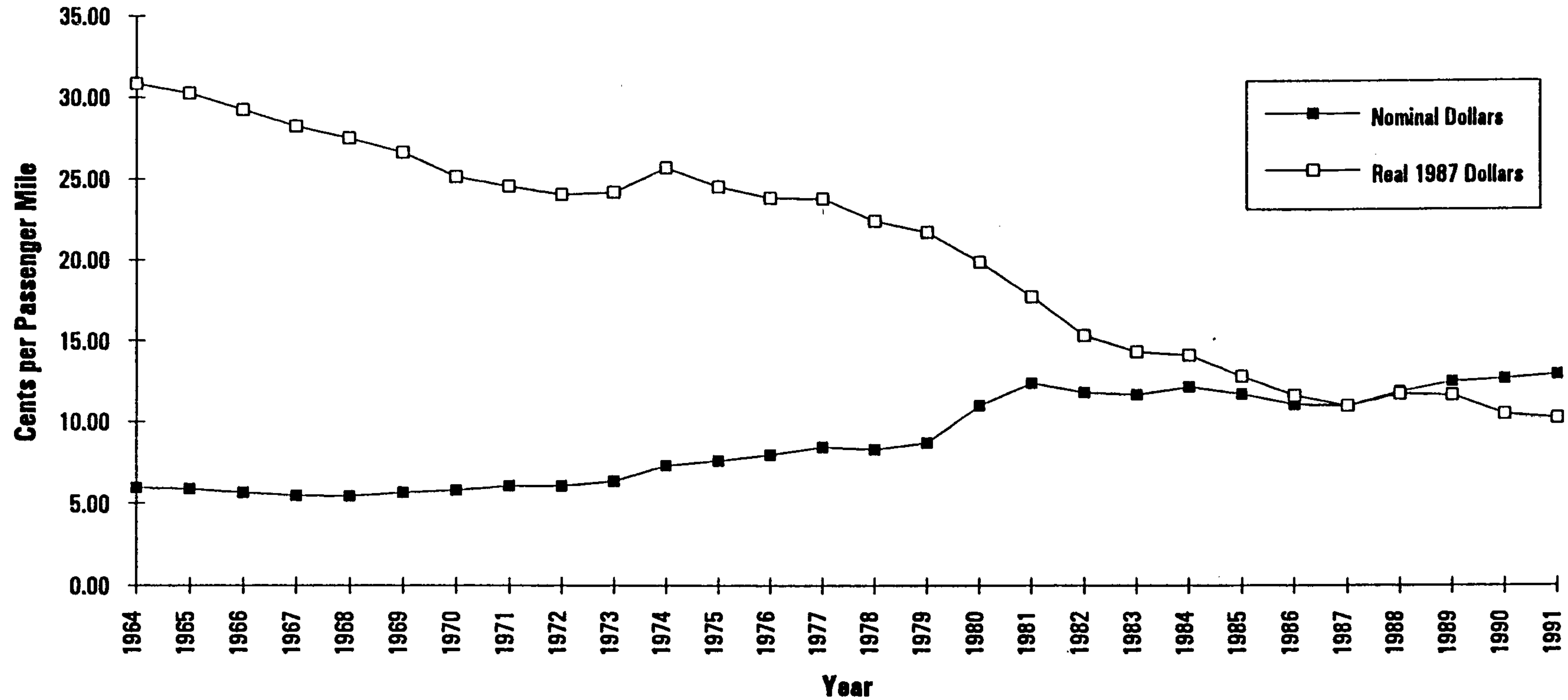
Air Traffic Control. Because of a lack of time series data on the cost effectiveness of the air traffic control system, it is difficult to make an assessment of this. However, the Capital Investment Plan has laid out specific investments and performed benefit-cost analysis of the system. According to the FAA, the completion of the Plan will result in significant cost reductions and increased safety and efficiency. Benefits of completing plans described in the 1991 Capital Investment Plan are expected to exceed $257.9 billion constant 1991 dollars.[47]

Figure 3-15: Load Factor



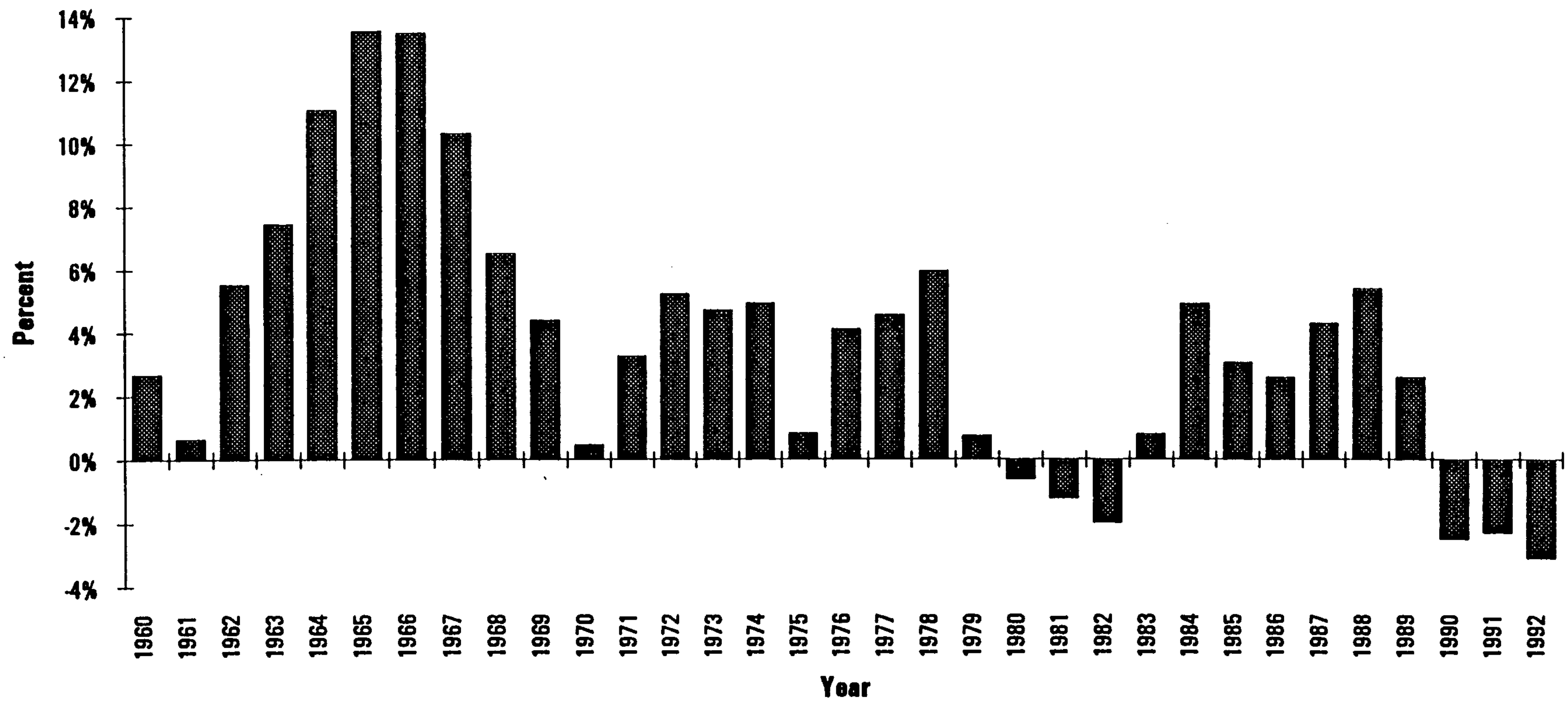
Source: FAA Aviation Forecasts.

Figure 3-16: Revenue Per Passenger Mile



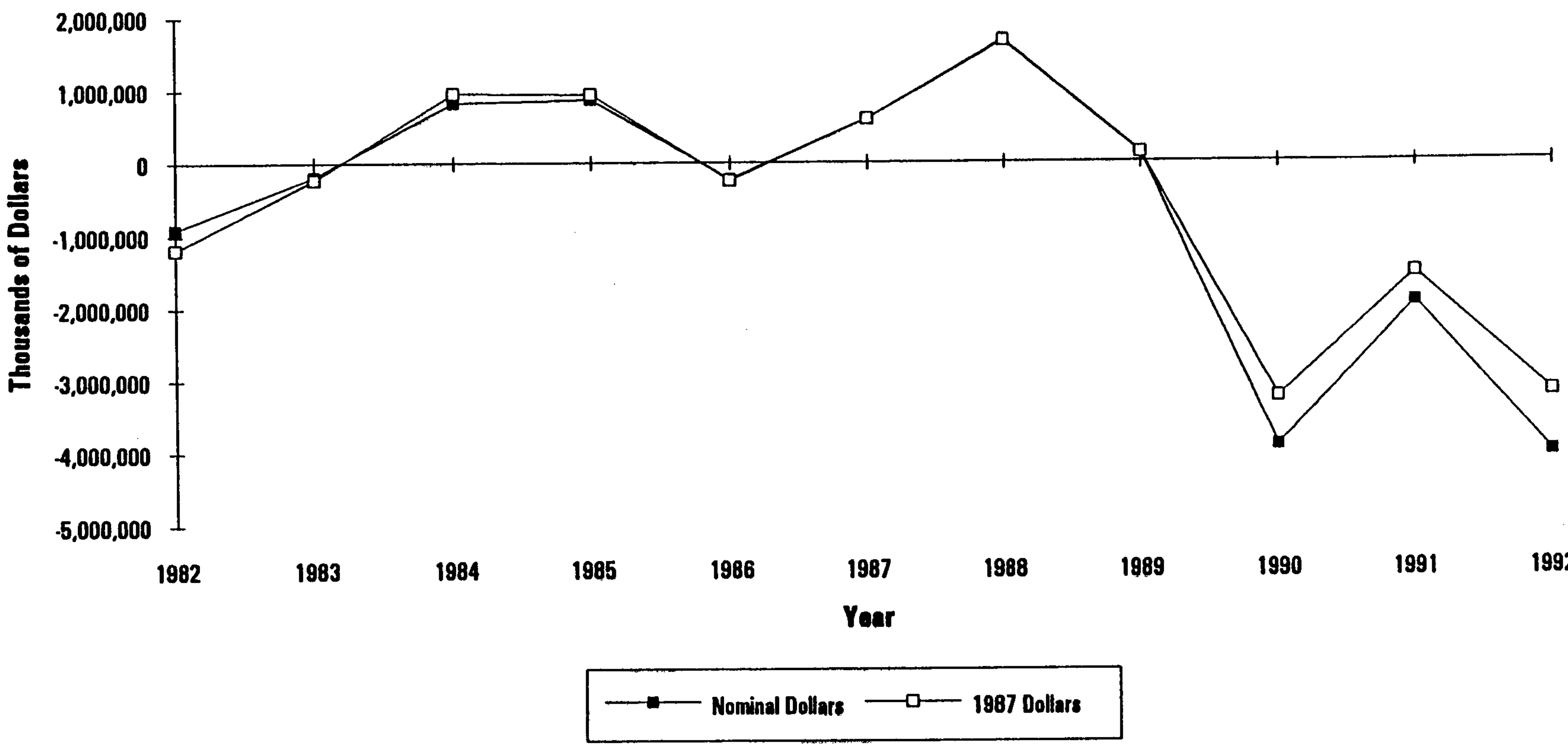
Source: FAA Aviation Forecasts and U.S. Dept. of Commerce

Figure 3-17: Airline Operating Profit



Source: FAA and ATA The Annual Report of the US Scheduled Airline Industry.

Figure 3-18: Total Profit/Loss of US Scheduled Airlines



Source: ATA, The Annual Report of the US Scheduled Airline Industry

CONSOLIDATED PERFORMANCE REPORT ON THE NATION'S PUBLIC WORKS: AN UPDATE

CHAPTER IV: HIGHWAYS

OVERVIEW OF HIGHWAYS

The highway system covers an extensive network of roads and bridges designed to facilitate the efficient movement of people and goods throughout the nation. In 1991, the nation's highway system consisted of nearly 3.9 million route miles and 8 million lane miles. In addition, this network served 2.17 trillion vehicle miles of travel, or 3.5 trillion passenger miles, and carried 735 billion ton miles of freight.

Until passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, the majority of federal financing and highway usage was targeted for the Federal-Aid highway system (Table 4-1). Although the Federal-Aid system comprises only one fifth of the total mileage, it carries more than four fifths of total vehicle miles traveled. In addition to 276,000 bridges, the Federal Aid system is comprised of four major components: 45,300 miles of Interstate routes; 260,000 miles of Primary highways; 400,000 miles of collector routes in the Secondary system; and 148,000 miles in the Urban system. The Interstate Highway System itself totals only 1.2 percent of the entire network but carries nearly 23 percent of all vehicle miles traveled.

ISTEA replaced the larger Federal-Aid highway system with the National Highway System (NHS) which is comprised mostly of the Interstate and other heavily used corridors. Currently, the NHS and all other major arterials are eligible for federal financing. According to ISTEA, the actual extent of the NHS, anticipated to be roughly 155,000 miles, will be determined by state transportation agencies, Metropolitan Planning Organizations (MPOs) and the US Department of Transportation.[48] Designations will be submitted by the Secretary of Transportation to Congress by December 18, 1993.

ISTEA also allows the use of federal funding for work on privately owned facilities. This change is expected to contribute to the already increasing number of toll-roads throughout the nation. However, private sector involvement in the highway system is not limited to toll-road construction. The primary user of the highway system is the private sector, and its total investment in motor vehicles and other equipment exceeds the public investment in roads and bridges.

The level of congestion on the highway system is an increasing concern of highway agencies and MPOs because of its effects on system efficiency. Primarily a problem in urban areas, congestion levels continue to increase. Urban interstate peak-hour congestion is measured by the ratio of cars traveling on a given stretch of highway during a certain time period to the total capacity of the highway. This ratio has increased at an average annual rate of three percent, rising from 55 percent in 1983 to 70 percent in 1991.

Table 4-1: Highway System Mileage

Highways by Finance Category	Route Miles	Percent of Total	Percent of VMT
Interstate	45,280	1.2	22.6
Primary	259,946	6.6	28.0
Secondary	400,309	10.3	8.6
Urban	148,291	3.8	22.3
Bridges	276,057	N/A	N/A
Total Federal Aid	853,826	21.9	81.5
Off Federal-Aid			
Roads	3,035,473	78.1	18.5
Bridges (Number)	298,644	N/A	
Total Bridges	574,701	N/A	N/A
Total Miles	3,889,299	100.0	100.0

Source: Highway Statistics, FHWA, 1991
Note: VMT is Vehicle Miles of Travel

In the 1992 Status of the Nation's Highways, Bridges and Transit, the Department of Transportation estimated that the cost in 50 urbanized areas due to delays caused by traffic congestion is more than $39 billion.[49]

Another concern of highway authorities is the condition of the nation's roads and bridges. The Federal Highway Administration (FHWA) estimates that 7.8 percent of the Interstate road-miles are in poor condition, a decrease from 10.9 percent in 1985. Arterial roads in poor condition totaled 4.8 percent in 1991, down from 5.4 percent in 1985.[50] In addition, the FHWA classifies 37.6 percent of the Nation's bridges as structurally deficient or functionally obsolete, down from 42 percent in 1985.[51]

OVERVIEW OF HIGHWAY MANAGEMENT

Government Roles

Federal Government. The federal government maintains direct responsibility for only 183,170 miles, or 4.7 percent, of the nation's highways (Table 4-2). These are located primarily in national parks and forests, Indian reservations and military bases. However, the federal government, through the Highway Trust Fund, provides funds for state and local government highway capital expenditures. In 1991, the federal government provided 41 percent of all highway capital expenditures, down from 55 percent in 1985. The federal share of all state and local government highway expenditures (capital and non-capital) was 22 percent in 1991. This reflects the historical emphasis of the federal government on capital expenditures.

Table 4-2: 1991 Route-Miles By Jurisdiction[52]

Jurisdiction	Rural Miles	Rural Percent	Urban Miles	Urban Percent	Total Miles	Total Percent
State	702,615	22.4	95,873	12.8	798,488	20.5
Local	2,254,680	71.8	652,961	87.1	2,907,640	74.8
Federal	182,140	5.8	1,030	0.1	183,170	4.7
Total	3,139,435	100	749,864	100	3,889,298	100

Traditionally, federal grants were targeted to the most heavily traveled roads. These funds were dedicated to construction of the Interstate Highway System. Completion of the Interstate System has been a fundamental goal of federal highway policy for much of this century, and starting in 1956 it received considerable funding through the Highway Trust Fund. However, expiration of the Interstate program and passage of ISTEA in 1991 expanded the projects and activities eligible for federal highway grant financing (see below).

State and Local Government. State governments are directly responsible for 21 percent of the nations highways while 75 percent is under the control of local governments. State roads include most larger arterials, while local governments generally control smaller collector routes. Although states control a much smaller percentage of the highway system, they are often authorized by local contracts to construct and maintain roads under local jurisdictions.

Because of the disparity in requirements for construction and maintenance of state versus local roads, state expenditures for highways are nearly double local expenditures.[53] In 1991, state governments accounted for 51 percent of total highway expenditures and local governments provided 27 percent. In addition, because federal government expenditures are generally administered through state governments, combined total disbursements of state and local governments are greater than 99 percent.

Private Sector. Private sector involvement in the highway system is mainly limited to capital expenditures for the construction of local roads and improvements to provide access to new private developments. Upon completion, these facilities are usually turned over to the local government for continued maintenance and operation. However, the role of the private sector is evident and can be seen in the use of impact fees and special districts to finance local roads. Both of these methods present ways to identify the beneficiaries of roads and to assess the costs of financing on the basis of those benefits. This is an innovative way in which local governments have financed roads in the face of growing budgetary constraints. Provisions under ISTEA allow Federal-aid funds to be allocated to privately owned facilities. As a result, it is expected that private outlays will begin to increase over the next few years.

Management Changes Under ISTEA

In many ways, ISTEA continues and reinforces past approaches to transportation management and financing. In other important ways, however, it is a significant departure from these approaches. Perhaps most importantly, the process of planning and identifying financing for transportation projects now emphasizes local and regional governments (but includes state governments) through "bottom-up" planning. In this new environment, the ultimate effect on the US highway system will depend largely on how ISTEA is implemented in each state and locality.

Although ISTEA provides an increase in federal funding, authorizing $152.3 billion through 1997, its most significant impact is to shift away from constructing single-mode projects toward more flexible approaches that emphasize local input and management. For example, large portions of highway program funds are eligible to be spent for transit or other programs, and, under certain conditions, transit funds may be spent for highways.

ISTEA emphasizes planning at both the state and regional levels. Specifically, it requires long-range transportation planning and the development of transportation improvement plans at both state and regional levels. Through this feature, ISTEA enhances the role of regional officials, through MPOs, in planning and project selection. The MPO must develop a Transportation Improvement Plan (TIP) in cooperation with state and local officials, that prioritizes projects and reflects expected financial resource availability; they can no longer be "wish lists".

Thus, from a government management perspective, ISTEA changes the focus to include regional authorities. The relative percentage of highways financed by various levels government is not likely to change significantly. The major change, from the perspective of the highway system, is the shift in federal expenditure priorities to the NHS, the use of funds for bi-modal solutions to "highway" problems, and greater local input. This also includes the increased possibility for private sector involvement through use of toll facilities.

Financial Trends

Eighty-eight percent of Federal highway funds come from dedicated excise taxes deposited in the Highway Trust Fund -- most importantly a 14.1 cent per gallon tax on motor fuel and a series of motor vehicle taxes. Similarly, user fees account for 71 percent of state highway funds and about one half of spending by local governments. However, 16 percent of state funds are derived from tolls and bond issue proceeds, while the federal government does not receive significant funding from either source.[54] State motor fuel taxes average 17.5 cents per gallon. Most states also use dedicated funds as a means to ensure user taxes are appropriated to highway purposes.

Total expenditures for highways have been quite volatile during the period from 1960 to 1991 (Figure 4-1). Real capital outlays and maintenance expenditures by all units of government were $41.8 billion in 1960, rising to a peak of $51.6 billion in 1968.[55] After 1971 total expenditures fell to $37.8 billion in 1981. In 1982, a five cent increase in the motor fuel tax allowed spending to increase again. In 1991, $52.2 billion was spent on the highway system.[56] The upward trend in total spending can be expected to continue at least through 1997; ISTEA, alone, authorized $152.3 billion in spending through 1997. Assuming the federal government maintains a constant share of total spending in the future, this implies a significant increase in future spending.

Real capital outlays by all levels of government declined after the push to build the Interstate System during the 1960s, although real maintenance expenditures have remained steady. In 1968, when capital spending achieved its peak, expenditures by all levels of government were $36 billion (Figure 4-2). By 1982, capital spending had fallen to a low of $20 billion. In 1991, total capital disbursements were $33.6 billion. In contrast, maintenance expenditures have varied only slightly from $13.7 billion in 1960 to $18.9 billion in 1986. In 1991, disbursements for maintenance were $18.6 billion.[57]

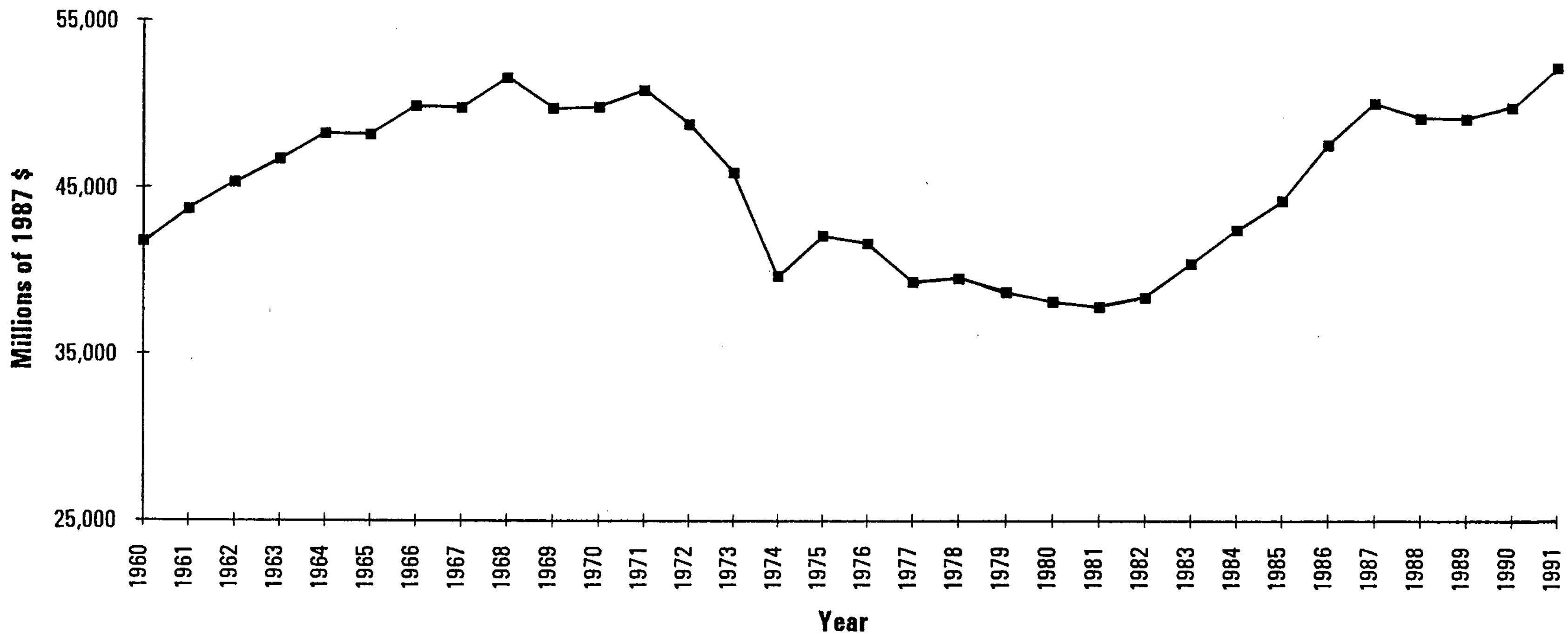
These figures indicate a significant shift in the allocation of expenditures. For the 50 years prior to 1970, the majority of Federal funds were used to construct new highways. However, starting in the early 1970s, federal funds were used more frequently for major resurfacing and reconstruction projects, reflecting concern over deteriorating road conditions. As a result, in 1991, capital expenditures account for only 49 percent of total spending, versus 62 percent in 1960.[58] Today, states use the majority of their federal funds for capital repairs. For example, only 25 percent of interstate spending is for new construction and non-local roads, 51 percent for capacity improvements and 42 percent is for system preservation.

IMPROVING PERFORMANCE REPORTING IN THE FUTURE

With the exception of information on private sector involvement, data on the nation's highways is generally complete and has been systematically gathered by state transportation authorities for publication in the annual Highway Statistics since 1945. Data is collected by state, road classification (rural of urban) and functional level (primary or local) for a variety of performance and finance measures.

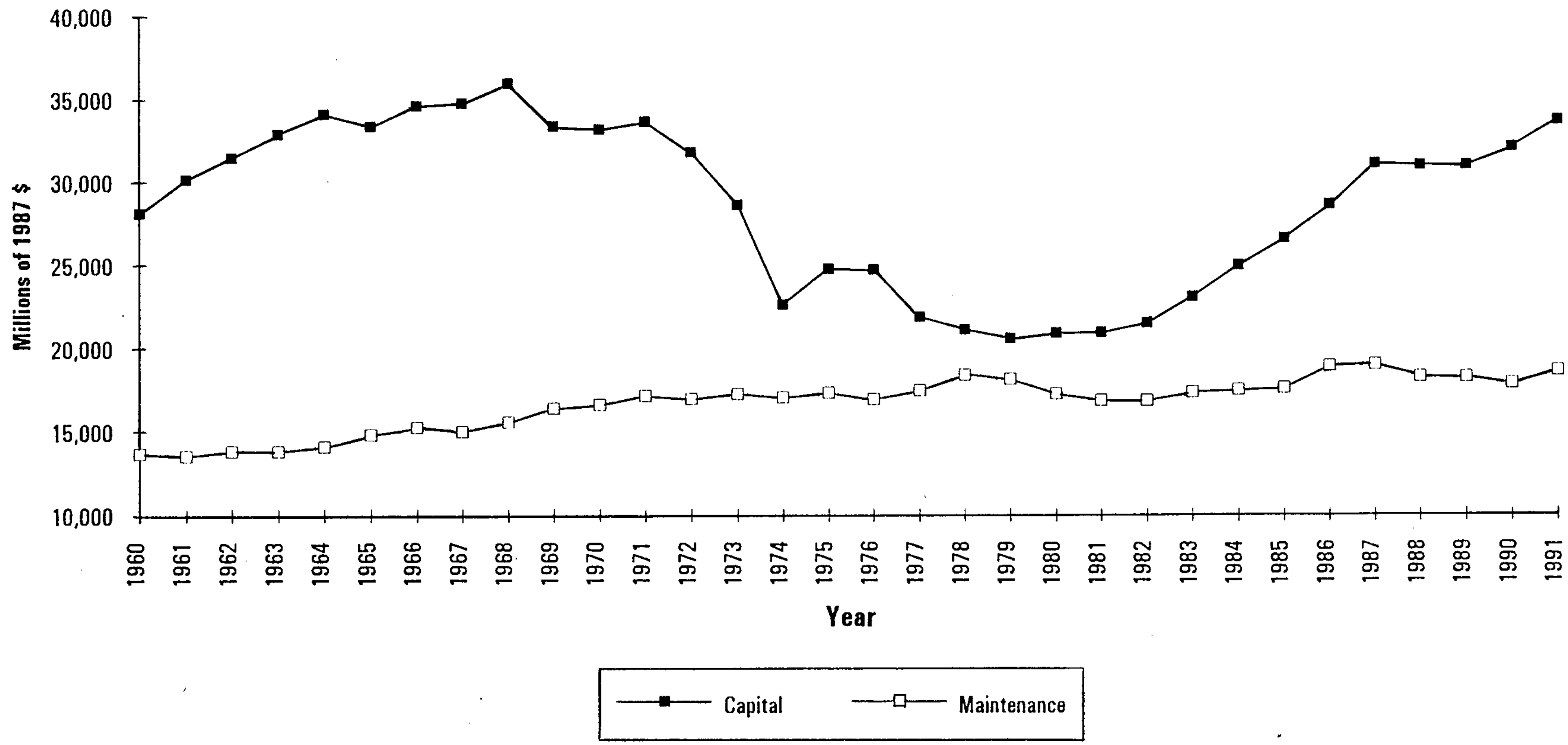
Further information on highway and bridge performance is available through the Highway Performance Monitoring System (HPMS) and the National Bridge Inventory (NBI). The HPMS data system includes a sample of 105,000 highway sections representing 1.2 million miles of arterial and collector miles. This information measures highway road conditions and develops criteria that are used to rank investment needs. The National Bridge Inventory contains detailed information on structural,

Figure 4-1: Total Spending on Highways



Source: Federal Highway Administration, Highway Statistics.

Figure 4-2: Capital and Maintenance Expenditures



Source: Federal Highway Administration, Highway Statistics deck condition and performance levels of all highway bridges greater than 20 feet in length. In addition, the Department of Transportation is required to submit an annual report, Status of the Nation's Highways, Bridges, and Transit Systems: Conditions and Performance. The report contains system characteristics, finance, and performance trends for the nation's highway system. It also includes a capital investment plan that estimates the costs to improve overall conditions and performance to a benchmark set of standards.

Data on private sector involvement needs some improvement. Estimates exist as to the magnitude of private sector spending for construction and planning of highways. However, the data is unreliable and estimates should be considered preliminary.[59] Because private sector expenditures are not included in the government accounting system there is currently no available data series that reports private expenditures. The increased role of the private sector under ISTEA will only enhance the need for this information.

PERFORMANCE OF THE HIGHWAY SYSTEM

Measuring the performance of highways is difficult due to their complexity and sheer scope. This task becomes more problematic when trying to find measures that are comparable across modes. Consistent with the analytic framework of this report, four categories were measured: physical assets; service delivery; quality of service; and cost effectiveness. Within these categories performance measures were identified and those that best portrayed the performance of the mode in each category were chosen. The goal of this analysis is to measure the performance of the entire mode synthesizing information from each category.

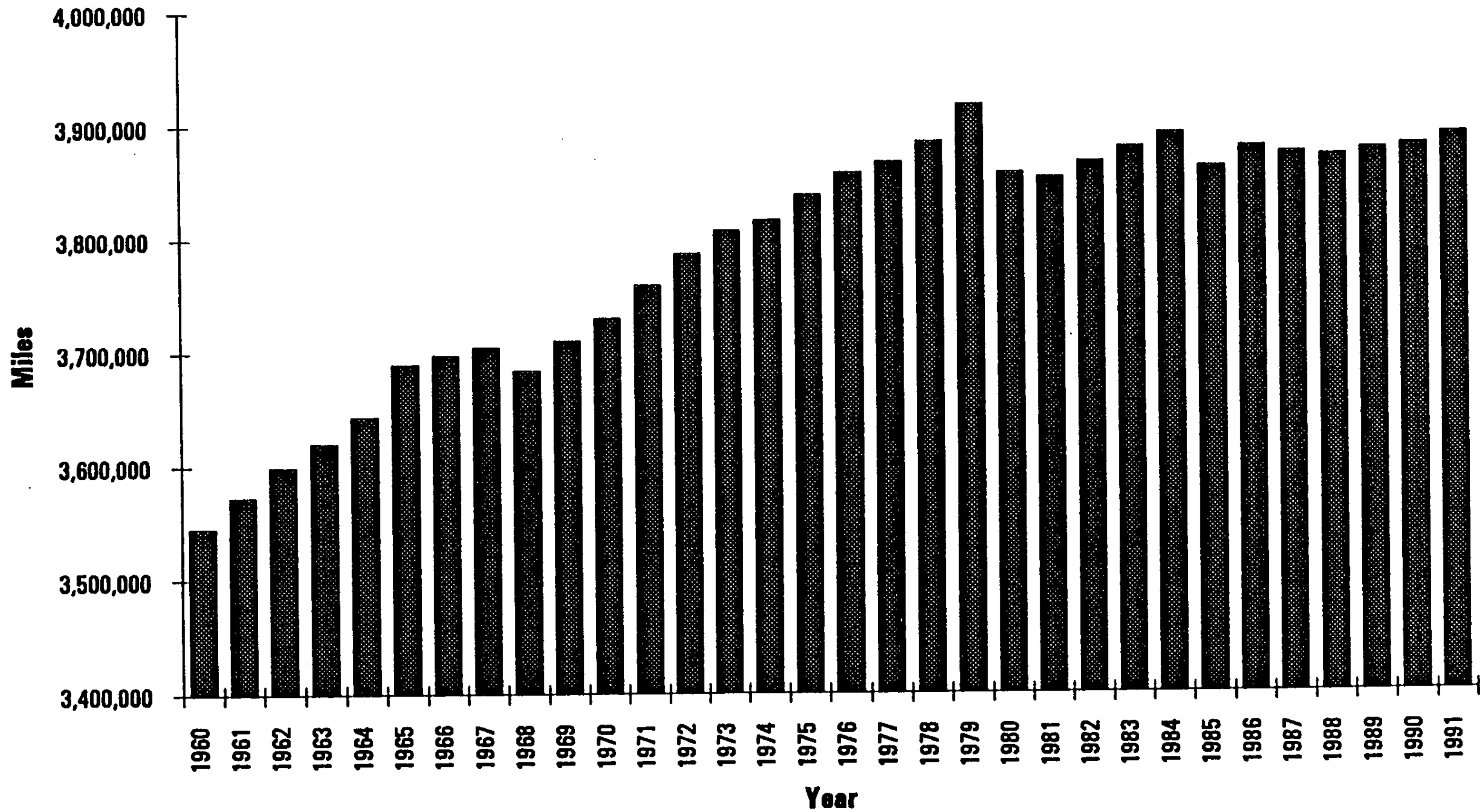
Physical Assets

Four measures are present the physical assets of the highway system: route-miles and lane-miles; net capital stock; number of bridges; and number of vehicles. Each criteria measures a different aspect of the system: total route-miles measures the extent of the system; net capital stock shows the accumulated value of all existing highway assets; the number of bridges measures the assets in the bridge program; and the number of registered vehicles serves as one measure of private assets in use on the highway system.

Route-miles. The most rudimentary measure of the highway physical assets is simply the number of miles in the system. Total miles grew from roughly 3.55 million in 1960 to a peak of 3.92 million miles in 1979. In 1985, total mileage had fallen to 3.86 million miles, but has since climbed to 3.89 million miles (Figure 4-3). The reason for the initial drop is not entirely clear. Some of the difference may be that many low volume, non-surfaced roads were taken over by the private sector while other segments have been closed. For example, a logging road might be taken over by the logging company that was using it. Definitional changes in reporting requirements may also be partly responsible for this decline.

Lane-miles. Total system-miles does not impart a great amount of information about physical assets beyond the extent of the system. Total lane-miles offers a similar, yet more comprehensive, measure of physical assets in that it provides an idea of capacity as well as distance. There is a large difference between one mile of road with two lanes and a mile of four lane highway in terms of traffic

Figure 4-3: Total System Route Miles



Source: Federal Highway Administration, Highway Statistics.

capacity provided--a difference which route-miles alone does not capture. For example, the 45,280 route-miles of Interstate highways represents 199,413 lane-miles and far greater capacity than its total route-miles would imply. Unfortunately, comprehensive lane-mile data exists only since 1982 and thus long term trends in the growth of lane-miles do not exist.

Since 1983, total lane mileage has grown at an annual rate of 0.15 percent, from 8.0 to 8.095 million miles in 1991. However, when viewed separately, urban lane-mileage has increased at an annual rate of 1.67 percent, from 1.473 million to 1.681 million, while rural lane mileage has actually declined by 0.21 percent,from 6.527 million to 6.414 million. The disparity exists because of differences in usage rates between urban and rural areas. For both urban and rural areas, the largest increases occurred on the higher functional systems (i.e., Interstate highways and major arteries). For example, the urban Interstate system grew at a rate of 2.08 percent annually. Rural local roads, on the other hand, experienced the largest decline, falling at an annual rate of 0.43 percent.

Bridges. In 1991, the total number of bridges stood at 574,701. Of these, 276,057 are part of the Federal-Aid System, including: 54,099 Interstate System bridges; 93,407 bridges in the Primary System; 90,465 bridges in the Secondary System; and 38,086 Urban system bridges. The remaining 298,237 bridges are off the Federal-Aid System. The number of bridges in the bridge inventory both on and off the Federal-Aid system had been growing since 1975, due in part to more comprehensive reporting, and to increased bridge construction as part of efforts to improve highway alignments. Since 1985, the total number of bridges has remained relatively stable. However, the number of Federal-Aid and particularly the number of Interstate System bridges has continued to increase whereas the number of non-Federal Aid bridges has declined.

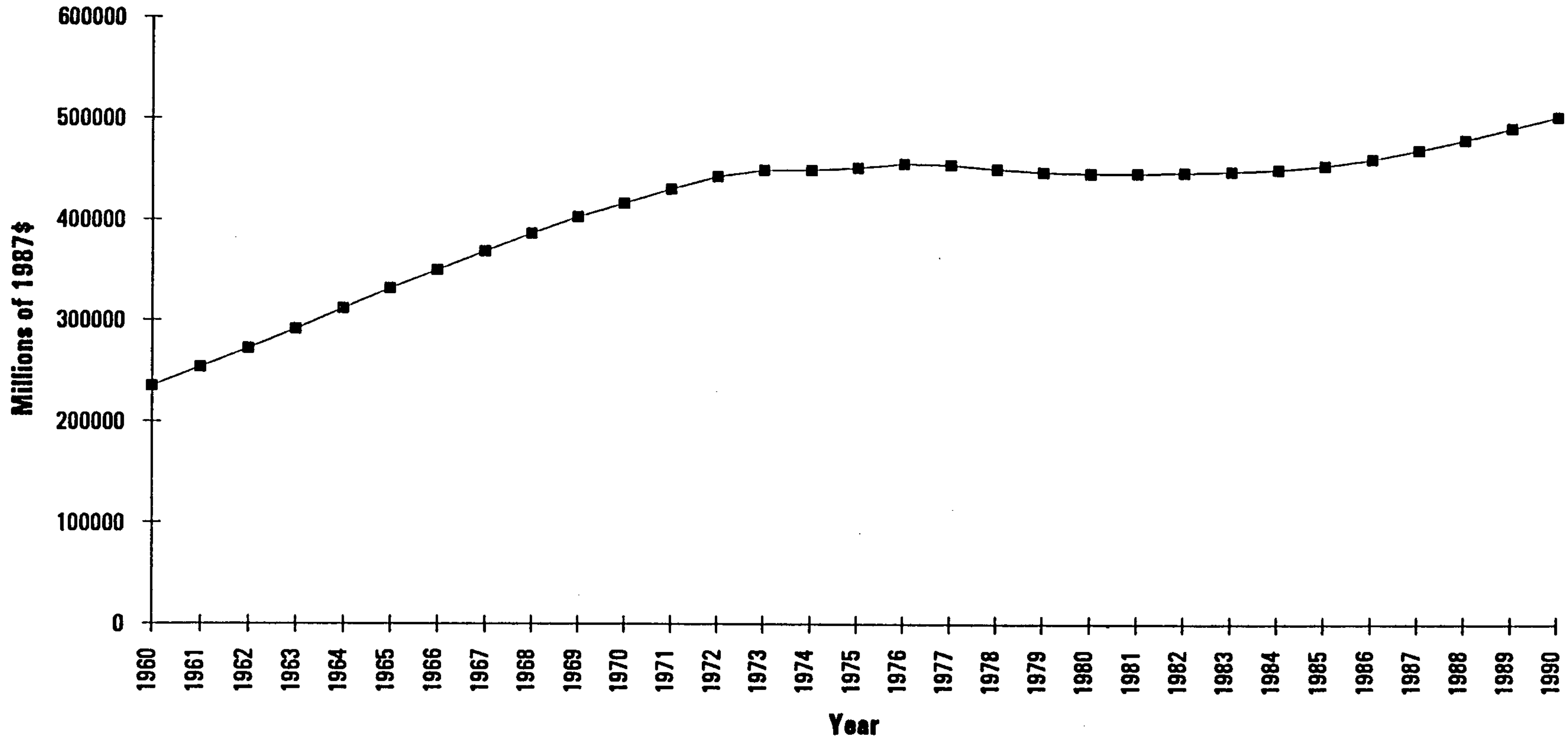
Net Capital Stock. Net highway capital stock is another measure of physical assets. After climbing at an annual rate of 4.2 percent from 1960 to 1976, net capital stock actually declined from $456 billion in 1976 to $454 billion in 1985, with a low of $446.6 billion in 1980 (Figure 4-4). From 1985 to 1990, net stock has increased at an annual rate of 2.05 percent, reaching $502.6 billion in 1990.

The decline in net highway stocks during the late 1970s and early 1980s is due largely to deterioration of existing stock and a decline in public highway investment. As a great deal of existing roads and bridges were put into place during the 1950s and 1960s, much of this stock reached the end of its useful life during this time period. In addition, annual total public capital spending peaked in 1968, falling off dramatically through 1982. Thus, new capital investment was declining at the same time existing capital was wearing out.

The trend in net capital stock has been increasing since 1982. In 1982, the federal motor fuel tax was increased by five cents per gallon and many states have raised their motor fuel taxes in recent years as well. Consequently, total capital spending began to increase in 1983 and accumulation of net capital stock followed.

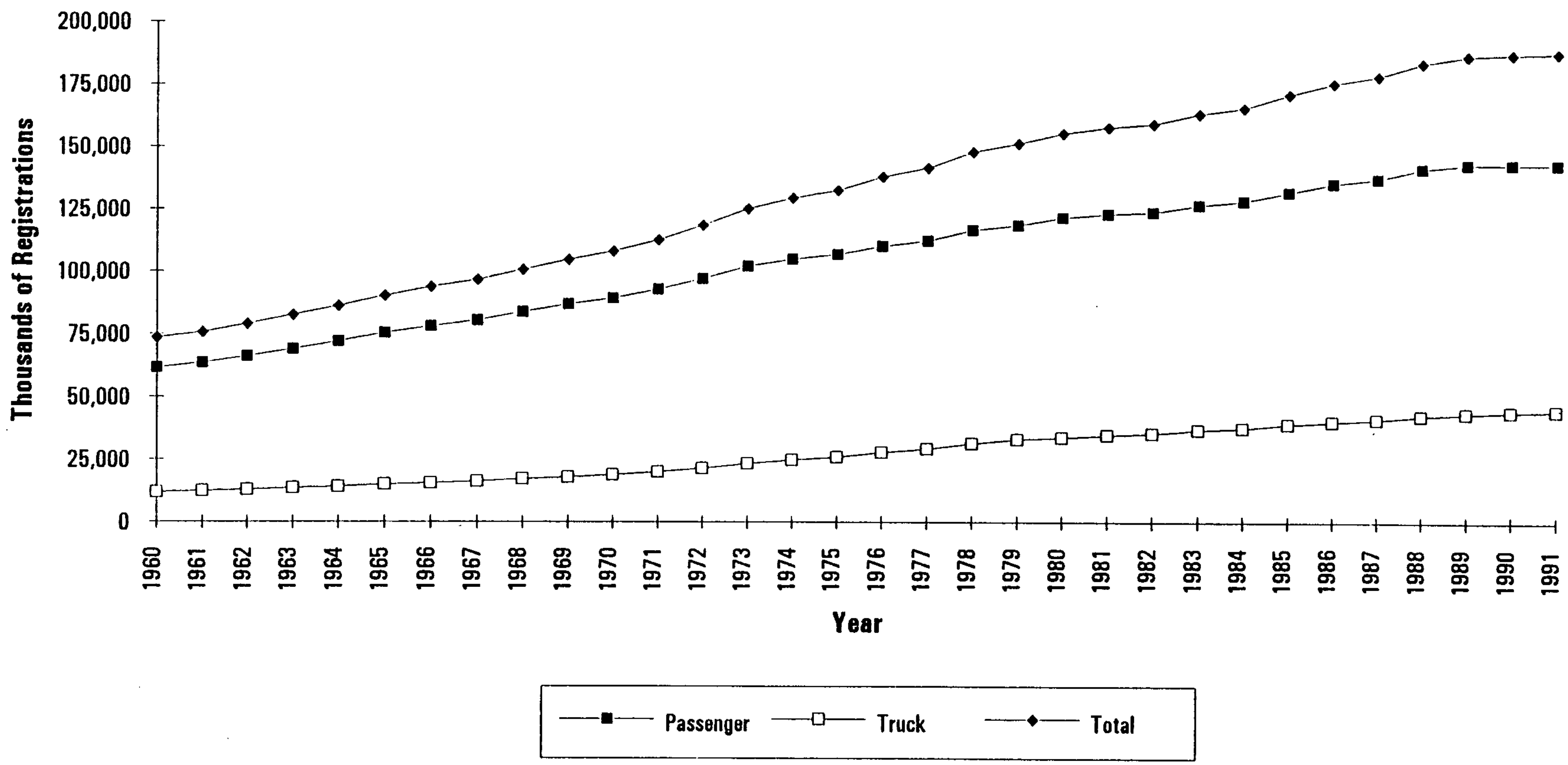
Private Sector Assets. Private sector involvement in highway construction and maintenance is limited, but as the main user of the system, the private sector has an investment in motor vehicles that is larger than the public sector's investment. The closest measure of the number of motor vehicles in the system is the number of vehicles registered in any given year. Total motor vehicle registrations have climbed steadily at a rate of 3.7 percent annually, from 70 million in 1960 to 172 million in 1985 (Figure 4-5). Since 1985 total growth in registrations slowed to a 1.5 percent annual rate. The decline

Figure 4-4: Net Highway Capital Stock



Source: Apogee Research, from Census Government Finances data

Figure 4-5: Motor Vehicle Registrations



Source: Federal Highway Administraton, Highway Statistics.

is due partially to the recession, of 1990, whose effect is further evidenced by an increase in average age of the automobile fleet from 7.6 years in 1985 to 8.0 years in 1990. A general slowdown in income growth, higher quality vehicles and market saturation are other commonly cited reasons for the slowdown.

The majority of vehicles in the total fleet are automobiles. In fact, automobiles have accounted for 75 percent of the increase in motor vehicle registrations since 1942. However, in recent years, the number of registered buses and trucks has been growing at an increasing rate, reflected in vehicle miles traveled by trucks as well as increasing ton-miles traveled (see service delivery, below).

Service Delivery

The most important output the highway system provides is the movement of people and goods. Three different criteria measure the output of the system: vehicle miles; passenger miles; and ton-miles. Vehicle miles traveled (VMT) measures the total miles of traffic, both passenger and truck, that move through the highway system. However, total VMT measures the service delivered to vehicles and not to people. On the other hand, passenger miles and ton-miles traveled measure output of the highway system as it is delivered to its users.

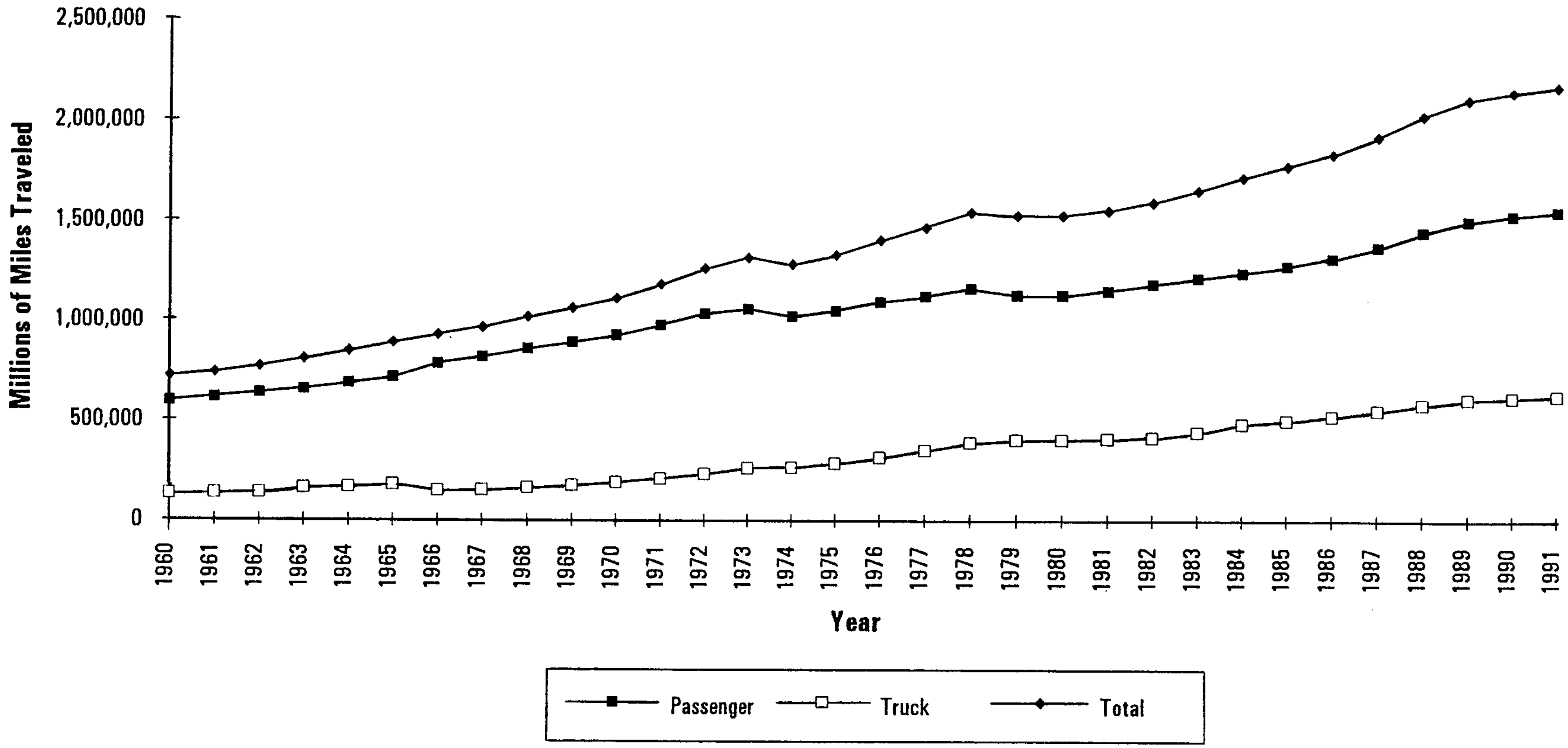
Vehicle Miles Traveled. Vehicle miles traveled (VMT) is the most comprehensive measure of highway output capturing both passenger and freight highway use. VMT has grown steadily at a rate of roughly 3.6 percent per year from 0.72 trillion miles in 1960 to almost 1.77 trillion in 1985 and continued at a 3.4 percent annual growth rate to 1991. In 1991 VMT reached 2.17 trillion miles (Figure 4-6). In fact, since 1960 highway use as measured by VMT has declined twice, in 1974 and 1979, both instances corresponding to petroleum shortages. VMT is predominately made up of passenger vehicle travel, although truck travel as a share of total VMT has been increasing since 1965.

The two downward blips in the steady upward climb of VMT are noteworthy for two reasons. First, historically VMT has increased every year regardless of economic conditions and external shocks. Thus, the oil shortage was dramatic enough not only to slow the rate of VMT growth, but to actually induce people to cut back on their travel. Further, the amount of truck travel was not greatly affected by either oil crisis. In fact, truck VMT continued to grow through both oil shortages. This occurred because petroleum is not a large portion of total trucking costs, and most of the added fuel cost can be passed on to consumers. Demand for truck transport is most sensitive to overall economic activity.

Passenger-Miles Traveled. VMT is an important measure of highway output, yet does not provide information on the number of people served but, rather, the number of vehicles served. Passenger miles is a more accurate measure of the number of people served. It is the product of the average vehicle occupancy rate and total passenger vehicle miles traveled.

Previously, the Department of Transportation assumed a constant 2.3 vehicle occupancy rate for passenger automobiles from 1960 to 1985.[60] Since then, revisions have been made to this rate so that comparisons to pre-1985 reports are not possible. The Nationwide Transportation Study shows that the rate of vehicle occupancy has been declining since the 1970s. In 1977, the vehicle occupancy rate was estimated at 1.9 and has fallen to 1.6 in 1990. This implies that although VMT has been rising rapidly, the growth of passenger service has been less rapid; only 1.6 percent annually from 1977 to 1990.

Figure 4-6: Vehicle Miles Traveled



Source: Federal Highway Administration, Highway Statistics.

Ton-Miles Traveled. In 1965, 359 billion ton-miles of freight traveled the nation's highways. By 1979, this figure had reached 610 billion tons-miles, an increase of 70 percent (Figure 4-7). The recession in the early 1980s depressed freight traffic by nearly 20 percent to 520 billion ton-miles. Since 1982, ton-miles have grown at a 5.1 percent annual rate to 735 billion tons-miles in 1990. The dramatic increase in truck freight up to 1979 is due to the completion of the Interstate Highway System. Although the trend began much earlier, the national network of high-speed highways allowed trucking to compete with rail freight on a national basis. Despite higher costs per ton-mile, the trucking industry was able to take market share from rail due to its greater reliability and speed.

Trip Purpose. Although trip purpose is not a direct measure of highway output, it does reflect the manner in which the highway system is used. Trip purpose has changed over time in both number and length of daily trips. The number of daily trips per household has increased from 3.8 daily trips in 1969 to 4.1 in 1983 and to 4.7 in 1990. However, the average length of each trip has fluctuated erratically throughout this period. According to a 1969 survey by the National Personal Transportation Survey, average trip length was 8.9 miles. A 1983 survey showed a significant drop to 7.9 miles per trip, increasing to 8.8 miles in 1990.

The amount of VMT each household devotes to specific trip purposes has also changed. For example, the amount of VMT categorized as home to work travel fell 15 percent between 1969 and 1983 but was up 31 percent in 1990. VMT logged for shopping purposes, on the other hand, has increased throughout this period.

Quality of Service

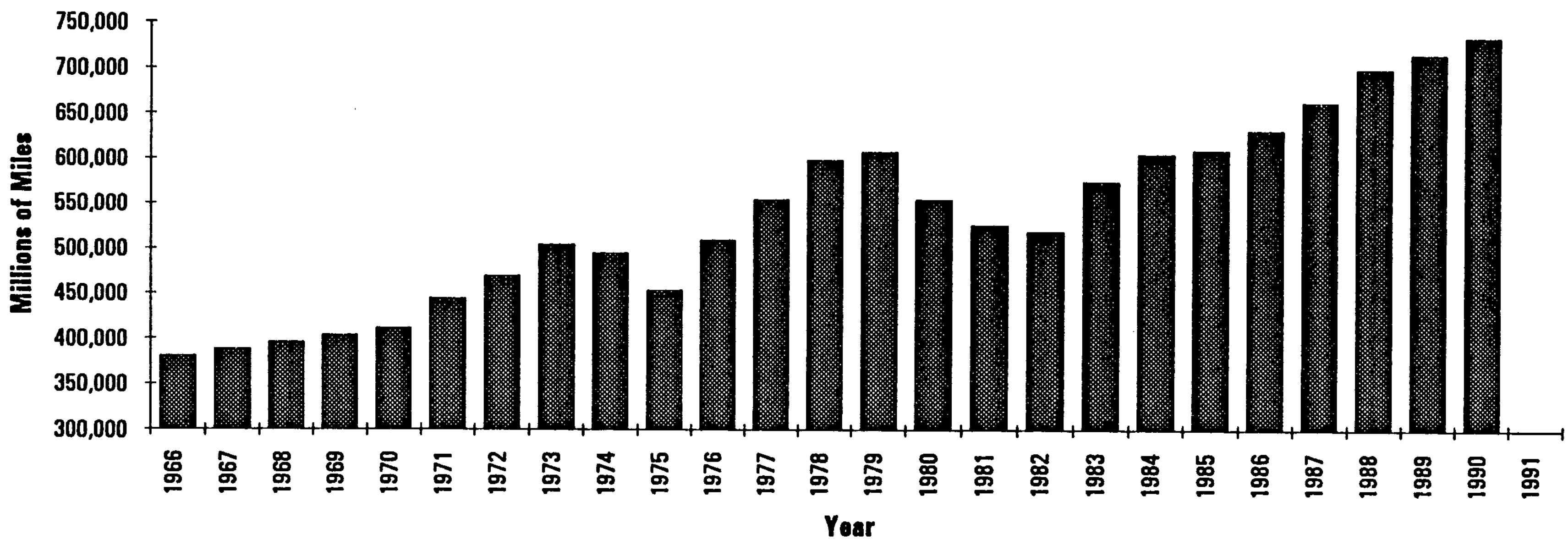
Four criteria measure the quality of service provided by the highway system: congestion; pavement conditions of the roadways, including the percent of paved roadway; fatality rates by functional class of road; and the number of registered drivers, in absolute value, and as a percentage of the total population.

Congestion. The severity of congestion is measured by the volume/service flow ratio (V/SF). This measures the ratio between the volume of traffic using a highway facility relative to its capacity. A ratio of one indicates that the theoretical capacity of the highway is exactly met. However, severe congestion generally occurs well before the theoretical limit is reached and would result in "gridlock". The Department of Transportation has determined that a ratio greater than 0.8 indicates severe congestion.

Most congestion is concentrated in urban areas and on other higher functional systems. In addition, congestion tends to occur at predictable, peak hours of the day. In 1990, 69 percent of urban peak hour traffic occurred under congested conditions; an increase from 1980 when only 52 percent of the travel occurred under congested conditions (Figure 4-8).

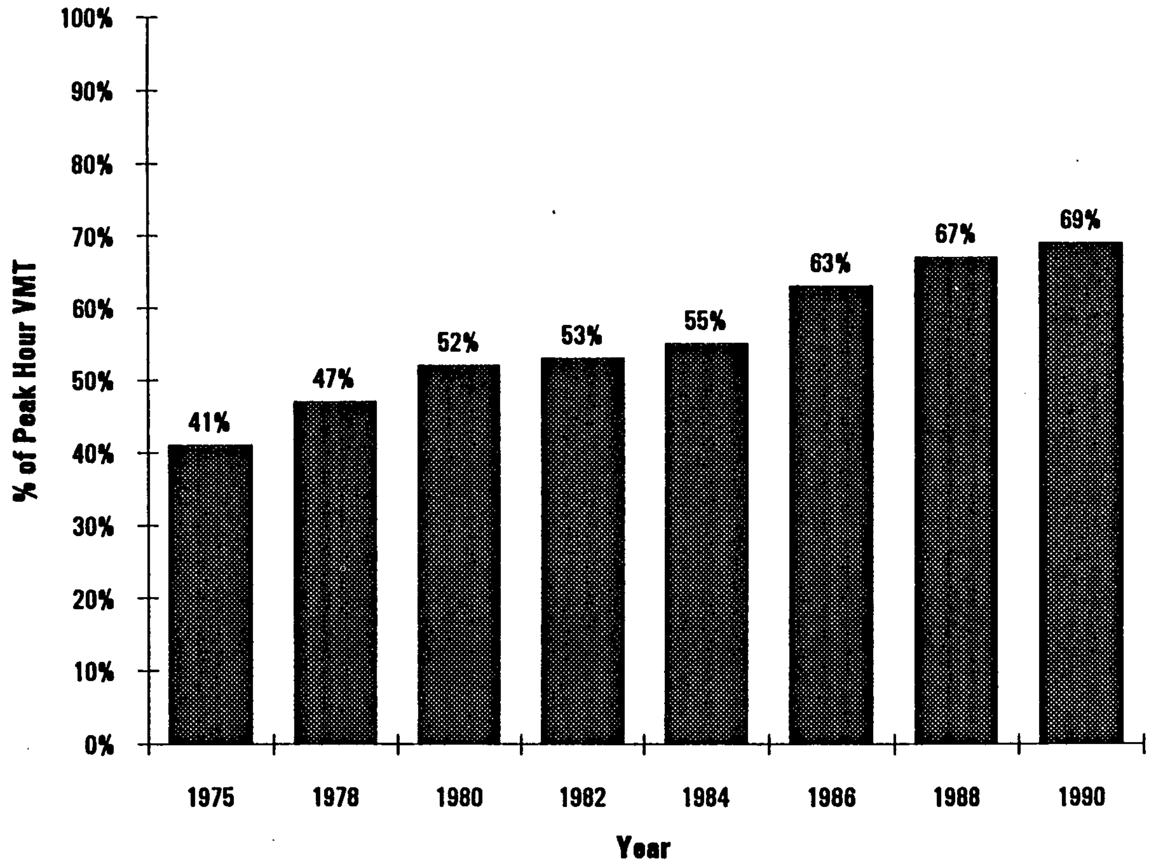
The Department of Transportation further examined the premise that urban congestion would be worse in the largest urban areas by using sample data from the 33 most populous areas. They found that 37 percent of the mileage, almost 41 percent of the lane-mileage, and more than 53 percent of the congested travel on non-local urban roads occurs in the 33 largest urban areas. A separate study of the 50 largest urban areas found that the costs of congestion exceed $39 billion annually. It appears that not

Figure 4-7: Intercity Ton-miles of Freight



Source: Federal Highway Administration, Highway Statistics.

Figure 4-8: Percent of Congested Travel



Source: Federal Highway Administration, Our Nations's Highways: Selected Facts and Figures.

only is congestion on the rise throughout the country, but that it is most severe in a few large urban areas.

Pavement Conditions. Pavement condition on the nations roads, as well as the type of surfacing itself, is an important measure of the quality of service provided by the highway system. Pavement condition affects the speed of travel, vehicle operating costs, smoothness of ride, safety, and other factors. Further, it is important that pavement conditions be addressed expediently because the cost of rehabilitation increases dramatically as conditions deteriorate.

The trend in pavement condition has been mixed. The percentage of paved roads has increased steadily (Figure 4-9). However, during the 1970s, overall pavement conditions for the Federal-Aid System declined, a trend that reversed itself in the 1980s. In 1975, the FHWA rated roughly 19 percent of urban and rural Interstate pavement as deteriorated or deteriorating. The portion of the Interstate pavement in deteriorated or deteriorating condition steadily increased through 1983 to a high of 29 percent. From 1983 to 1985, this trend reversed, and the portion of total Interstate mileage in deteriorating or deteriorated condition fell 3.2 percentage points from 28.9 percent in 1983 to 25.7 percent in 1985. This improvement reflects an increase in federal and state funding for resurfacing following the passage of the five cent tax increase in 1982.

A change was made in the way pavement conditions are categorized in 1985; making a comparison to the prior periods difficult. The same measurement system is used to rate highways, however the category definitions have changed since the 1987 performance report. A designation of poor condition indicates the mileage needs immediate improvement to restore serviceability; this is not the same as pavement conditions in deteriorated or deteriorating condition defined for the previous period.

While the definitions have changed, the trend toward improvement in the Interstate System has continued since 1985 (Table 4-3). Rural and urban Interstate mileage rated in poor condition have fallen during the period 1985 to 1991, from 10.8 to 7.6, and 11.1 to 7.7, respectively.

Pavement condition on arterials is not as good as that of the Interstate System, as a higher percentage of mileage falls into the category of deteriorating or deteriorated pavement. Further, the standards applied are more stringent for the Interstate System. Specifically, the Pavement Serviceability Rating (PSR) rating on Interstate pavement need fall only below 2.5 (on a scale of 5) to be considered in poor condition, whereas the PSR on other arterials must fall below 2.0.[61] However, because of the difference in definition, it is more instructive to compare the percentage of mileage on both systems classified in good condition. For the Interstate system, this is roughly 60 percent, whereas only 47.8 percent of non-interstate systems are rated good or better.

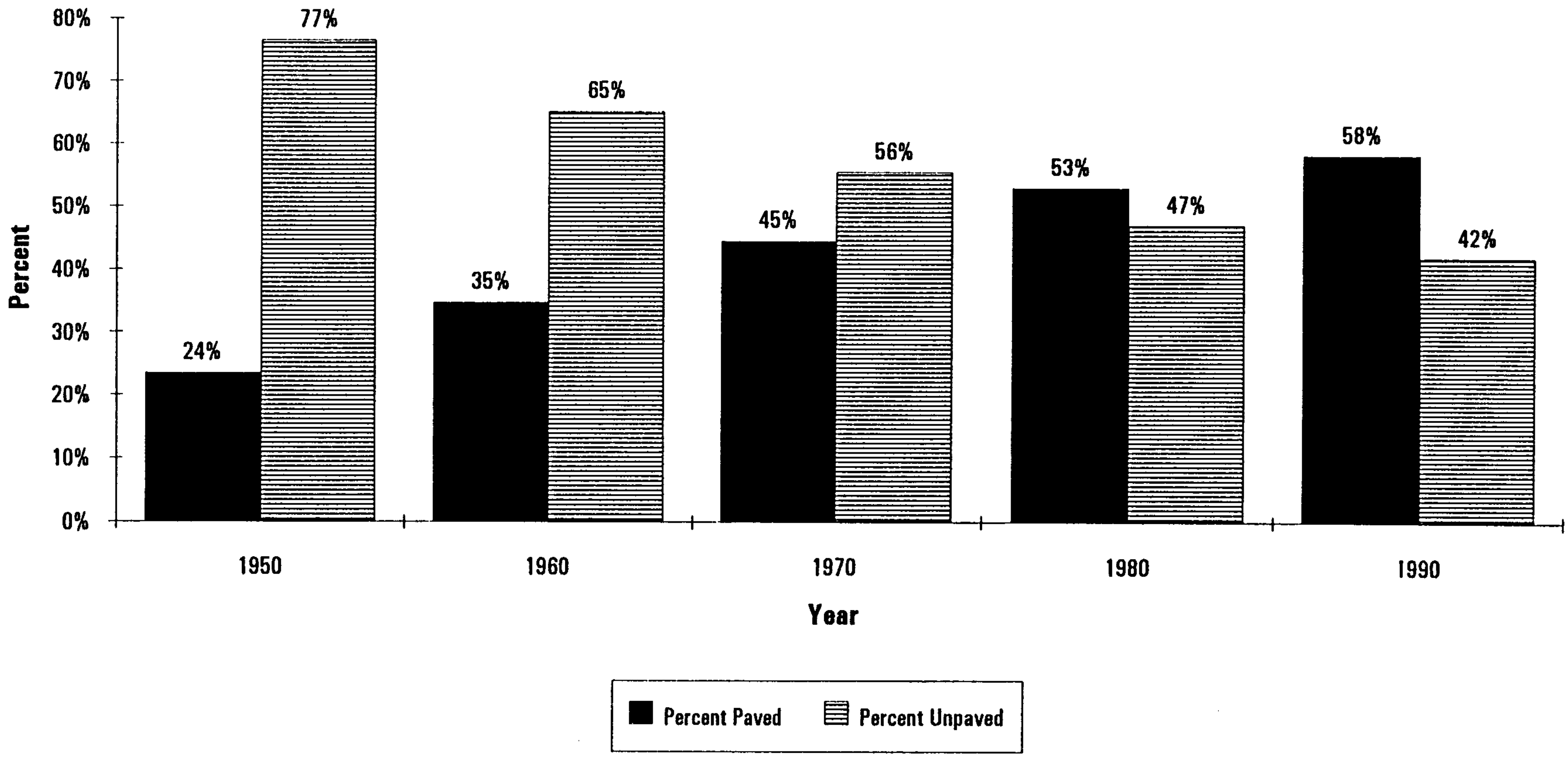
Conditions on the non-interstate arterials were erratic throughout 1970s and 1980s. Pavement condition deteriorated slightly between 1975 and 1978, improving slightly from 1978 to 1985. Since 1985, the percentage of roads in poor condition, or needing immediate improvement, continued to decline. Relative to the Interstate system, physical conditions may be expected to be worse for these systems simply because they are used less intensively. Changes for the Interstate System are more dramatic because it went from a new network in the 1960s to a middle-aged system in the 1970s. Although some deterioration as a result of aging was expected, these changes may have occurred somewhat prematurely due to a faster than anticipated rate of growth in long-haul trucks with heavy axle-weights.

Table 4-3: Pavement Condition

Functional System	Year	Pavement Condition					
		Poor	Mediocre	Fair	Good	Unpaved	Total
Rural Interstate	1983	13.3	13.8	14.3	58.6	0.0	100
	1985	10.8	14.1	15.4	59.7	0.0	100
	1987	11.6	15.5	14.4	58.4	0.0	100
	1989	9.1	15.4	17.1	58.4	0.0	100
	1991	7.6	15.6	15.9	60.8	0.0	100
Urban Interstate	1983	16.8	16.1	13.7	53.4	0.0	100
	1985	11.1	19.5	13.5	56.0	0.0	100
	1987	11.1	18.5	15.0	55.4	0.0	100
	1989	9.6	16.1	16.7	57.6	0.0	100
	1991	7.7	15.6	16.6	60.1	0.0	100
Rural Arterials	1983	11.1	11.8	35.3	41.8	0.1	100
	1985	8.3	10.0	36.7	44.9	0.1	100
	1987	6.6	11.0	37.3	45.0	0.1	100
	1989	4.8	9.9	37.4	27.8	0.0	100
	1991	3.9	8.0	38.3	49.8	0.0	100
Urban Arterials	1983	10.0	13.6	34.1	41.7	0.6	100
	1985	9.0	13.9	34.7	42.0	0.5	100
	1987	8.7	14.0	35.2	41.7	0.4	100
	1989	7.7	13.4	36.5	42.1	0.3	100
	1991	6.8	13.2	36.0	43.6	0.4	100
Rural Collectors	1983	15.0	12.1	25.5	24.7	22.8	100
	1985	12.8	13.4	27.2	24.2	22.3	100
	1987	12.0	13.0	26.9	26.5	21.7	100
	1989	10.5	12.7	27.9	28.6	20.3	100
	1991	8.2	12.0	29.8	30.1	19.9	100
Urban Collectors	1983	14.9	15.5	34.2	33.3	2.0	100
	1985	13.1	17.4	35.3	32.5	1.7	100
	1987	13.6	17.4	36.6	31.1	1.3	100
	1989	17.6	16.5	33.3	31.3	1.4	100
	1991	11.3	17.4	36.0	34.2	1.1	100

Source: Status of the Nation's Highways, Bridges, and Mass Transit, 1993

Figure 4-9: Percent of Roads Paved



Source: Federal Highway Administration, Our Nation's Highways: Selected Facts and Figures.

Registered Drivers. Quality of service depends, in part, on the percentage of the population served by the mode. The number of registered drivers is one measure of public access to the highway system. In 1950, 57 percent of the driving age population were licensed to drive a motor vehicle. By 1986, 86 percent of the driving age population were licensed drivers (Figure 4-10). Since 1986, this percentage has increased only slightly to 87.3 percent. Further the number of licensed drivers per motor vehicle has been falling, indicating that, on average, individuals have easier access to a motor vehicle, and that multiple ownership is rising. In 1950, there were 1.26 licensed drivers per vehicle. This fell to 1.1 vehicles per licensed driver in 1986 and has remained constant.[62] The number of registered drivers slightly underestimates the amount of public access to the highway system as it neglects mass transit.

Fatality Rates. The number of roadway fatalities has been declining over the years. From 1965 through 1973 annual motor vehicle accident fatalities rose from 50,000 to roughly 55,000. After 1973, fatalities declined dramatically, in part due to the 55 mile-per-hour speed limit law. Although there was a slight upward trend from 1975 to 1980, the number of annual road-related fatalities is generally declining once again (Figure 4-11). The decline in fatalities throughout the 1980s is due in part to better enforcement of drunk driving laws.

Not only is the absolute number of highway fatalities falling, but the fatality rate is falling as well (Figure 4-12). As noted previously, VMT has increased steadily from 1965 through 1985. Consequently, the fatality rate over all systems has declined over this period from roughly 5.5 fatalities per 100 million VMT to close to 2.5 fatalities per 100 million VMT. The fatality rate across all systems has fallen 41 percent since 1973. This downward trend has continued with a 23 percent decline from 1985 to 1991, reaching 1.91 fatalities per million VMT.

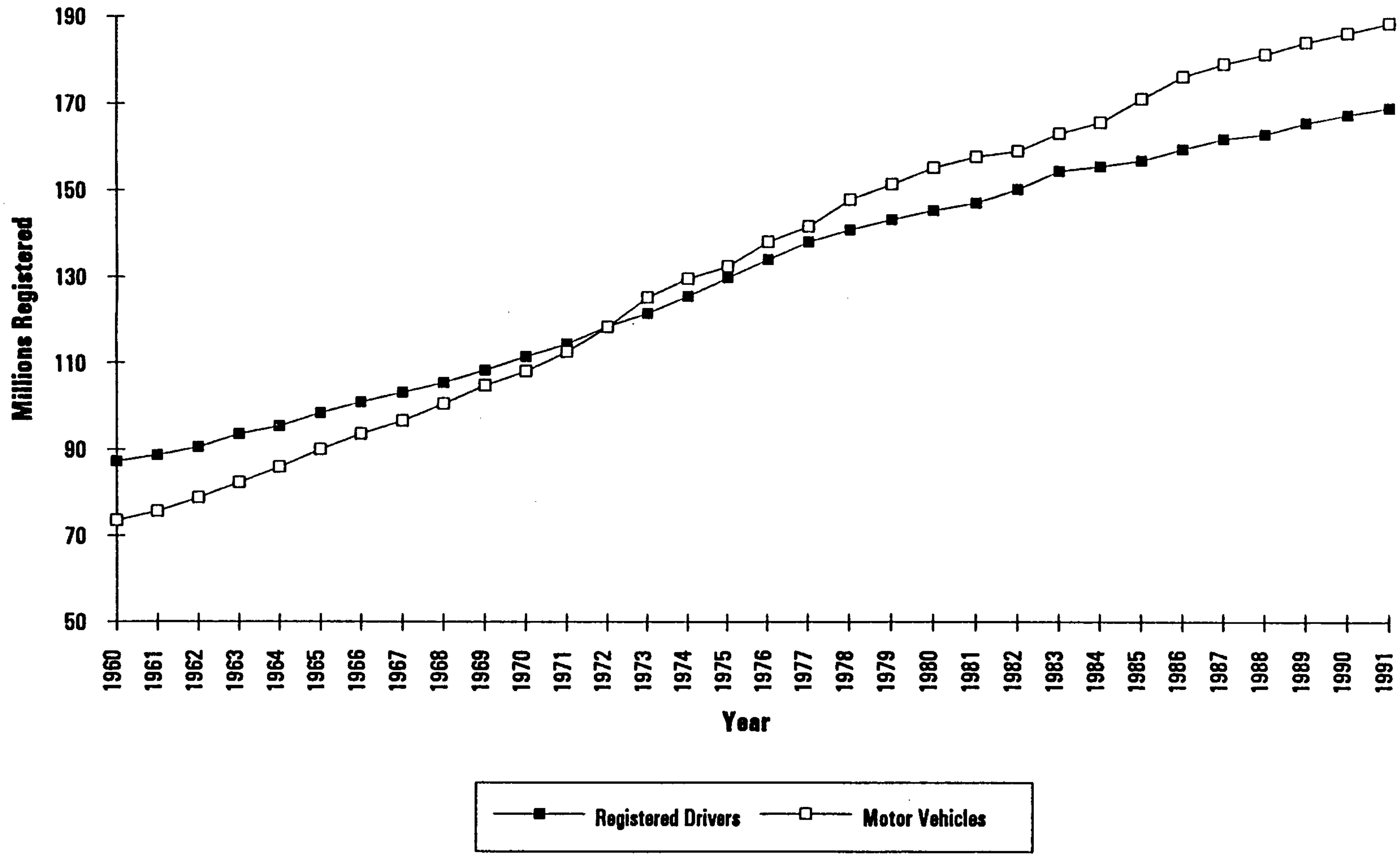
Despite its much higher average speed, the Interstate System has a lower fatality rate than the system as a whole. This is the result of the much higher design standards applied to the Interstate. As with the system as a whole, the interstate fatality rate has generally decreased, showing its biggest decline right after the 55 mile an hour speed limit was instituted. In 1991 there were 0.91 fatalities per 100 million VMT on the Interstate System, a decrease of 17 percent since 1985.

Externalities

Highways have costs and benefits not directly captured by its users. For example, environmental damage results from both highway construction and highway usage. Similarly, there can be economic impacts from a new highway network that significantly add to the growth of the local economy. In The Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance, the FHWA presents a set of categories that should be observed to understand the impact of highway construction and use:

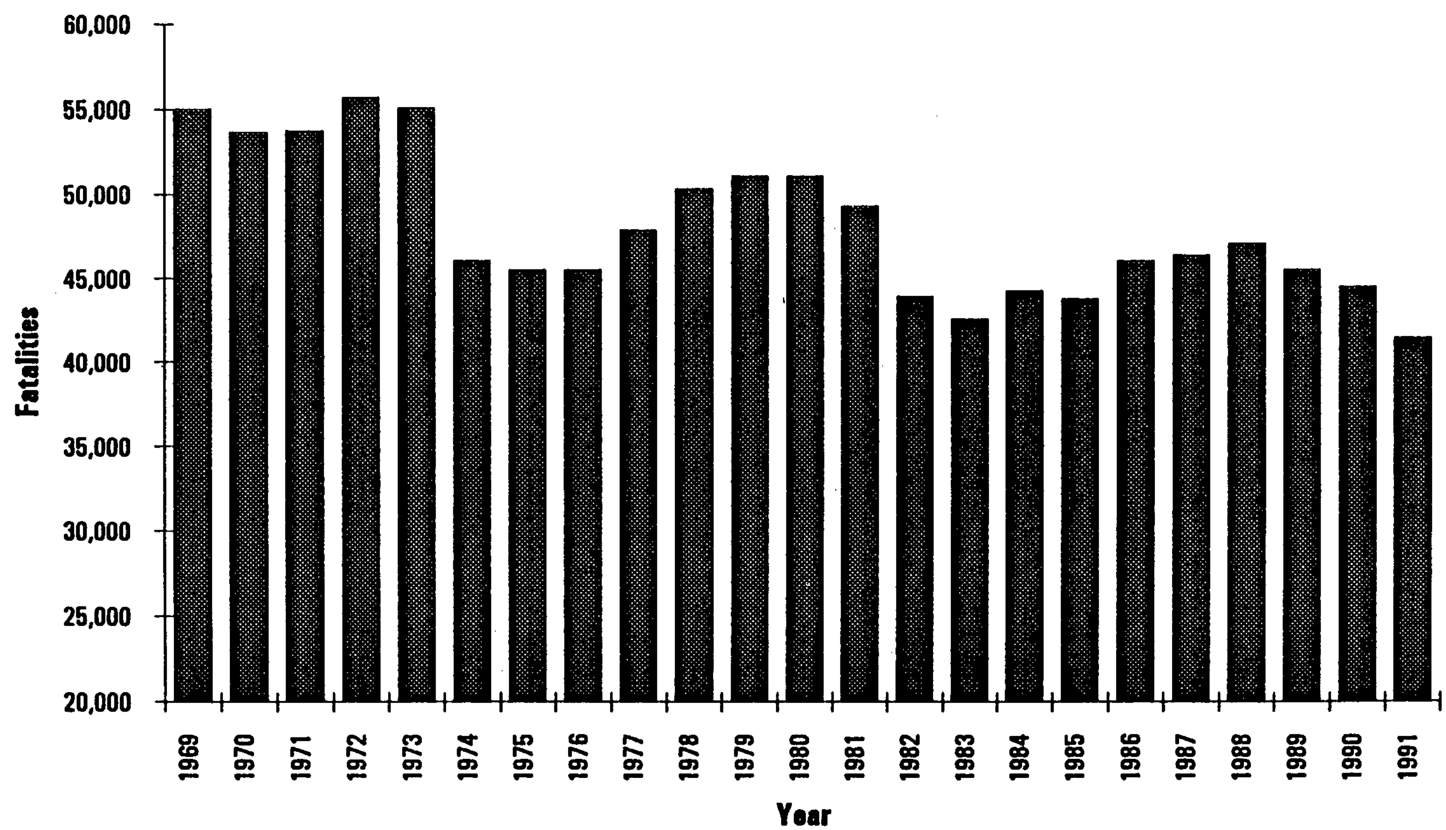
- Air quality;
- Water quality;
- Wetlands;
- Energy;
- Noise;
- Land/Open space;
- Threatened and endangered species; and
- Community impacts.

Figure 4-10: Trends in Registrations



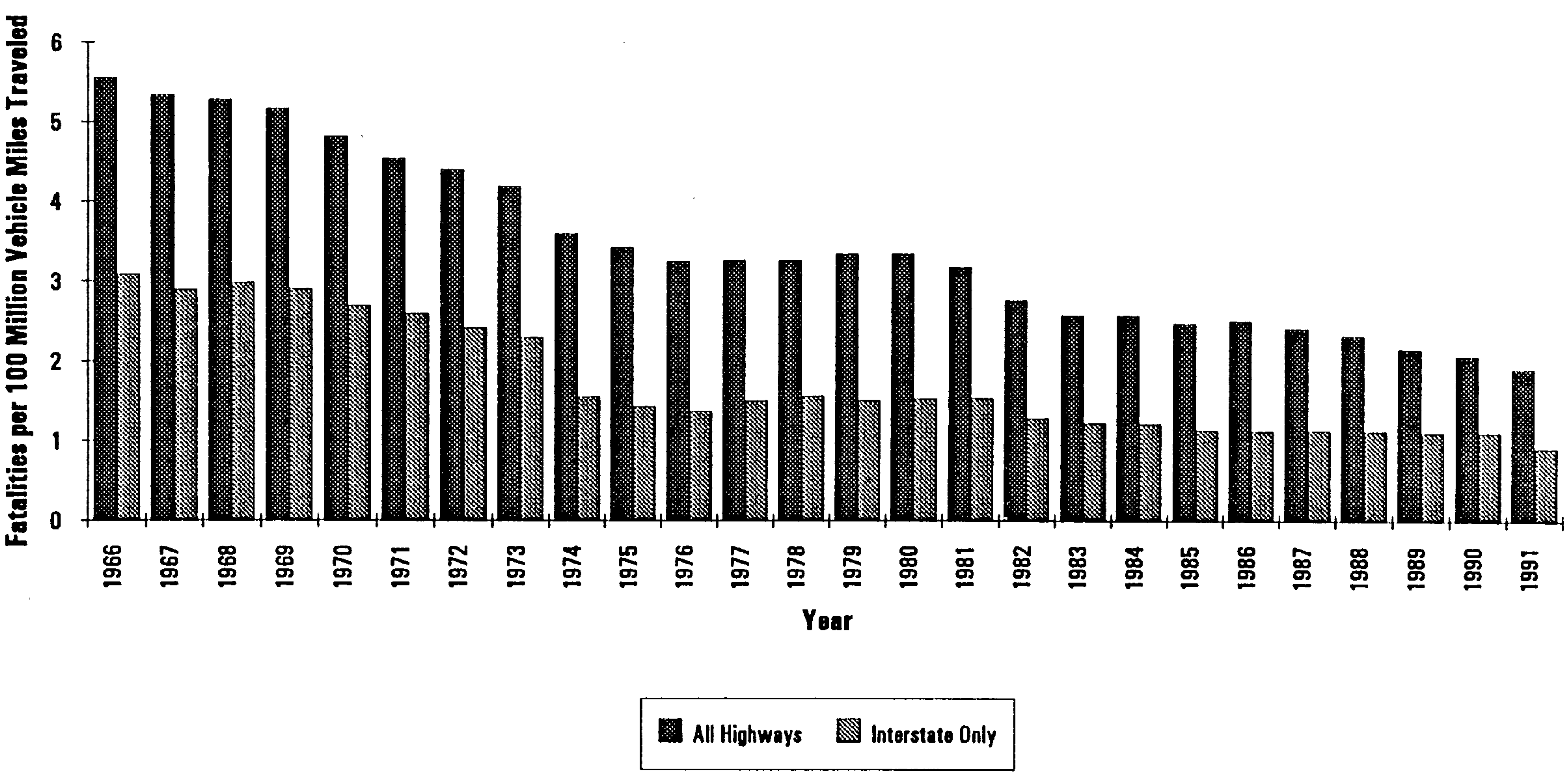
Source: Rederal Highway Administration, Highway Statistics.

Figure 4-11: Total Annual Road-Related Fatalities



Source: Federal Highway Administration, Highway Statistics.

Figure 4-12: Fatality Rates



Source: Federal Highway Administration, Highway Statistics.

Developing indices to track the impacts of highways on these areas is difficult. The FHWA has some performance measures but is currently developing more comprehensive methods to trace these impacts.

Limitations of current measures notwithstanding, there appears to be significant improvement in the mitigation of harmful environmental impacts associated with highways. The EPA's National Air Quality and Emissions Trends Report, 1991 shows that transportation sources, including automobiles and trucks, were responsible for a large part of emissions reductions throughout the 1980s even though travel increased throughout the period. For example, highway emissions reductions from 1982 to 1991, including 45 percent for carbon monoxide emissions, 97 percent for lead emissions and 32 percent for nitrogen oxide emissions.

Recently, several programs have been initiated to further curtail the harmful effects of transportation. These include the Congestion Mitigation and Air Quality Program (CMAQ) which funds programs to further reduce harmful emissions. ISTEA also provides funding for mitigation efforts to address the impacts on general water quality of highway storm water runoff. There are also significant attempts underway to reduce noise pollution through better planning and design.

Cost Effectiveness

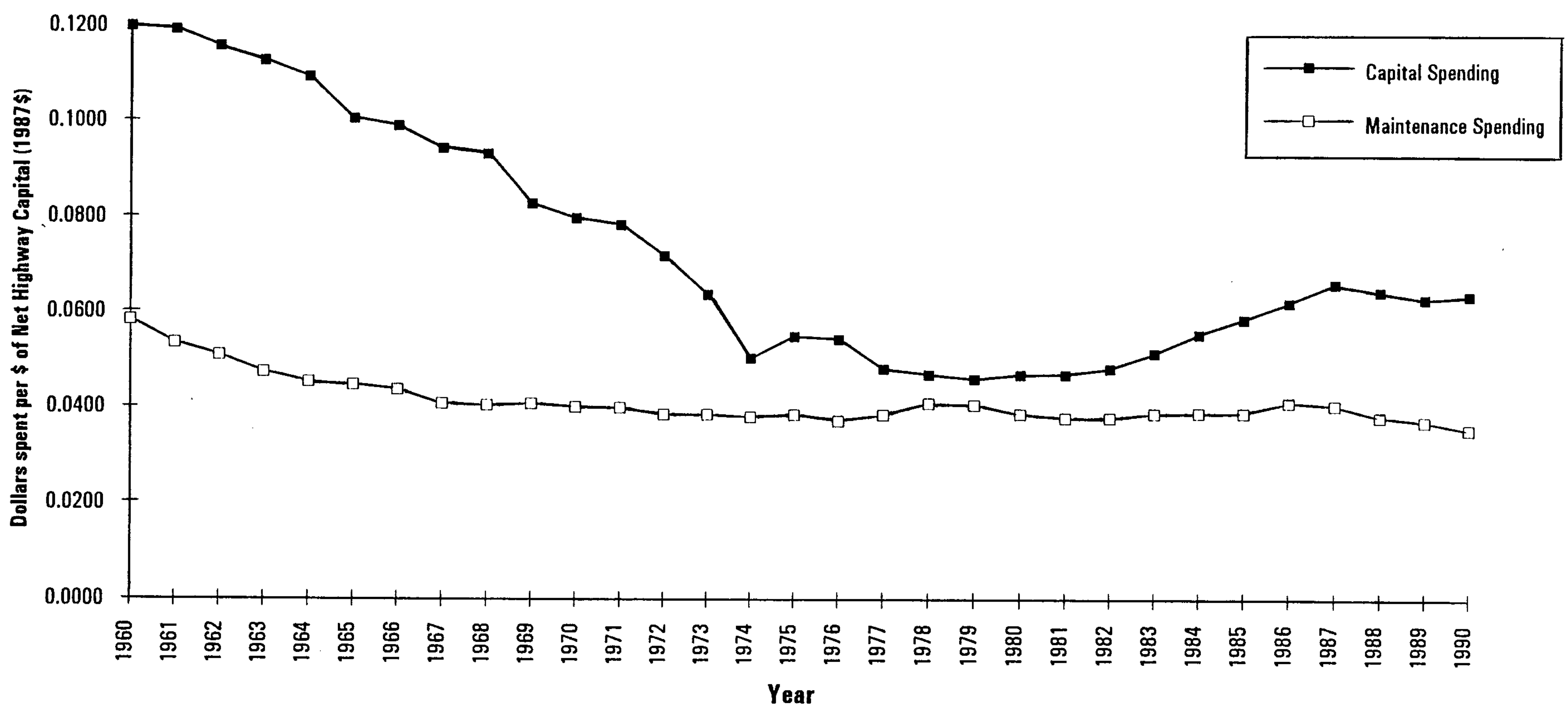
Cost effectiveness and benefit-cost analysis are two approaches to assessing the efficiency of a program. Benefit-cost analysis looks at the entire cost of providing a system in comparison to the overall benefit. However, this analysis requires large amounts of data covering both direct and indirect inputs and outputs. To date, there are no available benefit/cost studies on a programmatic level, although some states prepare these studies on a project by project basis. Consequently, this section focuses on cost effectiveness measures.

In recognition of the need for benefit-cost analysis at a programmatic level, the FHWA currently is incorporating traditional benefit-cost analysis into the Highway Performance and Monitoring System (HPMS). This is a simulation model used by the FHWA that determines the national roads estimate, performs investment analysis and projects changes in future highway performance and conditions over time. The model uses minimum tolerable conditions to trigger highway improvement needs. Although engineering criteria are the standard determinant of need, the model user can select a cost effectiveness index that can be used to rank projects. In this case, the model can be used to determine project funding subject to budget constraints for each functional class over different time periods.

Spending Relative to Capital Stock. The ratio of public capital outlays to net highway capital stock captures the rate at which assets are being replaced. In the period 1960 to 1990 capital spending relative to assets was at its highest in 1960 at 12 cents per dollar of assets (Figure 4-13). If no funds were used to add to capacity, this rate of spending implies a replacement cycle of about 8.3 years. However, only half of the capital spending represents new expansion.

The 1960s were dominated by the massive construction and expansion of the Interstate Highway System. By 1974, after the Interstate System was largely complete, capital spending had fallen to 5 cents per dollar asset, or an implied 20 year replacement cycle. This was not enough to cover depreciation in the system and resulted in a decrease in net assets. After reaching a low of 4.6 cents in 1979, capital spending per dollar of assets has increased, and as of 1990, is 6 cents per dollar.

Figure 4-13: Capital and Maintenance Spending per Dollar Net Capital Stock



Source: Apogee Research, from Census Government Finances data

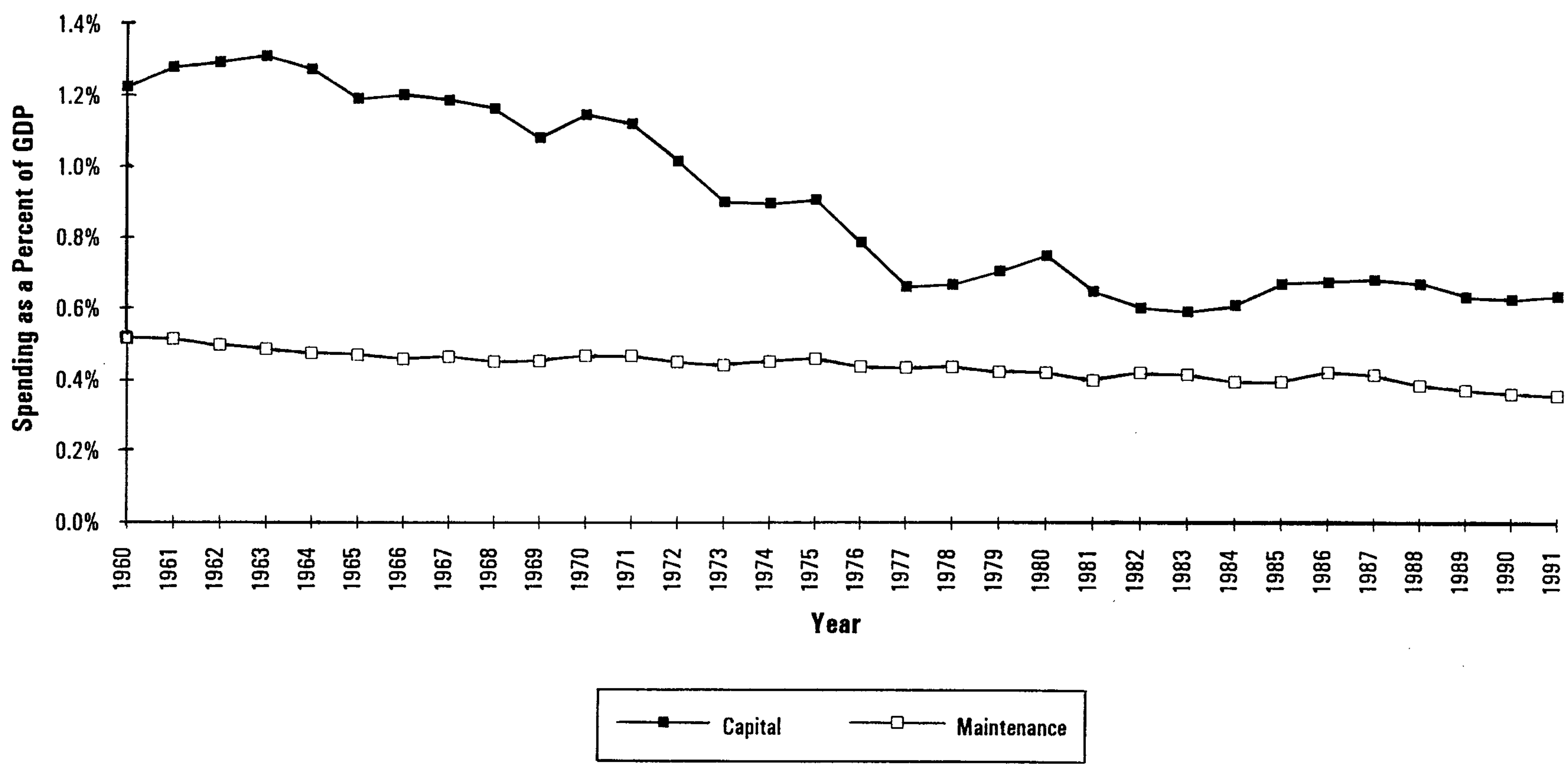
Highway maintenance expenditures per dollar of assets is a further measure of the adequacy of public spending on the highway system (Figure 4-13). This ratio has remained relatively stable despite growing highway use. In 1960, public maintenance spending per dollar asset value was 6 cents, declining to 3.7 cents per dollar asset in 1976. From 1985 to 1990, the rate has declined from 3.9 cents to 3.5 cents, reflecting the increase in net capital stocks during this time. In addition, much of the current capital outlays are for major repair and resurfacing work and could be considered maintenance related.

Public versus Private. While the nations economic and physical dependence on its highways has grown steadily for more than 80 years, public spending has not kept pace in recent years. Public capital outlays as a percentage of GDP peaked at 1.2 percent of GDP during the early 1960s and declined to only about 0.6 percent of GDP in 1984. Since 1984, this rate has remained constant. In contrast, maintenance outlays have remained relatively steady at between 0.35 to 0.5 percent of GDP over the past 30 years (Figure 4-14).

Capital and Maintenance Spending. Public capital and maintenance spending relative to highway use is one important measure of the adequacy of investment in, and the maintenance of, the nation's system of roads and bridges. Neither capital nor maintenance spending have kept pace with growing highway use (Figure 4-15). Total public capital expenditures per 1000 VMT peaked just over $40 in the early 1960s ($41.1 in 1962). Declining steadily into the early 1980s, it reached a low of $13.50 per 1000 VMT in 1981 and 1982. It has increased to $15.51 in 1991. The decline throughout the 1970s reflects completion of the Interstate System, while VMT on the system continued to grow. The subsequent rise in the 1980s is a response to the declining conditions of the nations roads and bridges, and to an increase in the motor fuel tax.

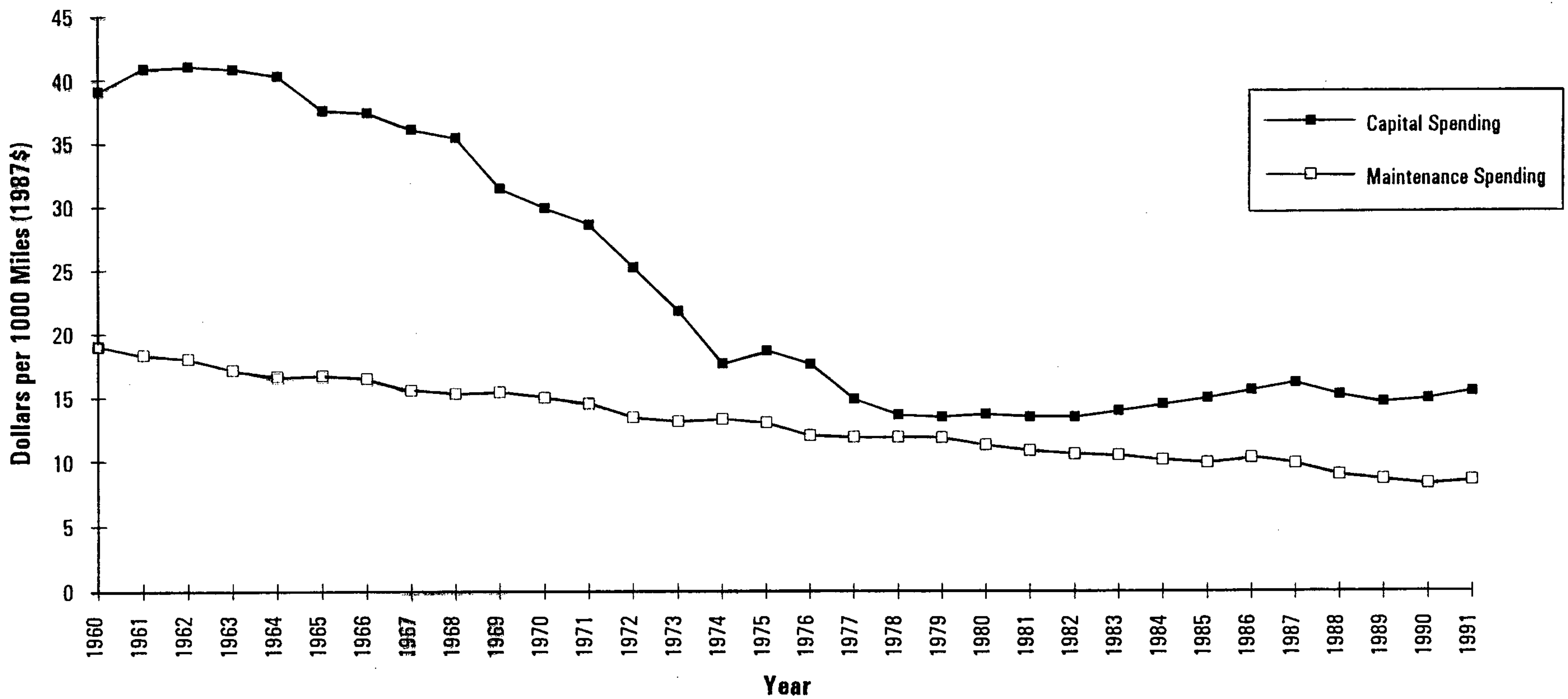
Maintenance expenditures per 1000 VMT fell throughout the 1960 to 1991 period, with a high of $19.0 in 1960 to $8.55 in 1991, a total decline of 55 percent (Figure 4-15). As with any such measure, it is difficult to determine whether a declining rate of spending relative to usage indicates a decline in the ability of the system to provide the services required, or that or that capital and maintenance expenditures are becoming more efficient.

Figure 4-14: Capital and Maintenance Spending Relative to GDP



Source: Federal Highway Administration ,Highway Statitics, and The Economic Report of the President

Figure 4-15: Capital and Maintenance Spending per 1000 Vehicle Miles Traveled



Source: Apogee Research, and Highway Statistics

CHAPTER V: MASS TRANSIT

GOALS OF MASS TRANSIT

The general category of mass transit encompasses a wide variety of service types. The more widely used mass transit modes are heavy rail (subway), light rail (street car), local and express buses and commuter rail. Other transit modes include trolley buses, ferries and demand-responsive (dial-a-ride or paratransit). The importance of transit services varies greatly among urban areas -- older, dense cities rely much more heavily on public transit than do small and medium-sized cities, for example.

The chief goal of mass transit is to provide mobility in urban areas. In recent years that goal has been restricted primarily to those domains of urban mobility which are not served by the private automobile, namely, congested central cities and for riders who lack cars. Today, outside the most densely populated cities, it is chiefly the poor and the elderly who rely on mass transit.

Transit has undergone a revival in the public imagination, however, because it is viewed as a solution to many of the ills brought about by the automobile -- congestion, urban sprawl, pollution, and import dependence. A secondary goal of transit could therefore be considered the provision of mobility with limited externalities.

This second goal may be the motivation for the most substantial change since 1987 in the institutional framework for transit: passage of the Intermodal Surface Transportation Act of 1991 (ISTEA). ISTEA lays the groundwork for reversing shrinking federal involvement in transit by permitting state and local governments more flexible use of surface transportation funds. Funding programs previously limited to highway construction have been combined and can now be diverted to transit use, and new funding sources have been created which encourage transit investment, such as the Congestion Mitigation and Air Quality program.

OVERALL PERFORMANCE OF MASS TRANSIT

Data on mass transit tell two different stories. The continued declines in transit labor efficiency and ridership that characterized transit for decades have ended, and in some cases reversed. Meanwhile, transit's role in providing urban mobility continues to shrink.

Overall labor productivity, which declined from 13,600 vehicle miles per employee in 1965 to 10,300 in 1985, has rebounded to 11,900 in 1991. This improvement occurred despite the expanding role of demand-responsive transit, a highly labor intensive mode, in serving rural areas and the elderly and handicapped. Excluding modes not included in the 1965 figure, such as commuter rail, demand-responsive transit and others, productivity stood at 12,400 vehicle miles per employee in 1991, its highest point since 1969.[63] Real operating expenses per passenger doubled between 1970 and 1991 (an increase of 75 percent for comparable modes), but rose only two percent between 1988 and 1991.[64]

Despite the continuing infusion of government funds, public transportation's share of urban person trips fell from 3.4 percent in 1969, to 2.7 percent in 1983, and to 2.0 percent in 1990.[65] Mass transit provides a larger share of urban commuting trips, but this share, too, continues to decline -- from 6.4 percent in 1980 to 5.3 percent in 1990.[66] The most important factors behind this shift have been social and demographic changes -- the continuing rapid suburbanization of jobs and workplaces, for example.[67] Because transit is more efficient at connecting concentrated origin and destination points, it is less able to serve most inter-suburban trips than trips that start or end downtown.

IMPROVING PERFORMANCE REPORTING

Not much has changed since the last performance report in the availability of transit performance data. The Federal Transit Administration (FTA) is fairly sophisticated at collecting performance information, comparing outputs such as passenger trips with inputs such as operating expenses. Data from the FTA report, National Transit Summaries and Trends for the 1990 Section 15 Reporting Year provides comprehensive data on the nature and extent of the nation's transit systems. There still is little if any, time series data on the overall physical conditions or ridership capacity. The performance measures presented in this chapter provide only a partial view of the efficiency of mass transit. Ideally, performance measures would reflect the following:

- Operating efficiency and the ability to provide sufficient cash flow;

- Short- and long-run capital investment efficiency;

- Efficiency defined with various goals and objectives in mind:
  - Effective movement of people in urban areas;
  - Mobility for the young, poor, elderly and disabled;
  - Encouragement of economic development;
  - Reduction of highway congestion;
  - Improvement of air quality; and
  - Support of land use objectives.

Standardized measures of conditions of vehicles and fixed assets, such as rail track and buildings, should be developed, and statistics should make greater use of seat miles instead of vehicle hours and miles. Labor inputs could be better measured if labor expenses were adjusted for cost of living in different regions, and if ratios such as employees per vehicle and seat miles per employee were reported. More meaningful measures of financial input use might be public subsidy per passenger or public subsidy per capita.

Performance measures can be devised that directly address consumption by the public and pertain to particular market segments. Given changing land use patterns and the increase in circumferential travel between suburbs rather than radial travel to and from a city center, new measures of performance need to be developed to address travel in the suburbs and exurban development. Census and FTA data should be combined to develop statistics on the availability of service to transit-dependent populations.

Currently there is insufficient time series data concerning aspects of service quality such as travel time and reliability. Measures should compare transit and automobile travel times, and consider average waiting times and variability of both headways and running times.

Benefit-cost analyses are not possible until better measures of transit benefits are available. In traditional highway benefit-cost analysis, travel time savings and accident costs are routinely quantified in dollars. This type of analysis is usually performed at the local level for individual projects, but simplified procedures could be devised for performing similar analysis at the national level. There are other societal benefits of transit that should be taken into account in developing efficiency measures, including pollution reduction and preservation of land used in a socially desirable manner.

The transit industry would benefit from better use of its depreciation data, especially if this information was incorporated into capital recovery accounts. Publicly owned transit systems generally see little reason to establish capital recovery accounts because they can turn to governmental sources of funding for capital replenishment under very attractive terms. But as far as planning is concerned, capital recovery accounts would be very helpful in assessing the degree to which transit is replacing its capital stock.

A far more perplexing issue is whether or not performance measures can be developed to determine whether major capital improvements are warranted. This type of analysis has to be performed on a case by case basis at the local or regional level, but should follow a systematic framework. Benefit-cost analysis may have an important role to play here.

Finally, American Public Transit Association (APTA) and Section 15 data reporting conventions should remain consistent from year to year. Changes in the scope of services surveyed and in the definition of terms complicate time series analyses.

OVERVIEW OF MASS TRANSIT MANAGEMENT

What historically had been a private, for-profit enterprise has become a government-funded public service over the past several decades. Modern mass transit was developed largely by entrepreneurs in the early years of this century. Today, virtually all mass transit is either directly provided or subsidized by the government.

Government and Private Roles

Federal Government. The first federal assistance for mass transit came in 1961, in the form of demonstration grants and loans. Capital grant programs began three years later, with passage of the Urban Mass Transportation Act of 1964.. The Federal Aid Highway Act of 1973 greatly expanded the program and raised the federally funded portion of capital projects to 80 percent from two thirds. In 1974, Congress expanded the formula grant program to remit grants for operating assistance (up to 50 percent of costs).

To this day, the role of the federal government in transit capital investment is limited to providing capital grants directly to operating authorities and to states. Federal transit programs are administered by the Federal Transit Administration (FTA), successor to the Urban Mass Transportation Administration, as authorized by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). Major federal grant programs are the following:

- Section 3 -- Discretionary and formula capital assistance;
- Section 9 -- Formula capital and operating assistance;
- Section 16(b)(2) -- Elderly and disabled transit capital assistance; and
- Section 18 -- Rural capital and operating assistance.

Transit capital grant programs require a twenty percent local match; however, in most instances the local share of capital expenditures is higher than mandated levels. Other federal grant sources for mass transit include the Federal Highway Administration's Interstate Trade-in program, which permits construction of transit facilities in place of canceled interstate highways, and the National Capital Transportation program, which provides supplemental capital and operating assistance directly to the Washington Metropolitan Area Transportation Authority. In addition, other non-capital, federal transit expenditures support transit research and planning.

Although passage of ISTEA did not bring major changes to the four major transit grant programs, the changes it brought to highway funding will have a significant impact on mass transit. Under ISTEA, most federal capital assistance for highways can be redirected for transit capital expenditures by state and local planning authorities.

In 1991, the federal government provided $3.2 billion in aid for mass transit, including $1.1 billion of discretionary capital assistance, $1 billion of formula capital assistance, $250 million of other capital assistance, and $830 million of operating assistance. Capital assistance in 1991 was slightly below 1987's total of $3.3 billion, representing a real drop in funding of 16 percent.[68]

State Government. States assist in administering the federal program, frequently providing matching and other supplemental funding for local transit operators. States also provide substantial technical assistance and help localities in transit planning and to improve their operations and productivity. A few smaller states directly operate transit services.

Local Government. All direct capital investments in mass transit are made by state and local governments, usually by a transit authority, which is generally an independent local operating authority but can also be a department of the county or municipal government. Local and regional planning agencies, with the cooperation of transit authorities, initiate most major capital programs.

Decisions requiring only marginal modifications to existing service are the responsibilities of transit managers and their boards. Ideally, transit managers should have responsibility for day-to-day decisions with transit boards providing general guidance concerning the goals and objectives of providing service as well as authorizing major decisions. While these roles can become tangled, most operational and maintenance decisions are made by mass transit managers.

Sources of capital funds for transit authorities vary by jurisdiction. In addition to federal grants, nearly all jurisdictions receive state capital assistance. Many also receive local capital assistance, and some have local dedicated taxes. In virtually all cases, farebox revenues are spent on operating cost and do not support capital investment.

Private Sector. Large scale public involvement in provision of mass transit is a relatively recent phenomenon. Historically, transit was provided by private, for-profit companies, generally subject to government regulation. Declining ridership and inflexible regulation bankrupted most private urban transit operators, and public authorities were established to take over service. Although numerous transit providers for the rural and elderly operate without public support, provision of urban mass transportation remains an unprofitable operation, and every significant urban transit system is subsidized. The fraction of publicly owned transit systems increased from 5 percent in 1960 to 55 percent in 1980, with the share of publicly owned vehicles rising from 36 percent to 90 percent over that period. While the inclusion of demand responsive transit in statistical analyses caused the reported share of transit systems which are publicly owned to drop to 31 percent by 1990, it appears that there has been little change in the underlying trend since 1980. Publicly operated or subsidized systems account for 86 percent of transit vehicles and 94 percent of transit trips. These numbers have remained fairly constant since the mid-1970s.[69]

The private role in mass transit has, nevertheless, rebounded in the past ten to fifteen years. FTA policies have encouraged transit authorities to contract bus service to private carriers, which receive government subsidies to operate specific route systems. Roughly half of all transit authorities contract out services, although some contracts are awarded to other public agencies. Authorities frequently contract for demand responsive, or paratransit services, vanpools, and elderly and handicapped transit services. Many authorities also contract for regular, scheduled bus service, and several contract commuter rail service either to Amtrak or to private carriers.

Since nearly all transit service currently receives public support, the lack of data on private capital expenditures causes a serious undercount of total spending in the earlier years of long data series. In addition, certain performance data is unavailable for contracted services.

Financial Conditions and Trends

The current financial condition of mass transit partly reflects its ridership history. Originally operators of mass transit systems obtained exclusive franchises, and thus operated as publicly created private monopolies. The Great Depression brought a sharp drop in ridership, which remained flat until World War II when fuel rationing caused transit ridership to soar.

Following World War II, auto ownership and travel grew rapidly, spurred by cheap fuel, suburbanization and lower density development. Transit operators found that even rising fares and service cutbacks would not temper their financial losses but would discourage riders. With the enactment of federal programs to support mass transit beginning in 1964, there was a rapid conversion of privately operated mass transit firms into public properties.

Socio-economic trends continue to work against transit, meaning that large public subsidies will continue to be required without a significant change in how transit service is provided. Cities are less dominated by their downtowns. Major urbanized areas now have multiple foci, and the relative amount of travel between the suburbs and central business districts has declined while circumferential travel between lower density residential and business development has increased.[70] This has increased public reliance on automobile travel as has the decline in the real price of energy.

Major demographic shifts have also contributed to the decline in transit use. Spurred by increases in the number of women in the workforce, jobs have grown faster than the population as a whole. The growth of automobile ownership has paralleled these new jobs. Automobile ownership per capita, which grew from 0.34 vehicles per person in 1960 to 0.54 in 1980, stood in 1990 at 0.59.[71] Although low income groups, central city residents, and the elderly have lagged behind the rest of the population in gaining access to automobiles, auto ownership is rising for these groups, permitting them to reduce their use of mass transit.[72] This has happened despite inflation, recessions, and energy shocks of the 1970s.

Capital Assistance. In real terms, total public capital assistance increased nearly six-fold over the 20 years ending in 1984 -- more than nine percent per year -- according to data from the Congressional Budget Office (CBO).[73] Since 1984, growth in transit capital spending has slowed dramatically (Figure 5-1). From 1984 to 1989, transit capital assistance increased only nine percent, less than two percent annually. State and local capital expenditures dropped to zero by the late 1970s, as federal expenditures ballooned. Since then, state and local spending has grown, replacing declining federal dollars.[74]

Operating Revenues and Expenses. Revenues for mass transit come from the farebox and from federal, state and local government operating subsidies. As reported by APTA, farebox revenues declined from 53.9 percent of all revenues in 1975 to 36.9 percent in 1985, and to 36.1 percent in 1991. Including other operating revenue, such as sales of advertising space, transit authorities generated 41.7 percent of total revenue.

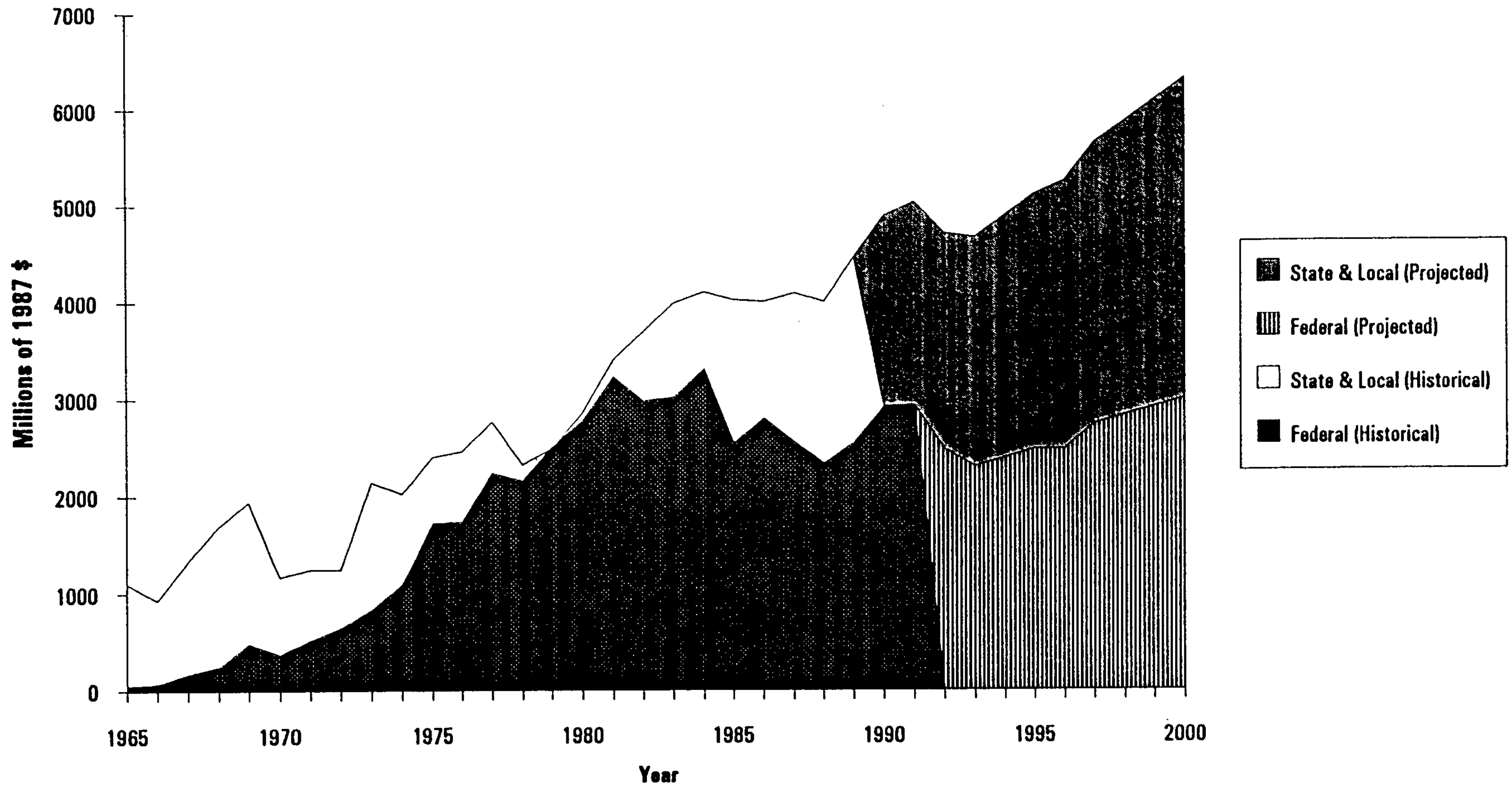
Governmental operating assistance makes up the difference between farebox and other system revenues and total operating costs. In the 1960s and early 1970s, state and local governments began large-scale assistance to transit systems. Growth in state aid slowed as the federal government began providing operating assistance in the mid 1970s, but again accelerated when federal aid dropped off. Since the last performance report, the state and local share of operating expenses has increased slowly, from 49.0 percent in 1985 to 52.6 percent in 1991. The federal share now stands at 5.6 percent, down from 7.7 percent in 1985.[75] Real expenditures on transit are shown in Figure 5-2.

Transit expenses can be viewed either by object class or by function. Examples of object classes are labor, services, materials and supplies, utilities, and casualty and liability costs. Examples of functions are transportation, maintenance, and general administration. Between 1975 and 1983, maintenance expenses climbed from 23.5 percent to 30.1 percent of transit operating costs. Since then, they have remained steady, at 30.3 percent of costs in 1990. The direct costs of transportation, which hovered around 50 percent in the early 1980s, fell to 45 percent by 1990, and general administration costs rose to 25 percent.[76]

Net Capital Stock

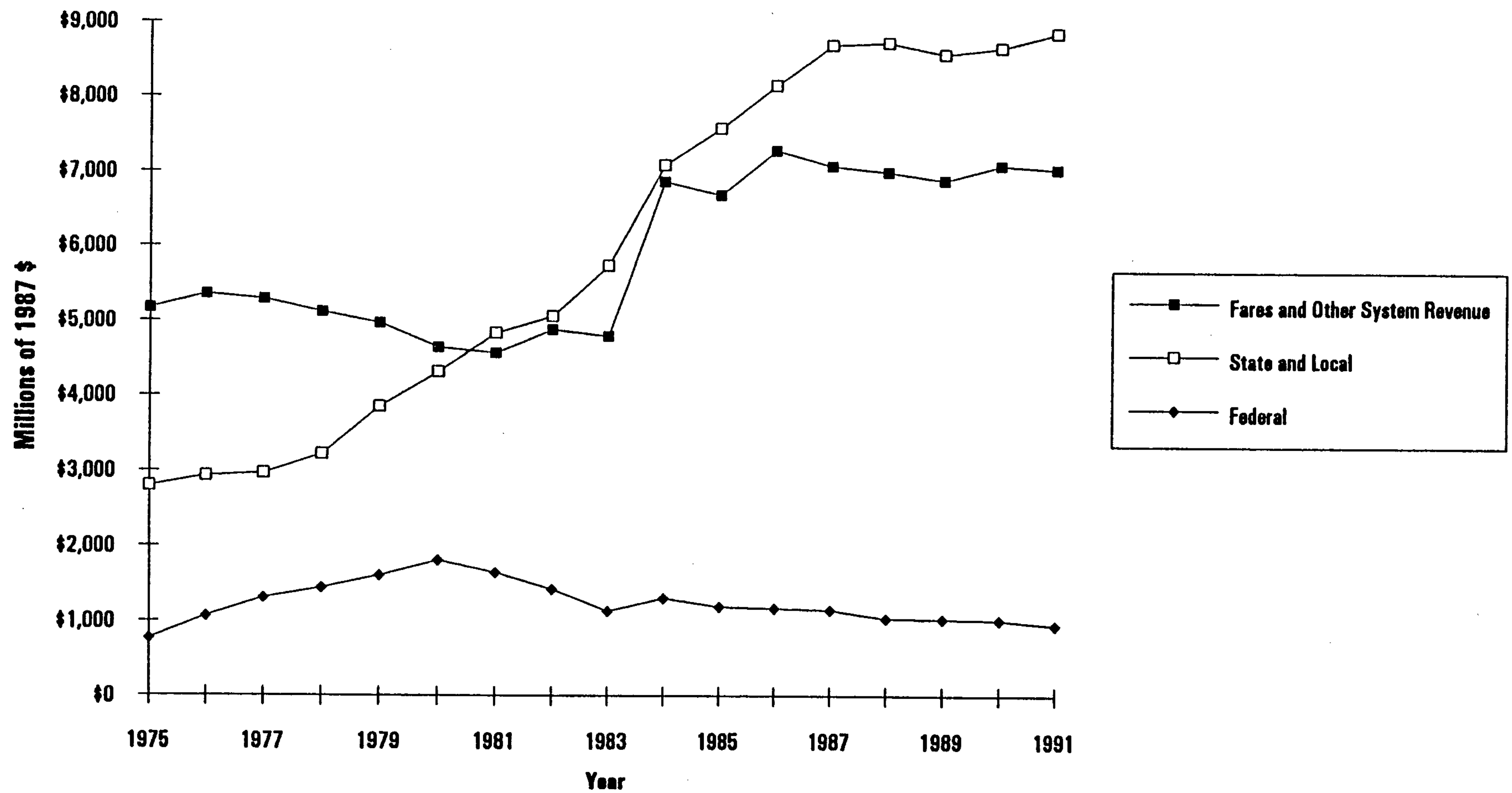
The trend in the net mass transit capital stock reflects historical growth in capital spending. The net depreciated value of public transit's fixed assets, both equipment and structures, has grown unabated from $7.9 billion in 1960 (1987 dollars), to $38.1 billion in 1985, to $49.2 billion in 1990 (Figure 5-3).[77]

Figure 5-1: Real Capital Assistance for Transit by Source



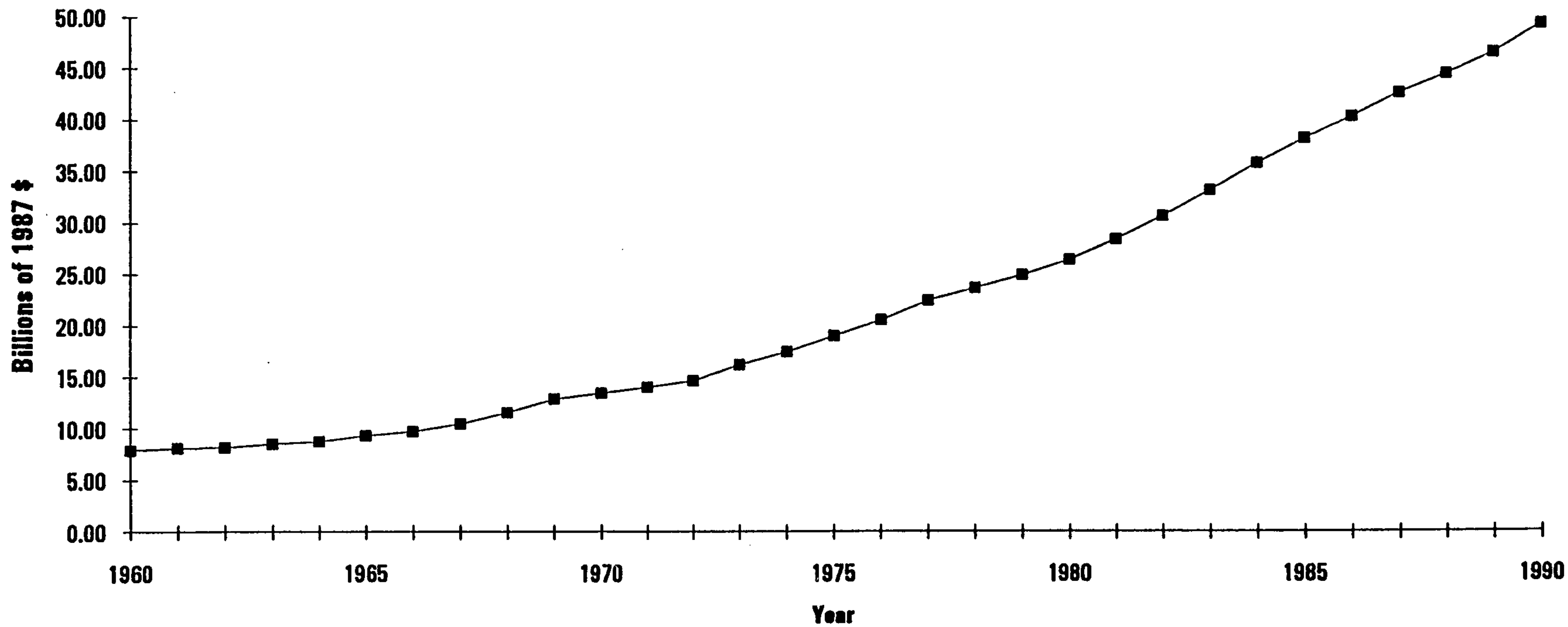
Source: Apogee Research, Inc., from Congressional Budget Office and Office of Management and Budget Data

Figure 5-2: Real Operating Expenditures on Transit



Source: American Public Transit Association, 1992 Transit Fact Book.

Figure 5-3: Net Transit Capital Assets



Source: Apogee Research, Inc., from Government Finances Data.

This represents an average annual increase of 6.5 percent from 1960 to 1985, and 5.2 percent from 1985 to 1990. This growth in net assets has greatly outstripped increases in ridership.

Three components make up this increase in capital value. The first comprises public takeover of previously private transit service. In 1960 there were only 58 public transit systems, operating 36 percent of all transit vehicles. In 1990, there were 1,580 publicly owned and subsidized systems, operating 86 percent of all vehicles.[78] In 1947, the value of private transit structures (track, for the most part) stood at close to $11 billion. In 1967 the value was less than $3 billion, and in 1989, less than $1 billion.[79] Some of these assets were simply abandoned, but many were taken over by public authorities.

The second component is public replacement of deteriorating transit capital. As private transit providers ceased investment in track and rolling stock in the decades following World War II, the condition of private transit assets dropped dramatically. On public systems, vehicle age increased and fixed asset maintenance fell. Federal support of bus replacement and a combined effort to upgrade fixed facilities has since produced an increase in asset value.

The third significant portion of asset growth represents the addition of new capacity in the form of new transit systems, such as those in Atlanta, San Francisco, and Washington D.C., or extensions of existing systems, as in Boston. Data do not allow the determination of each component's share of overall asset growth.

Capital Spending Projections

Figure 5-1 also shows projections of potential future trends in public capital spending on transit. Federal expenditure estimates are taken from Office of Management and Budget projections in the current U.S. budget, while state and local projections are based on current spending trends. According to these projections, total real capital spending should increase 3.2 percent annually, to $6.3 billion in the year 2000 (1987 dollars). Federal assistance should increase 1.5 percent annually, to $3 billion, while state and local spending should increase by 5.0 percent annually, to $3.3 billion in 2000.[80]

These projections indicate that the federal government will no longer provide the lion's share of capital funding; instead, state and local capital expenditures should roughly equal federal expenditures over much of the period. This assumes that, contrary to previous trends, federal and non-federal assistance do not substitute for each other. In the past, states and localities reduced assistance levels as federal funding grew, then increased it as federal dollars became more scarce. If states respond to the resumption of gradual increases in federal funding by slowing their own spending growth, increases in total capital assistance will be smaller.

PERFORMANCE OF MASS TRANSIT

A consistent set of national performance measures is particularly difficult for mass transit because of the different sub-modes, extreme variation in transit uses in different size communities, and different markets served: work trips, elderly and handicapped, etc. In addition, since one transit provider -- the New York Metropolitan Transportation Authority -- accounts for one-fourth of all transit ridership, local factors affecting New York have national implications for transit statistics.

As with other categories of public works, the appropriate measures of performance depend on the desired output and outcomes, which in turn are functions of the goals and objectives for mass transit. It is a normative, not statistical, question whether the key output of mass transit is simply the efficient movement of people or its support of broader societal goals, such as stimulation of economic growth, mitigation of pollution problems, or promotion of more desirable land use patterns.

The performance measures presented here are intended to provide a national perspective. But subsuming information on large numbers of systems into a single measure can obscure important insights. Consequently, there is always a tension between providing measures that give a national viewpoint and yet simultaneously respect the individuality of specific transit systems.

Transit performance measures rely on three primary data sources: FTA Section 15, APTA, and the Bureau of the Census. Congressional Budget Office data also provide information on federal, state and local spending.

As a result of Section 15 reporting requirements, the FTA publishes a large quantity of descriptive information. Section 15 data are most relevant to transit managers seeking to run their systems better, the data's original purpose. Thus, the focus is on measures of individual system performance and not on performance in regards to broader national objectives. Since the Section 15 program began, reporting requirements have changed frequently and the number of modes covered has expanded, causing serious data discontinuities.

The chief advantage of the APTA data is that it contains the only long-term historical data available. Section 15 data are available only since 1980. The APTA data, however, suffer from inconsistencies in the number of properties covered each year, and other collection and reporting variations. In 1984, APTA began collecting data for rural transit systems, which typically have lower cost effectiveness than urban systems because of the dispersed travel patterns in rural areas. In the same year, APTA tables began to contain the FTA's Section 15 data, which include commuter rail, demand-responsive, and non-urban transit systems. Virtually all data series are therefore discontinuous between 1983 and 1984.

A variety of relevant Bureau of the Census data can be obtained. In addition, the Nationwide Personal Transportation Study was conducted in 1969, 1973, 1983 and 1990. These data allow for many meaningful comparisons over time, but the evolution of the computer and software packages has clearly influenced the type of statistical reporting in the published documents and comparable data are not always easily found.

Physical Assets

More than 5000 mass transit organizations, public and private, provide more than three billion vehicle miles of mass transit service per year nationwide, operating more than 100,000 vehicles and moving close to 9 billion passengers. The vast majority of these transit providers, however, operate very small systems or serve specialized populations. Many are paratransit services operated by social service agencies. According to APTA, more than three-fourths of transit systems operate outside urbanized areas or provide only demand-responsive service.[81]

In 1991, some 515 transit systems received federal aid, up from 438 in 1984. In 1991, 462 of the 515 transit systems responded to a survey ranking transit systems by their number of vehicles. Over half these systems have fewer than 50 vehicles. Most service is concentrated in the small number of large bus and rail systems (Table 5-1).

Table 5-1: Transit Systems by Size[82]

Vehicles	Systems
1000 and over	9
500-999	18
250-499	22
100-249	52
50-99	62
25-49	107
Under 25	192
Total Reporting	462

In general, the largest mass transit systems are found in the major cities of the northeast and midwest, although many Sunbelt cities are expanding their transit systems rapidly. In 1991, 25 percent of all passenger trips were taken on New York's Metropolitan Transportation Authority. The next seven largest systems -- Chicago, Los Angeles, Washington, Philadelphia, Boston, San Francisco, and New Jersey -- together accounted for another 30 percent of ridership.[83]

The number of systems offering rail transit continues to grow. In 1991, 12 systems provided heavy rail service, and 18 offered light rail, an increase from 8 heavy rail and 8 light rail systems in 1974.[84] Although rail was traditionally located in older, eastern cities, new light rail systems have been established in recent years in such cities as San Jose, Sacramento and Portland. Bus systems are found throughout the country, but the most developed ones are found on the East Coast, the larger cities of the Midwest, and some larger West Coast cities.

Demand-responsive transit, or paratransit, has only recently been recognized as a component of the total transit picture. Demand-responsive systems resemble taxis as closely as they do traditional, scheduled, fixed-route bus service. Passengers call a dispatching office to arrange their rides; the dispatcher tries to combine several passenger trips into one vehicle run. Paratransit serves two primary markets: in rural areas and outlying sections of metropolitan areas where scheduled bus service is not viable, and for transit-dependent elderly and handicapped patrons. While paratransit still accounts for only 1.3 percent of passenger miles, its share of vehicle miles has grown from 9.3 percent in 1984, the first year statistics were collected for the mode, to 10.7 percent in 1991.[85]

Vehicle Fleets. The best summary indicator of the physical facilities available for mass transit is the size of the transit fleet. The most detailed information is available from Section 15 including peak-period vehicles, vehicles in active service, vehicles with major rehabilitation, average age, length, number of seats, and vehicles equipped with air conditioning, two-way radios, or wheelchair lifts. Of the 102,000 transit vehicles in public and private service, almost 53,000 are transit buses (Table 5-2).

Table 5-2: Mass Transit Fleet, 1990[86]

Mode	Vehicles
Bus	52,945
Subway cars	10,325
Streetcars and cablecars	940
Commuter rail cars	4,174
Commuter rail locomotives	404
Vans	2,412
Other urban (incl. ferryboats)	372
Rural service vehicles	10,101
Elderly/handicapped vans	20,970
Total	102,643

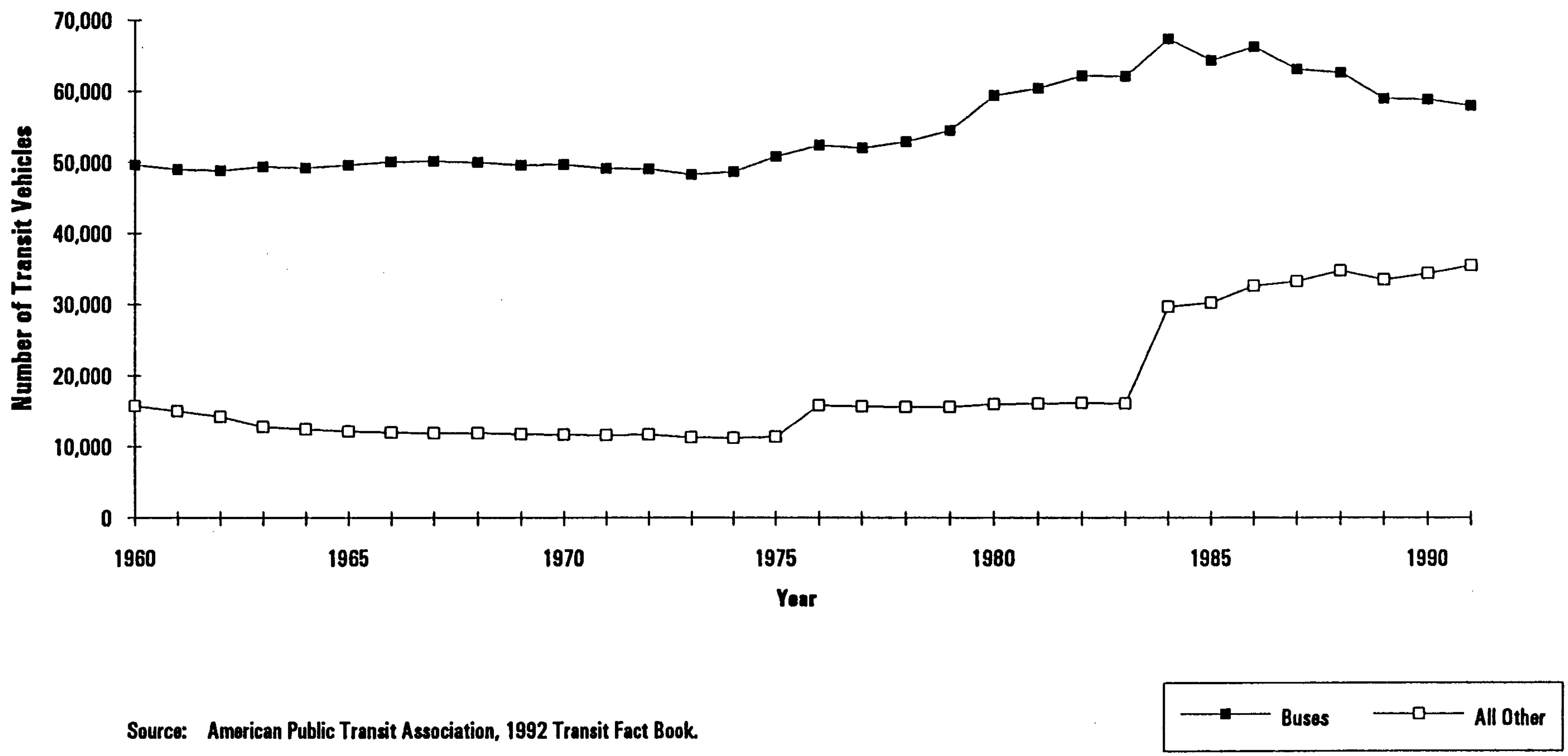
APTA fleet size figures exclude some rural service vehicles counted in the U.S. Department of Transportation (DOT) report. According to APTA, total passenger vehicles, which once stood as high as 90,000 at the end of World War II, declined from 65,292 in 1960 to 59,590 in 1973, paralleling drops in ridership. Numbers then began to recover as the federal government began to provide substantial levels of capital funding, reaching 73,700 by 1983. In 1984, authorities began reporting numbers of active vehicles, rather than total vehicles, along with their demand-responsive fleets. In 1991, there were 93,232 active passenger vehicles, a slight decrease from 96,901 in 1984.

The number of heavy rail cars has changed only slightly from 1960 through 1991. Following post-war declines, the number of vehicles stood at 9,000 in 1960, then slowly increased to 10,170 in 1991. Despite the large decline in the number of transit passengers, there has been relatively little change in the number of transit buses since 1960. The size of the bus fleet, which was steady at about 50,000 in the 1960s and early 1970s, climbed past 60,000 in the early 1980s before dropping to 57,875 in 1991. Figure 5-4 shows the size of vehicle fleets.[87] The FTA estimates that the current bus fleet may be 23 percent larger than needed for peak-hour travel.[88]

Light rail vehicles and trolley buses have both begun to reverse long-standing declines in numbers. In 1960 there were 13,000 total light rail vehicles and 6,500 total trolley buses; by 1986 there were only 697 light rail vehicles and 680 trolley buses remaining in active service. In the past decade, nine new light rail systems have opened, and five are under construction.[89] Seattle, one of only five trolley bus operators in the nation, has greatly expanded its fleet.[90] In 1991 there were 1,058 light rail vehicles and 919 trolley buses in operation.[91]

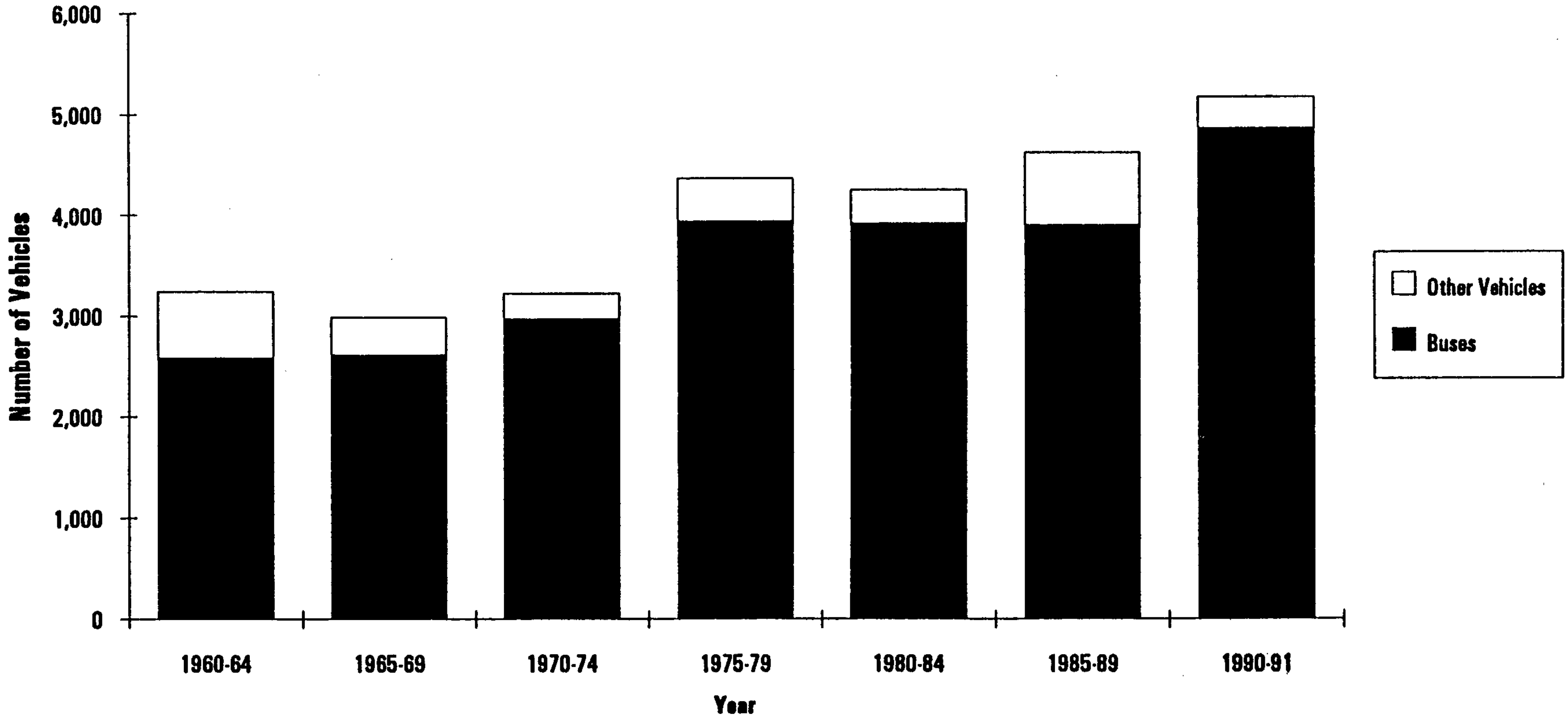
New passenger vehicles were delivered at an average of 4,000 a year, down from the 5,000 of the mid-1970s but substantially more than the roughly 3,000 a year average from 1950 through 1975 (Figure 5-5). Buses make up 80 to 90 percent of all new vehicles, reflecting their greater proportion of

Figure 5-4: Number of Transit Vehicles by Year



Source: American Public Transit Association, 1992 Transit Fact Book.

Figure 5-5: New Transit Vehicles Delivered per Year



Source: APTA, Transit Fact Book, various years.

the total vehicle fleet and their shorter life expectancy. The number of air-conditioned buses, which increased from 46,000 in 1980 to 61,000 in 1985, fell to 50,000 in 1991. Largely in response to federal regulations, many more buses are accessible to wheelchairs -- 30,000 in 1991, up from 6,500 in 1980 and 22,000 in 1985.[92]

Fleet Age. Data on age of the current bus fleet, available from Section 15 and from APTA, give greatly conflicting reports. APTA data show no discernable trend in average fleet age. The age of motor buses has climbed from 7.8 years in 1987 to 8.1 years in 1990; for heavy rail vehicles the average has climbed from 16.2 to 17.3 years; for commuter rail from 15.9 to 17.2 years; and for trolley buses from 10.4 to 11.2 years. Only light rail vehicles have declined in average age, from 21.0 to 20.1 years.[93] FTA data, by contrast, show a substantial decline in vehicle age between 1987 and 1990. Average ages dropped from 11 years to 8 years for buses, from 27 to 17 for heavy rail, from 19 to 17 for commuter rail, from 17 to 13 for light rail, and from 7 to 3 for demand-responsive vehicles.[94] Since 1981, the average overall fleet age for comparable transit modes has fallen from 10.9 years to 9.1 years, according to FTA data.[95] Figure 5-6 shows current vehicle age distributions according to the FTA.

Average fleet age data can sometimes be misleading. For example, the average transit bus age of 8.1 years old is high relative to the expected life of 12 years. However, newer buses tend to be used more intensively than older ones--many of which are used as a reserve fleet. Thus, if bus age were weighted by use, the effective average age would likely be somewhat lower.

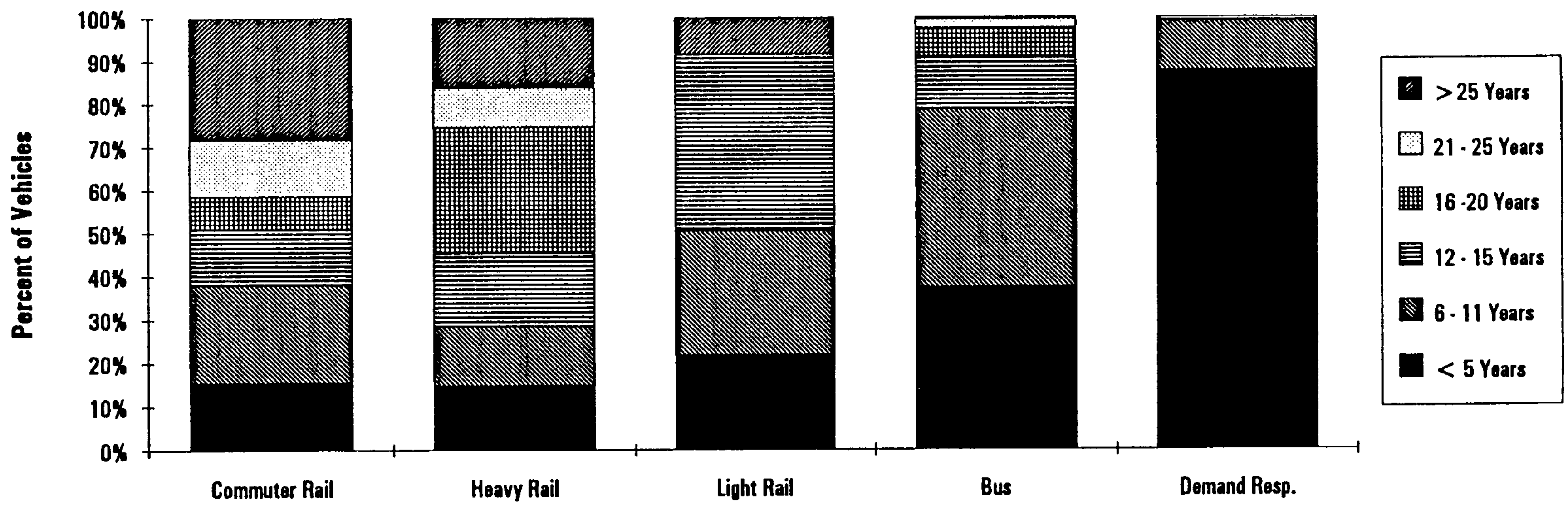
Age alone does not describe either the current physical condition of a vehicle or facility, nor its expected future life. For example, a rail car that receives only minimum maintenance, may take only 20 years to reach what the FTA calls "poor" condition, while a program of major corrective maintenance can mean an effective life of 50 years.

Fixed Assets. In addition to vehicles, transit systems control track, stations and maintenance facilities. In 1990 there were 1,351 directional route miles of heavy rail track, up from 811 miles in 1981, and 483 miles of light rail track, up from 375. Two separate one-mile tracks, one in-bound and one out-bound, correspond to two directional route miles. The increase in rail miles represents a substantial capital investment over the past nine years. Other transit facilities in 1990 included 4,830 miles of commuter rail track, generally shared with intercity and freight railroads, 911 heavy rail passenger stations, 958 commuter rail stations, and 705 maintenance facilities for buses, vans and rail vehicles.[96]

Road and Rail Conditions. There is a close link between transit operating costs and service levels and the physical condition and level of service of local streets and highways. For example, traffic congestion slows buses, adding to labor costs and discouraging bus riders. Local street conditions, which deteriorated during the 1970s (see Chapter IV), have shown a definite improvement in recent years. With some local exceptions, conditions are adequate for most mass transit purposes. Urban road congestion, by contrast, continues to become more severe. In 1990, the average speed of a transit bus was only 12.8 miles per hour.[97]

The physical condition of rail transit facilities was last evaluated in 1984, with results published in the U.S. Department of Transportation's *Rail Modernization Study*. The study's findings are summarized in Table 5-3.

Figure 5-6: Age Distribution of Mass Transit Vehicles, 1990.



Source: FTA, National Transit Summaries and Trends.

Table 5-3: Physical Condition of U.S. Transit Rail System in 1984[98]					
Element	Bad	Poor	Fair	Good	Excellent
Track	0%	7%	49%	31%	12%
Rail Cars					
Self-Propelled	23%	24%	18%	28%	7%
Unpowered	3%	13%	35%	49%	0%
Locomotives	3%	10%	32%	43%	12%
Power Systems					
Substations	6%	23%	5%	43%	23%
Overhead	20%	12%	27%	36%	6%
Third Rail	13%	26%	19%	36%	6%
Stations	0%	15%	56%	23%	6%
Structures					
Bridges	1%	16%	51%	28%	4%
Elevated	0%	1%	80%	3%	16%
Tunnels	0%	5%	49%	35%	11%
Maintenance					
Facilities	4%	54%	14%	24%	4%
Yards	4%	53%	26%	16%	1%

Generally maintenance facilities and rail yards were in the poorest condition with 58 percent rated as bad or poor. Self-propelled cars -- rapid transit, light rail, and commuter cars --also appear to have significant condition deficiencies. In contrast, more than half the unpowered rail cars were rated in good or excellent condition while only 3 percent were bad. Two-thirds of the power substations were rated good or excellent. Only a small percentage of structures (including tunnels) were rated poor or bad -- however most were classified as fair, indicating a future need for significant expenditures to replace or reconstruct those essential facilities.

Although these data have not been updated since the study was undertaken in 1987, it is the opinion of the FTA that investment in maintenance of rail facilities has been sufficient to keep conditions at a roughly constant level.[99]

Service Delivery

Relatively speaking, transit has been meeting fewer and fewer of the mobility requirements of the general population. Transit usage is concentrated in the largest cities -- 89 percent of passenger trips are in urbanized areas of over one million inhabitants.[100] In many cities, particularly smaller ones, the transit system is predominately used by the poor. Nationwide, one-third of transit riders earn less than $15,000 per year, but in urbanized areas of less than one million, the majority of riders earn less than $15,000.[101]

Employment. Over the past decade, there has been a steady and substantial growth in the number of transit employees, although changes in accounting practices and sources of information cause some distortion in the numbers reported. Between 1970 and 1983, the number of transit employees increased 41 percent. Total employment climbed another 45 percent between 1983 and 1991, reaching a record 281,000. Excluding employees of demand-responsive transit and commuter rail to make post-1984 figures comparable with earlier numbers yields a somewhat lower employment level of 222,000, a gain of 14 percent from 1983. Vehicle operators comprise 47 percent of the total employment, while vehicle mechanics and other maintenance personnel total 28 percent, only slightly changed from 1985.[102]

Mileage. Perhaps the most widely used measure of transit output is passenger miles per year. This measure provides greater weight to longer trips such as those by commuter rail. Passenger trip data is available over a longer historical period. The measure is more problematic because it has been reported in various sources and at various times as unlinked (boardings) or linked (transfers subtracted out), and because it fails to capture changes in average trip length. Figure 5-7 shows both trends.

Following several decades of decline, transit passenger miles increased from 1977 to 1980, then declined through 1983. Changes in data reporting from 1983 to 1984 make comparisons of raw numbers difficult, but it appears that an upward trend in passenger miles travelled has been underway since 1984. All the dominant modes of transit have exhibited roughly constant or gradually increasing levels of passenger miles of output, with minor fluctuations.[103]

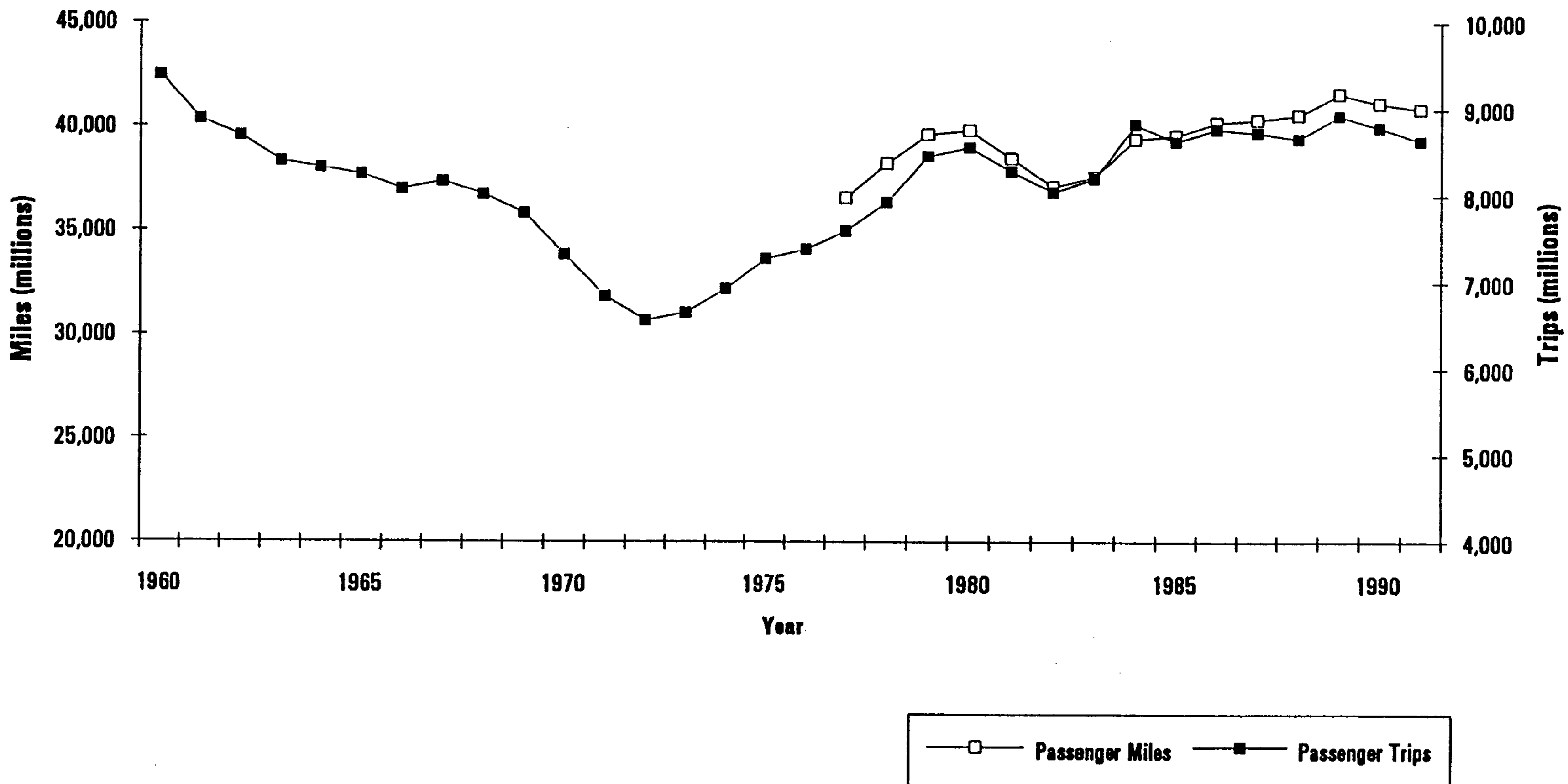
Another measure of transit industry output is annual vehicle miles. The total number of vehicle miles stood at a low point of 1.8 billion in 1972, climbed to 2.8 billion by 1985, and reached 3.3 billion in 1991 (2.7 billion, excluding commuter rail and demand responsive transit). The overall increase in vehicle miles of service has not been matched by a commensurate increase in transit use, however. In 1977, the average load factor, the number of passenger miles of travel for every vehicle mile, was 16.5. In 1991, the figure was 12.2, a 26 percent drop in the intensity of use (Figure 5-8). Motor bus and heavy rail load factors have fallen by at least twenty percent, far outweighing a 27 percent increase for light rail, a much smaller component of transit ridership.[104]

The DOT uses vehicle revenue hours to measure output in addition to passenger miles. They define a unit of transit service produced as a vehicle (bus, rail car, street car, etc.) operated in revenue service for one hour or one mile. Since labor costs comprise more than 70 percent of the total cost of transportation service, the DOT argues, it is preferable to use vehicle revenue hours as the unit of transit service output for purposes of measuring efficiency and the productivity of labor.

In 1984, buses accounted for 76.9 percent of total revenue vehicle hours, while rapid rail accounted for 15.9 percent. In 1990, buses totalled 71.1 percent of hours, and heavy rail 15.6 percent. While both saw gains in absolute number of vehicle hours, rapid increases in other modes caused the relative share of hours to decline for bus and heavy rail.[105] Disaggregated by size of urbanized area, vehicle revenue hours are highly concentrated in larger metropolitan areas. In 1990, 79 percent of revenue vehicle hours occurred in urbanized areas of over one million residents.[106]

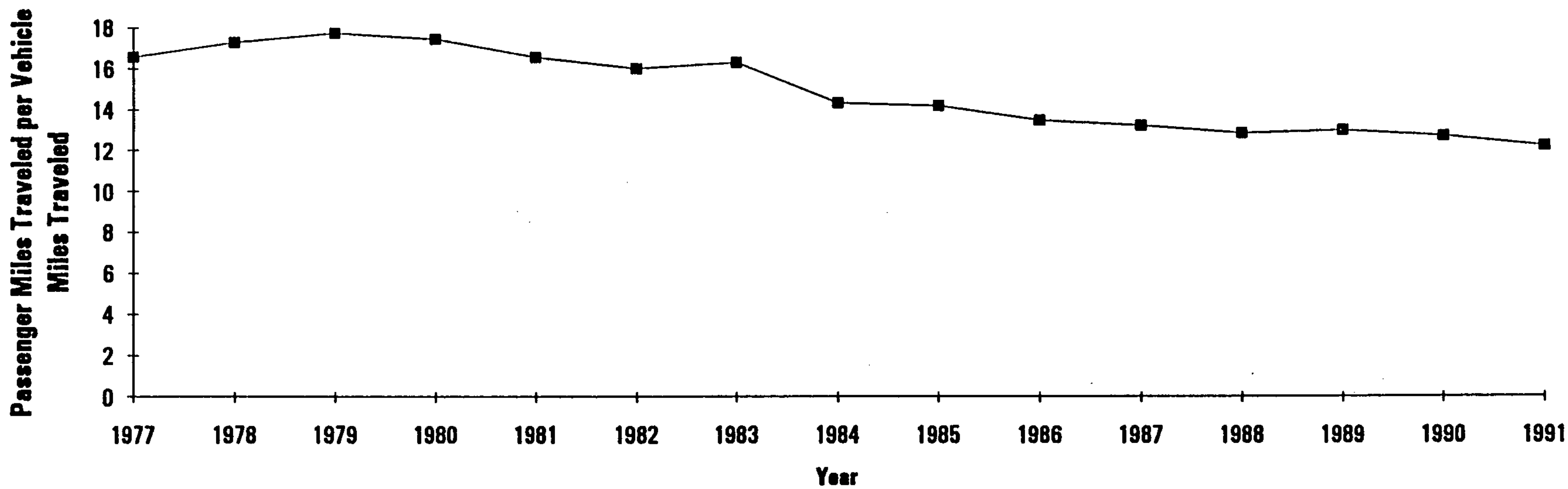
Cost Effectiveness. Changes in data reporting particularly complicate measurement of transit cost effectiveness since the cost structure of different types of transit systems varies greatly. Cost effectiveness can be measured in terms of operating cost per unit of service delivered (cost per vehicle mile traveled) or per unit consumed (cost per passenger mile traveled or per passenger trip).

Figure 5-7: Annual Transit Ridership



Source: APTA, 1992 Transit Fact Book.

Figure 5-8: Average Load Factor



Source: APTA, 1992 Transit Fact Book.

Real operating costs per vehicle mile traveled (VMT), a measure of service supply, have only risen a total of 8.5 percent from 1977 to 1991, from $3.89 to $4.22, respectively (an average annual increase of less than one percent).[107] However, cost per VMT rose steadily from 1977 to a peak of $4.86 in 1985, and has declined since that time. While this indicates improving cost effectiveness, declining vehicle loads have hurt other measures of cost effectiveness.

From 1977 to 1991, operating costs per passenger mile have risen almost 50 percent, from $0.24 to $0.35, and costs per passenger trip have risen 73 percent, from $0.95 to $1.64.[108] All figures exclude demand responsive transit and commuter rail, for which costs were not reported in 1977.

Quality of Service. Quality of service is difficult to measure, and consists of such factors as passenger safety, vehicle reliability, service frequency, vehicle cleanliness, and numerous others. One of the few measures for which data is collected is safety. Section 15 data suggest that transit's safety record improved between 1980 and 1984 for every mode except light rail.[109] Between 1984 and 1990, safety improved or remained constant for all modes by every measure -- accidents per million revenue miles, injuries per million passenger miles and fatalities per billion passenger miles (Figures 5-9 to 5-11). Overall in 1990, there were 1.2 personal injuries per million passenger miles, and 6.4 fatalities per billion miles.[110] For comparison, in 1991 there were 13.2 fatalities per billion miles for automobile travel on urban roadways.[111]

The standard measure of vehicle reliability is frequency of maintenance road calls. The 1987 performance report indicated that time between road calls grew for all modes. Increases from 1981 to 1984 ranged between 4 percent for demand responsive transit and 50 percent for light rail. Since then, the FTA has ceased to require road call data reporting for all modes except bus and demand responsive, and has changed reporting data from hours per road call to miles per road call, making comparisons difficult. Bus reliability appears to have continued its improvement, however.

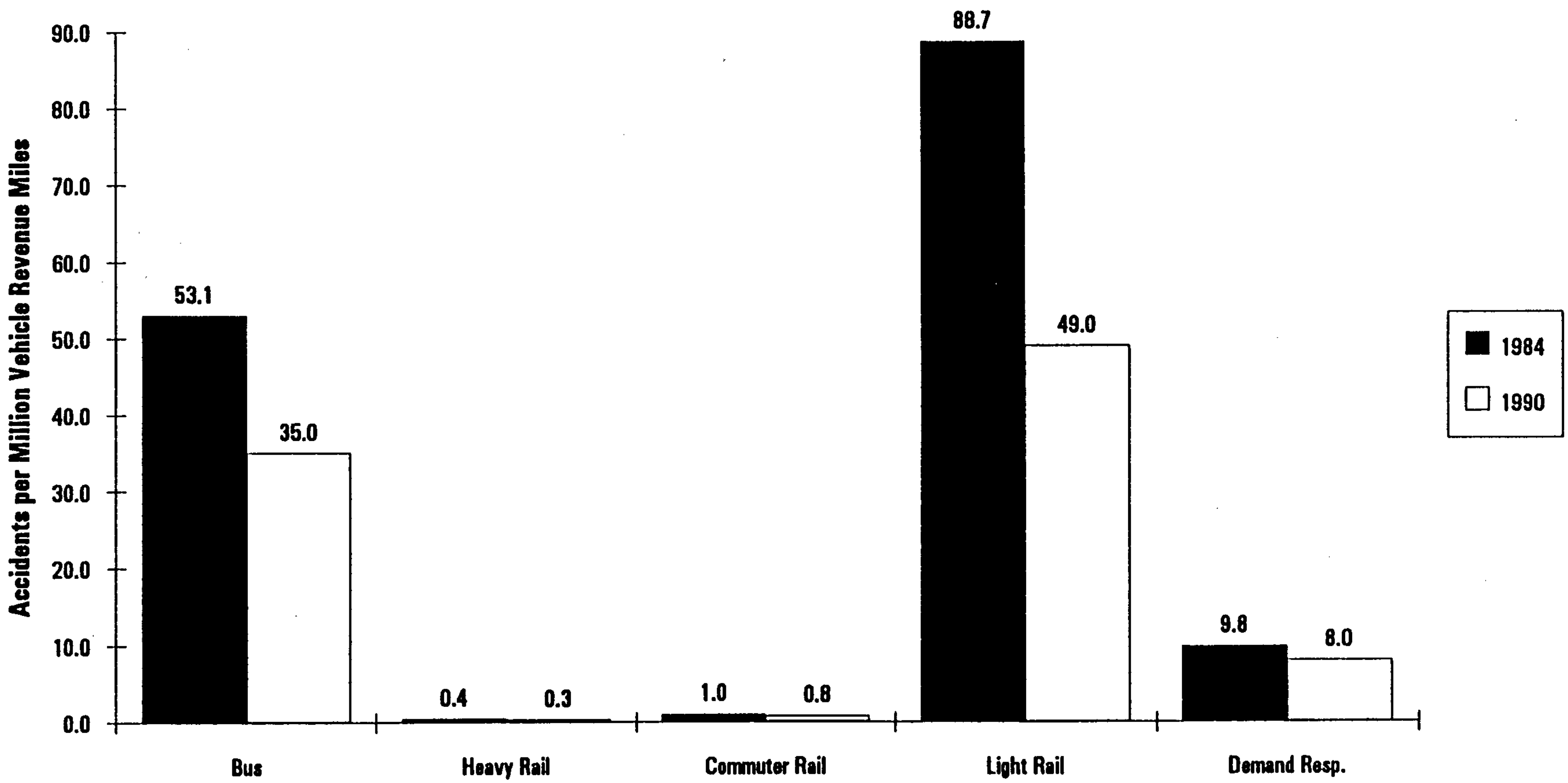
Other aspects of service quality, such as convenience and comfort, are even more poorly documented. The 1991 NPTS reported that 58 percent of transit riders waited five or fewer minutes for their ride, and only twenty percent waited more than ten minutes. Just over half of all rides did not require transferring between transit vehicles. Of all riders, 71 percent were able to sit their entire trip; 16 percent had to stand the entire way, and 13 percent stood part of the way.[112] This last statistic illustrates the tradeoffs between service quality and efficiency. Improving quality by providing more seats for patrons reduces vehicle loads and farebox recovery.

Externalities

Transit has other objectives in addition to providing mobility. These include reductions in congestion and automobile travel time; reductions in air and noise pollution, savings in energy consumption, and preservation of land for certain preferred uses. In a very broad sense, one outcome of transit is to provide additional social benefits of various sorts. Some of these outcomes would be reflected in increases in local and regional income due to more effective economic growth, but others are not quantifiable in dollars.

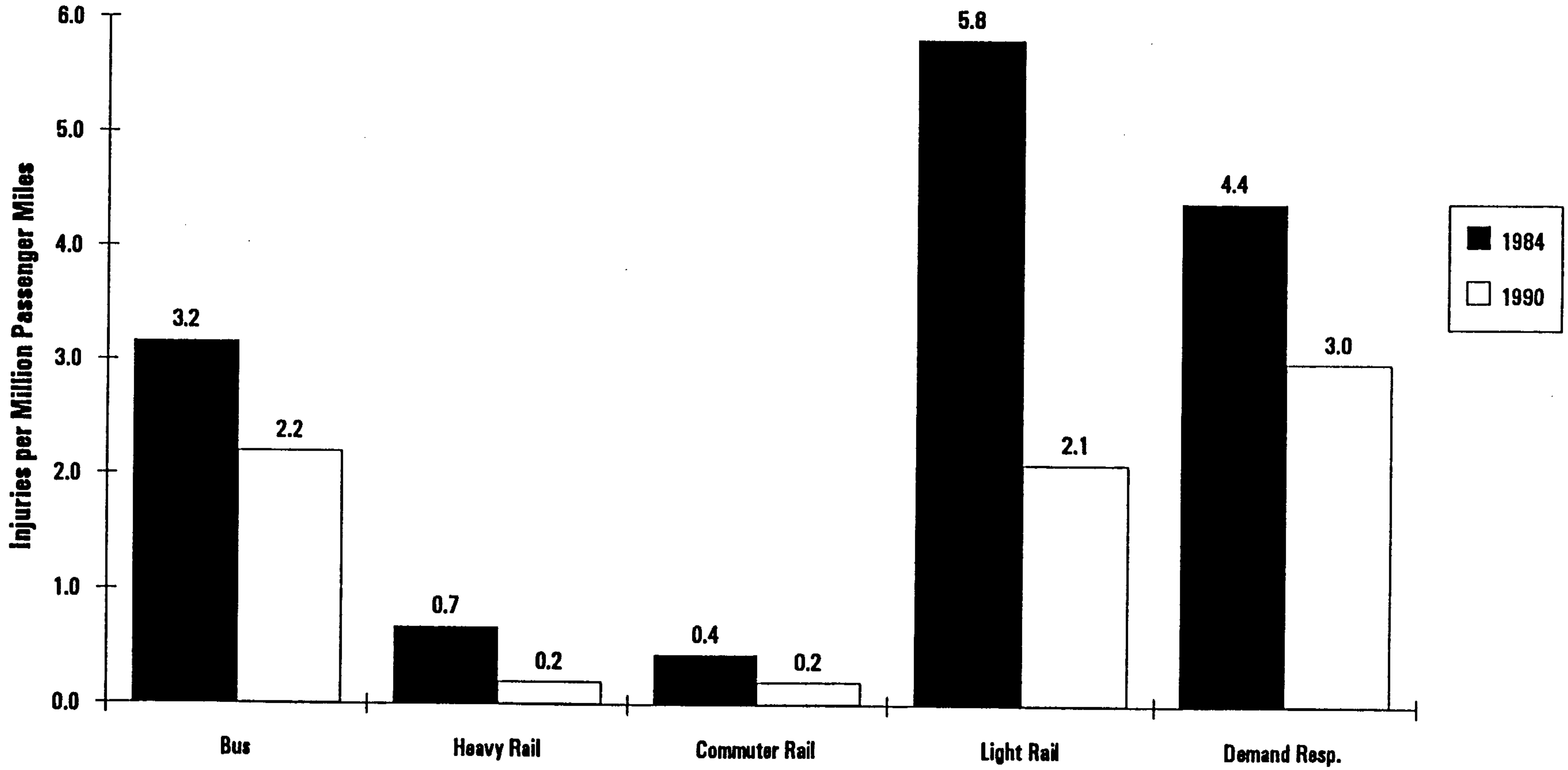
The amount of energy consumed per revenue passenger mile, which had declined in the late 1970s and early 1980s, has risen since 1984. This increase is due predominately to reductions in bus

Figure 5-9: Accident Rates by Mode



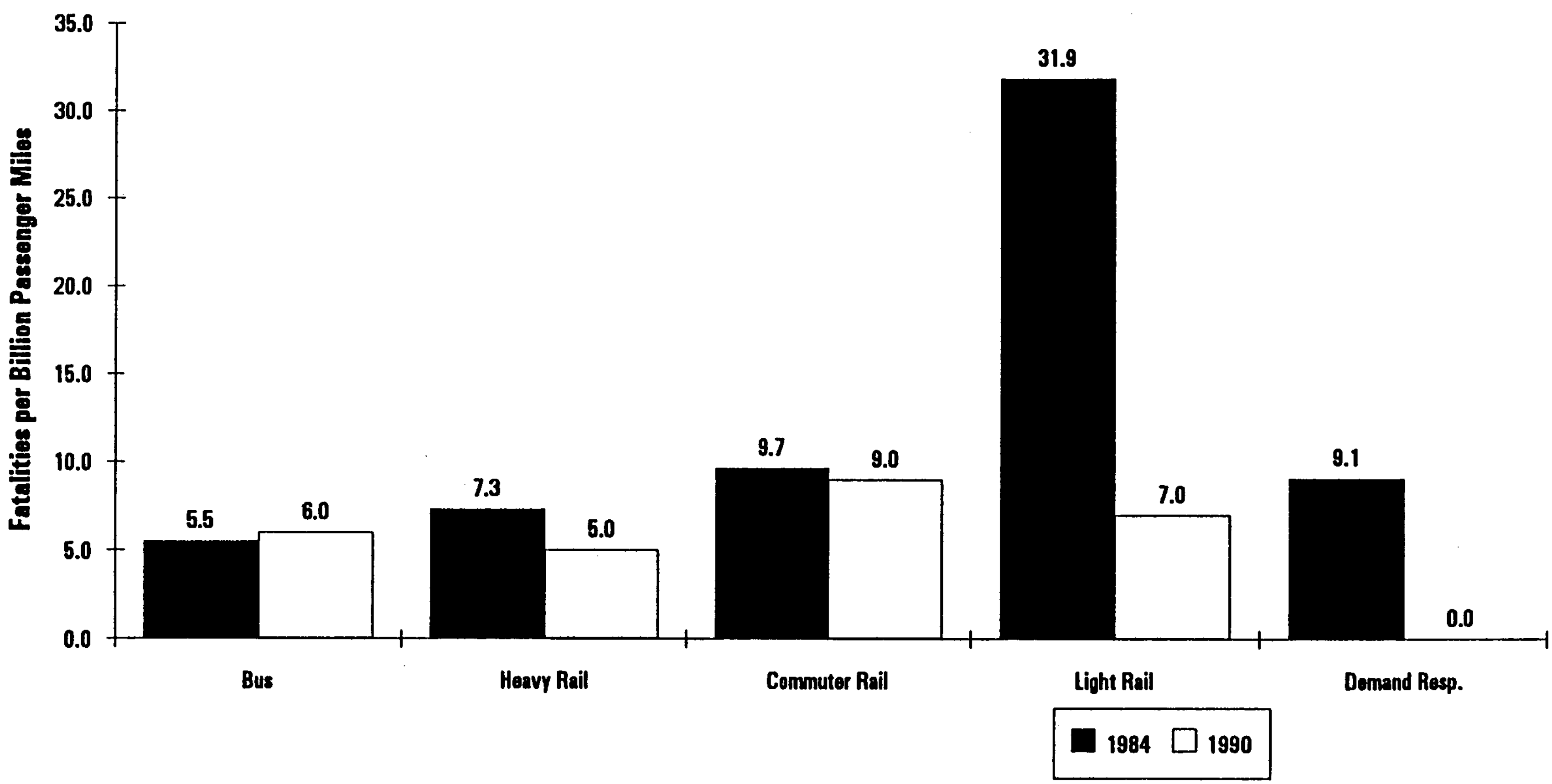
Source: APTA, various years.

Figure 5-10: Injury Rates by Mode



Source: APTA, various years.

Figure 5-11: Fatality Rates by Mode



Source: APTA, various years.

efficiency. Although the fuel consumption of transit buses has not changed overall in the past several years, declining load factors have resulted in an increase in energy use per passenger mile, from 43 passenger miles travelled (pmt) per gallon in 1984 to 37 pmt/gallon in 1991. Other modes have seen changes in load factors offset by changes in fuel consumption, yielding little change in efficiency.[113] At the same time improvements in automobile efficiency have reversed, as increases in fuel efficiency have slowed as passenger loads have decreased. Thus, the relatively higher efficiency of transit remains, particularly at peak hours when transit loads are higher, while automobile's are lower.

Cost Effectiveness

For many years, the transit industry made ever less productive use of its labor and capital, despite (or perhaps because of) increased public subsidies. In the past few years, authorities have scrambled to serve new ridership patterns, and productivity declines have largely halted. Nevertheless, most measures of direct output show that transit is operating less efficiently than it once did. It is questionable, given changes in residential and commercial land use patterns, whether or not transit can ever return to its previous levels of efficiency. Trends in efficiency could look different, however, if the available performance measures were supplemented by benefits provided to non-users.

Labor. Since 1985, transit labor productivity has ended, and according to some measures reversed, its decline. Revenue vehicle miles per employee dropped 9 percent between 1970 and 1975, 10 percent between 1975 and 1980, and 3 percent from 1980 to 1985 (Figure 5-12).[114] From 1985 to 1991, however, productivity increased 15 percent. As a result of declining load factors, passenger miles per employee, another labor productivity measure, have not shown an increase. That measure, which declined rapidly through the late 1970s and early 1980s, has been stable since 1985.[115] A key question for the future productivity of transit is whether or not recent productivity improvements will continue over time.

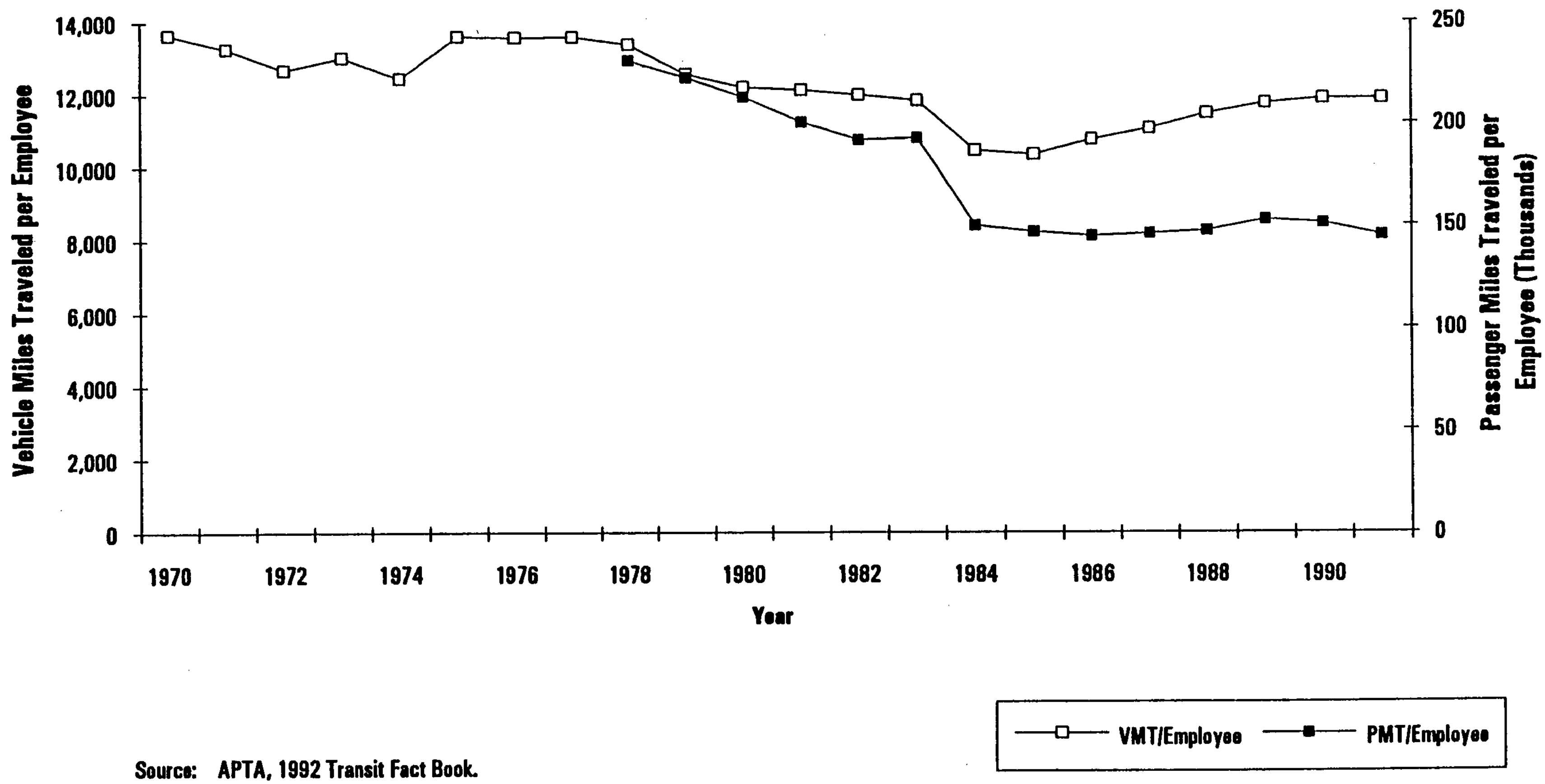
FTA analyses use vehicle revenue hours as a measure of productivity. Between 1987 and 1990, vehicle revenue hours per employee climbed nine percent. Improvements were greatest for heavy rail and demand-responsive transit. Vehicle hours per employee were lowest in larger cities and in the Northeast, which the FTA attributes to the higher staffing required for the heavy passenger usage and for the rail modes found in those areas, as well as to more restrictive work rules.[116]

Capital. The continued increase in public transit capital assets has outpaced increases in ridership, leading to declines in measures of capital investment cost effectiveness. Despite a 12 percent increase in passenger miles traveled, the number of miles per dollar of transit assets fell by half between 1977 and 1989 (Figure 5-13).[117]

There does not appear to be evidence, noted in the previous performance report, of overcapitalization of transit vehicles. That report cited a 1.5 spare ratio, meaning that there were fifty percent more active vehicles than were needed for peak service. In 1990 the spare ratio was 1.23, only slightly above the 1.2 recommended by FTA. The spare ratio was highest for light rail, at 1.44, and lowest for commuter rail, at 1.17.[118]

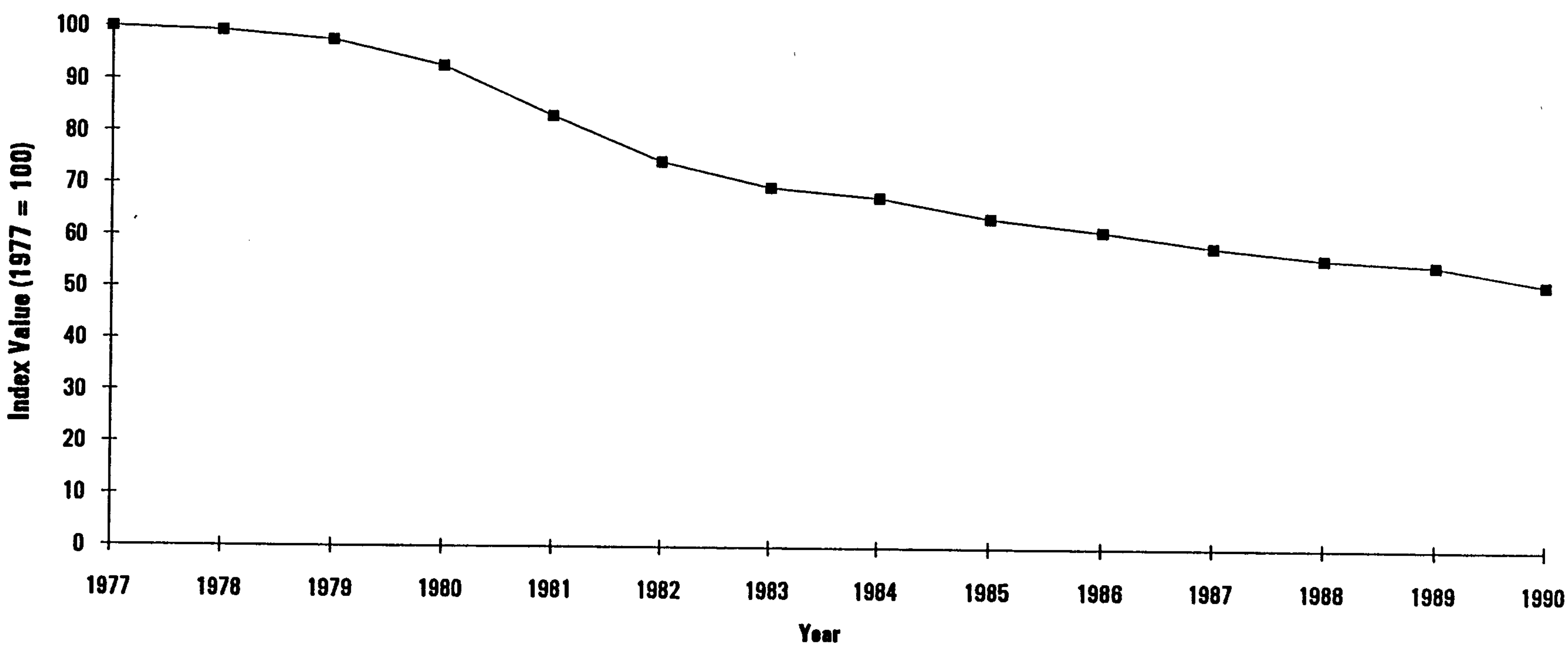
As stated earlier, the average age of buses and other vehicles is somewhat higher than it should be if transit authorities followed recommended replacement schedules. According to the FTA, 21 percent

Figure 5-12: Labor Productivity of Transit



Source: APTA, 1992 Transit Fact Book.

Figure 5-13: Index of Passenger Miles per Dollar of Transit Assets



Source: Apogee Research, from APTA and Government Finances Data.

of buses are beyond the 12 year expected service life,[119] and fleet replacement has not been sufficient to maintain the current average age.[120]

It is difficult to judge whether or not service expansion for fixed guideway modes has been excessive. There are few, if any, adequate measures of appropriate capitalization for trackage, tunneling, grade separations, power stations, signalization, and fare collection systems for heavy and light rail.

Part of the dramatic decline in asset performance may be attributable to the greater asset value of newer buses; part may be attributable to the large number of capital intensive rail transit systems which have opened for service since 1977. Where they replace existing bus service, rail systems constitute a substitution of capital for labor.

CONSOLIDATED PERFORMANCE REPORT ON THE NATION'S PUBLIC WORKS: AN UPDATE

CHAPTER VI: WATER RESOURCES

OVERVIEW OF WATER RESOURCES

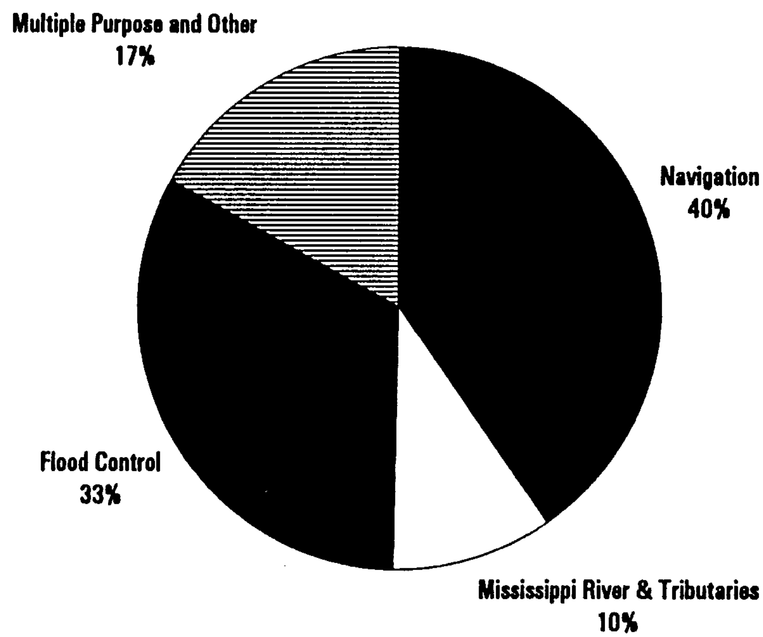
Measuring the historical performance of our nation's water resources development program is difficult because of the wide spectrum of services delivered. Broadly defined, water resource programs consist of services that support domestic and foreign waterborne commerce (ports and inland waterways); prevent or contain natural hazards affecting land, property, and lives (flood control, urban drainage, dam safety, shoreline and streambank protection); enhance crop production (irrigation and agricultural drainage); produce electricity (hydropower); and provide water-related recreation as well as enhancement to fish and wildlife habitat areas. The facilities that provide these services include a vast number of ports, locks, dams, levees, channels, breakwaters, storm sewers, and other drainage facilities. Compounding the analysis is the fact that a single facility -- a multi-purpose dam, for example -- can be designed to deliver a multitude of services such as water supply, flood control, hydropower, and recreation.

Consistent with the 1987 performance report, this report singles out flood control (the U.S. Army Corps of Engineers' program only) and navigation (coastal ports and inland waterways) for detailed study. These two areas represent the largest federal investment in the construction and operation and maintenance of water resources projects, as measured by recent outlays of the U.S. Army Corps of Engineers (Figure 6-1). In 1992, single-purpose flood control and navigation expenditures represented 34 percent and 42 percent, respectively, of total Corps civil works spending.

Water resources development is unique among federal public works programs for two reasons. First, unlike most other federal infrastructure programs, the federal government invests directly in water resources projects. Federal agencies plan, finance, construct, and operate water projects. As illustrated in Figure 6-2, direct spending in 1990 by the U.S. Army Corps of Engineers accounted for 63 percent of total water transport and terminals (navigation) and water resources (flood control) outlays. However, as is evident in Figure 6-3, the federal share of spending for water resources development has been decreasing since 1960 (water transport and terminals shown).

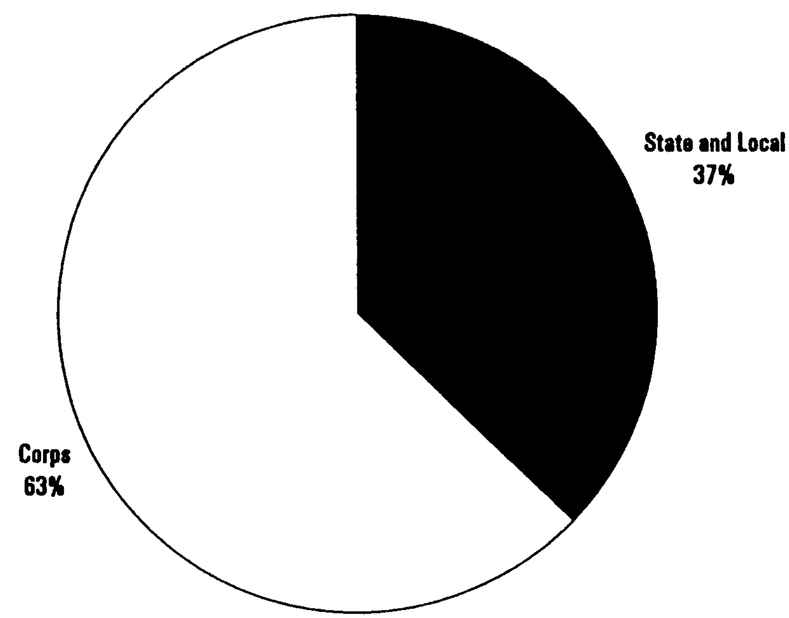
Water resources development is also unique among federal public works programs because individual projects are authorized, in large, part, on the basis of their economic merits. No other public works program relies on project-by-project benefit/cost analysis to such an extent. Federal water resources programs operate under policy guidelines that define federal interest in financing development of various types of projects. The 1986 Water Resources Development Act (WRDA of 1986) set forth new policies for sharing project planning and construction costs between the federal government and project sponsors. Under the WRDA of 1986, local sponsors finance up to 60 percent of the cost of navigation projects and up to 25 percent of flood control projects with mandatory non-federal

Figure 6-1: Total Project Purpose Expenditures by the U.S. Army Corps of Engineers, 1992



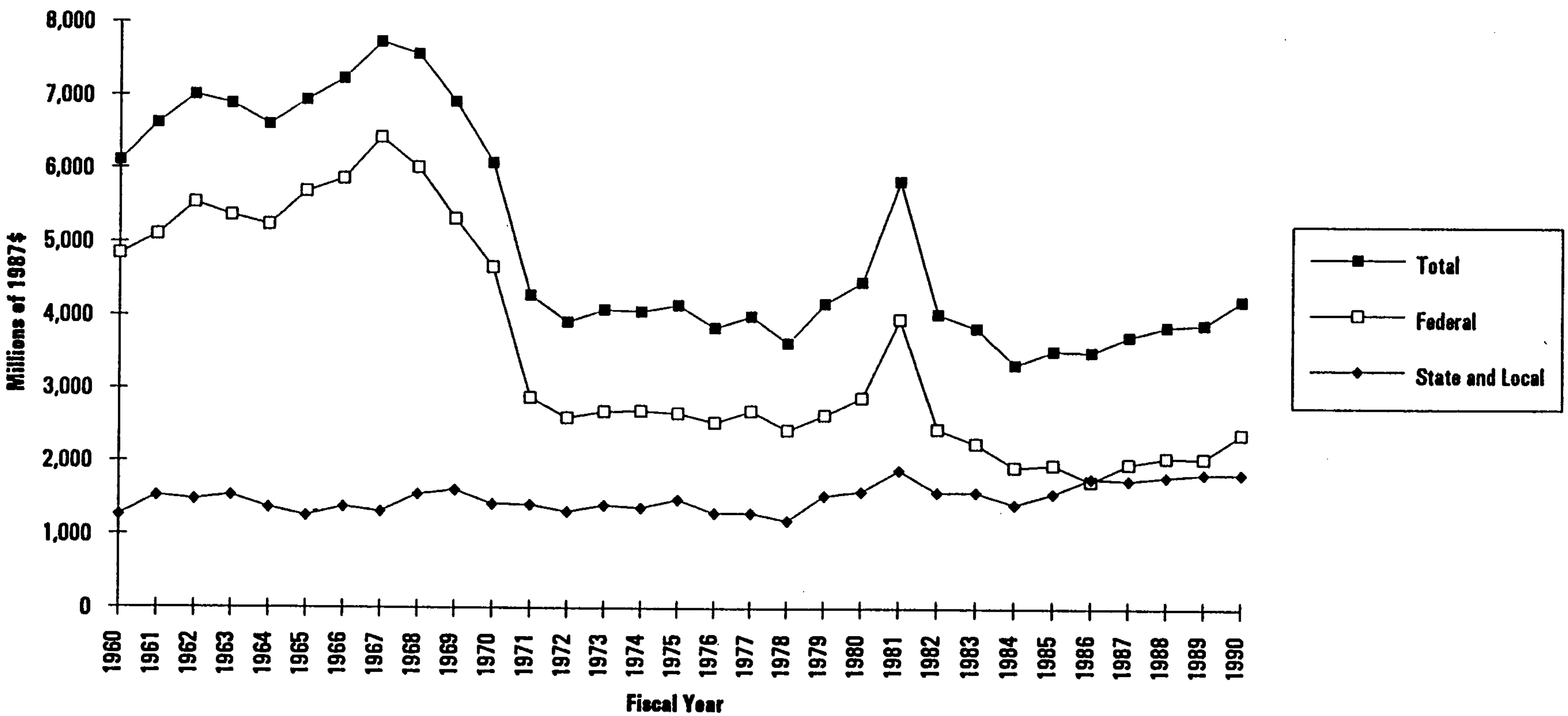
Source: U.S. Army Corps of Engineers, Civil Works Expenditures by State database, Programs Division.

Figure 6-2: Percentage Share of U.S. Army Corps of Engineers and State and Local Expenditures for Water Transport and Terminals and Water Resources, 1990



Source: Federal Expenditures are from U.S. Army Corps of Engineers, Institute for Water Resources; and State and Local Expenditures are from U.S. Bureau of the Census, Government Finances Data Series.

Figure 6-3: Federal, State and Local, and Total Direct Spending for Water Transport and Terminals, 1960-1990



Source: U.S. Bureau of the Census, Government Finances Data Series.

contributions during the construction period. Local governments pay for half the costs of project feasibility studies that were at one time fully federally financed.

In continuation of the biennial authorization process begun in 1986, P.L. 101-640, the Water Resources Development Act of 1990, and P.L. 102-580, the Water Resources Development Act of 1992, authorized numerous additional flood control and navigation projects as well as amending some of the financing provisions of the WRDA of 1986.

As stated above, this chapter is divided in two main sections. The performance of Corps' flood control facilities and structures is evaluated first. The second section presents performance data on the Corps' navigation program, further divided between inland waterways and ports and harbors. Recent events, such as the 1993 flooding of the Mississippi and Missouri Rivers, are not accounted for in this report. In general, dollar figures are presented in real 1987 dollars; the noted exceptions to this are due to data provided in different base-year values.

OVERALL PERFORMANCE OF FLOOD CONTROL STRUCTURES

From 1982 to 1992, Corps' flood control projects prevented $141 billion (1987 dollars) in potential flood damages at a total cost of over $14 billion for construction and operations and maintenance (1991 dollars). Damages prevented from 1982 to 1992 averaged $12.8 billion per year (1987 dollars). During this same period, floods caused $22.8 billion (1987 dollars) in damages and caused the deaths of over 1,100 persons. From 1985 to 1992, annual flood damages averted averaged $11 billion, while flood damages sustained averaged $1.6 billion. During this period, in effect, Corps flood control structures prevented 87 percent of the total damages that could have occurred from floods; this does not include damages sustained during the 1993 flooding of the Mississippi and Missouri Rivers.[121] While many of the 313 Corps major flood control reservoirs in operation today are over 50 years old, dam safety data suggest that the integrity of the Corps' structures is basically sound.

Program Goals

The nation's flood control works are designed to prevent flood damages to property, prevent the loss of life due to flooding, and to stimulate regional and national economic development. There are two basic strategies to achieve these goals: **structural** retention of flood waters; and **nonstructural** avoidance of flood damages. Relatively little is known about the performance of non-structural flood damage reduction programs. Hence, this section will focus on the performance of structural methods.

Structural solutions include: dams, channels, levees or floodwalls that reduce property damage and the risk of loss of life by controlling the flow of water. Dams built upstream of flood-prone areas store flood waters for later gradual release or use after the threat of flooding has subsided. Artificial channels or enlarged natural water courses are designed to contain flood flows within river banks. Levees and floodwalls perform similar functions.

Non-structural solutions include all other methods to reduce flood losses including those designed to modify human behavior. Typical non-structural methods include flood plain regulations (zoning ordinances) that restrict development in flood-prone areas; flood warning systems; public information and education on early evacuation procedures or flood fighting during a flood; and floodproofing measures, such as sandbagging, to reduce the impacts of flooding.

Flood Control Overview and Description

Currently, the Corps of Engineers operates 313 reservoirs built primarily for flood control. In addition, the Corps has constructed or contributed to 27 flood control reservoirs that are operated by other public agencies. The Soil Conservation Service, Tennessee Valley Authority and the Bureau of Reclamation also build and operate an array of flood control structures. For example, as of 1990, the Bureau of Reclamation had under operation or construction 247 multiple purpose reservoirs many of which provide flood control services.[122]

Government Roles

The federal government is responsible for most of the activities associated with flood control projects. Large dams for flood control are operated by the federal government. Smaller flood control projects are operated and maintained by local or state sponsors.

Today, some 25 federal agencies have some role in providing flood damage prevention or control services. But there are five main federal agencies dealing with various aspects of flood control. The U.S. Army Corps of Engineers carries the bulk of this responsibility through construction and operation of numerous flood control structures nationwide. The Bureau of Reclamation includes flood control storage in its Western reservoirs, but the purpose of many these reservoirs is primarily for irrigation and hydropower. The Tennessee Valley Authority provides flood control services in the Tennessee River basin, but all the major structures are now complete. The Soil Conservation Service provides smaller, upland flood control services (mostly in the form of construction grants) mainly to rural regions. Finally, the Federal Emergency Management Agency operates the national flood insurance program and is the coordinating agency for dam safety. A sixth agency, the National Weather Service, collects statistics on flood damages and deaths resulting from floods.

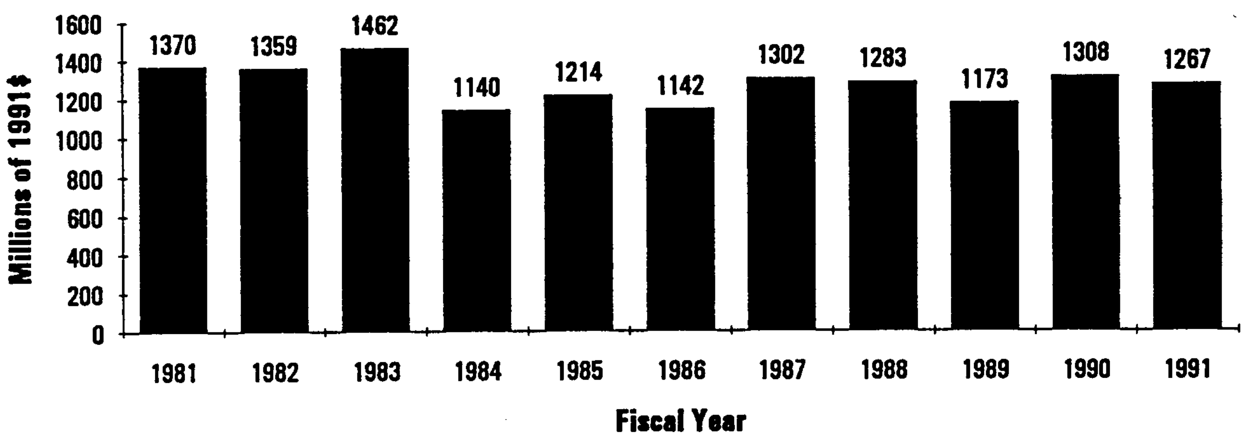
State and local governments play two major roles in funding flood control projects: constructing and operating their own projects; and financing their share of and maintaining the projects built for them by the federal government. Variations exist in the extent of state and local involvement in each role. As of 1988, 23 states provided technical assistance to communities for flood control activities; many more states are directly involved in local structural flood projects in other ways.[123]

Prior to 1986, the Corps funded, built, and operated the majority of the nation's large flood control projects. However, under the landmark 1986 Water Resources Development Act (and subsequent reauthorizations), local governments are required to take a much more active role in project planning and financing.

Description of Financial Trends and Condition

Although Corps' annual outlays for flood control fluctuated considerably in the 1960s and 1970s (as described in the previous performance report), they have remained relatively stable at around $1.3 billion (1991 dollars) since 1982 (Figure 6-4). This total includes spending for construction, major rehabilitation, operation and maintenance, preconstruction engineering, and surveys. For the ten-year

Figure 6-4: Total U.S. Army Corps of Engineers Expenditures for Flood Damage Prevention, 1981-1991



Source: U.S. Army Corps of Engineers, expenditures database, Institute for Water Resources.

time period from 1981 to 1991, total construction outlays (construction, major rehabilitation, and preconstruction engineering) peaked in 1983 at $1.04 billion and have fallen to about $843 million in 1991 (Figure 6-5). Operation and maintenance outlays (O&M and surveys) have continued to increase over this period, from about $357 million in 1981 to $424 million in 1991.

The WRDA of 1990 and the WRDA of 1992 authorized 26 new flood control projects at an estimated cost of $2.8 billion. The largest single flood control project, Passaic River Main Diversion Tunnel, is estimated to cost $1.9 billion upon completion.

Flood Control Performance Indicators

Performance data analyzed in this section suggest that the Corp's flood control program performs well. Flood control projects have averted damages substantially in excess of the costs incurred to build and maintain structures. There is no practical way to calculate the lives saved by Corps' projects. Except for a few major calamities, most flood-related deaths are caused by flash floods on small streams that cannot be protected by structural flood control measures.

This section presents and analyses flood control performance data at four levels: physical assets; service delivery; quality of service; and cost effectiveness. Where data allow, performance is evaluated over a 32-year period, 1960-1992. Unfortunately, adequate data are not available for many of the structures that provide flood control services.

Physical Assets

Flood control assets are measured as the number of flood control facilities. While the Corps maintains data on the number of flood control reservoirs, limited physical asset data are collected for the other types of flood control structures -- levees, dikes, floodwalls, and so on. It has been estimated that the Corps has constructed about 10,500 miles of levees and floodwalls, most of which have been assigned to nonfederal sponsors for operation and maintenance after construction.[124]

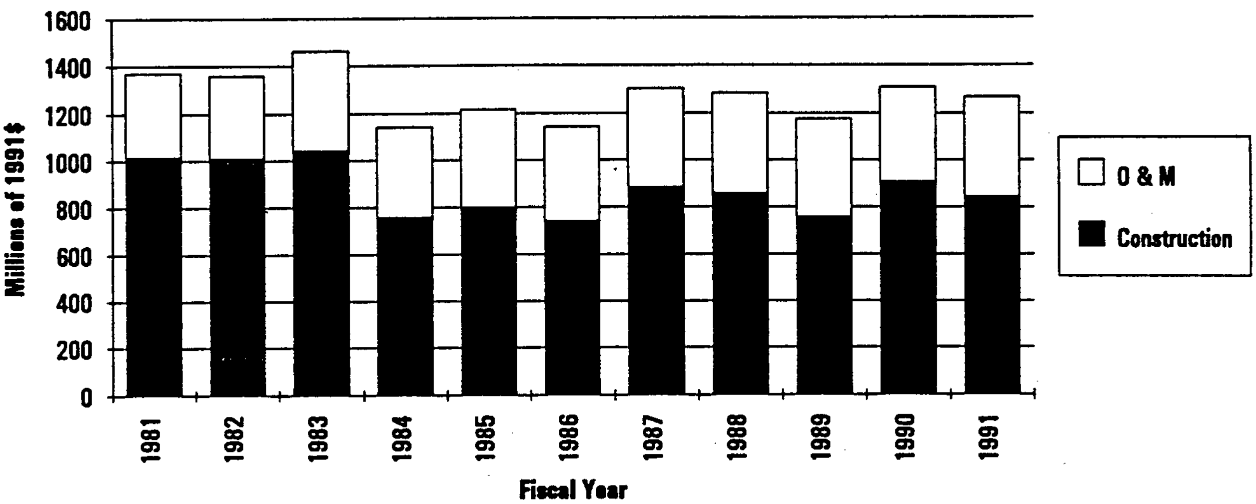
Data on the U.S. Army Corps of Engineers' flood control reservoirs indicate that their number has doubled since 1960, but the rate of increase over the years has declined (Figure 6-6 and Figure 6-7). The data suggest three distinctive periods in the addition of new flood control reservoirs: the 1960s, when 95 facilities were put into service (average 9.5 per year); the 1970s, when facility construction slowed to about 6 reservoirs per year; and the 1980s and 1990s, when net additions slowed even further (averaging less than 3 per year).

Service Delivery

Two indicators of service delivery at the national level (for which data are available) include the volume of flood storage and the population protected by flood control works.

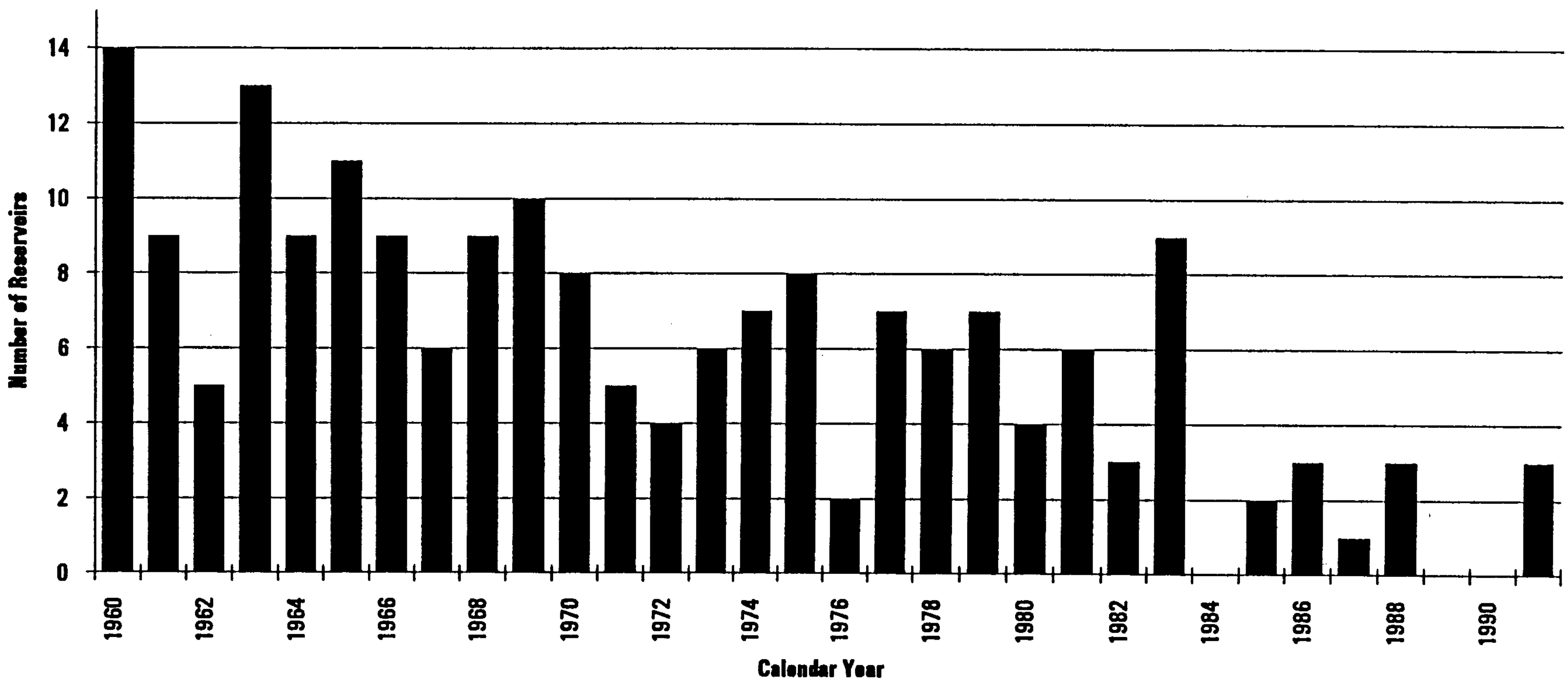
<u>Flood Storage</u>. Flood storage capacity in the U.S. Army Corps' reservoirs is based on two factors: the dam's design; and the allocation of overall storage capacity to various uses if the reservoir serves multiple purposes. Obviously, higher dams tend to provide greater storage capacity than smaller structures. The allocation of storage often has more to do with the a priori perception of project benefits

Figure 6-5: U.S. Army Corps of Engineers Flood Control Expenditures for O&M and Construction, 1981-1991



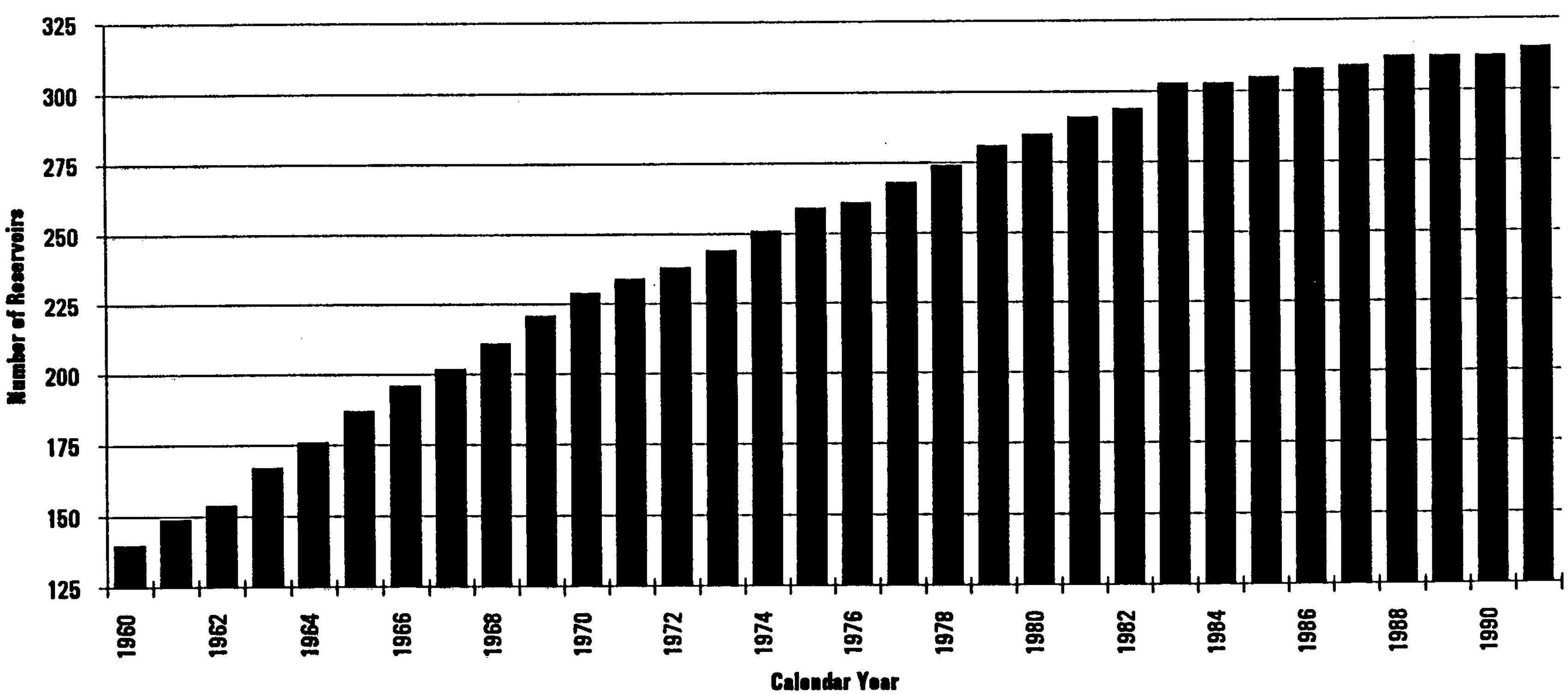
Source: U.S. Army Corps of Engineers, expenditures database, Institute for Water Resources.

Figure 6-6: Number of Flood Control Reservoirs Put in Service by Year, 1960-1991



Source: U.S. Army Corps of Engineers, Annual Report of the Secretary of the Army on Civil Works Activities, Appendix A, various years.

Figure 6-7: Cumulative Number of Flood Control Reservoirs in Service, 1960-1991



Source: U.S. Army Corps of Engineers, Annual Report of the Secretary of the Army for Civil Works Activities, Appendix A, various years.

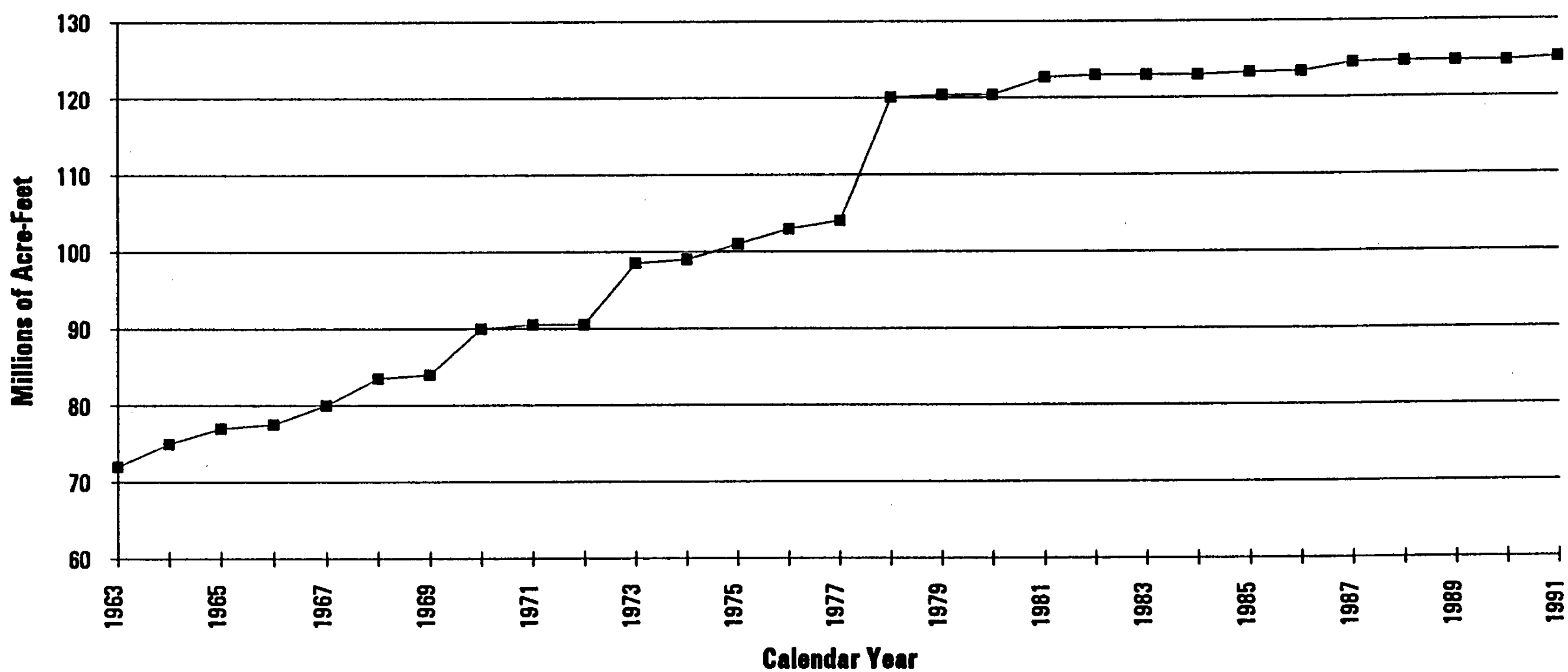
calculated during the feasibility stage than the actual reservoir operation once the project is built. The data cited in this study are based on original allocations. Cumulative flood control storage is closely related to the number of reservoirs added each year (Figure 6-8). As noted in the previous performance report, compared to the 4 percent annual growth in flood storage characteristic of the 1960s and 1970s, the rate of growth in the nation's capacity to store flood waters in major reservoirs has slowed considerably during the 1980s and 1990s (to less than one percent).

Total flood control reservoir storage at Corps' facilities topped 86 million acre-feet in 1991. As shown in Table 6-1, thirteen states provide the majority of storage capacity in the U.S.[125] Regionally, the states of Texas, Kansas, Oklahoma, and Arkansas account for almost 37 million acre-feet and over 43 percent of total storage. These states fall under the jurisdiction of the Southwestern Division of the U.S. Army Corps of Engineers. There are 18 individual flood control reservoirs that have total storage of over 1 million acre feet. The largest of these is Red Lake reservoir in Minnesota with total storage of 3,270,000 acre-feet.

Table 6-1: U.S. Army Corps of Engineers Flood Control Reservoirs by State, 1991[126]

State	Number of Reservoirs	Total Storage	Percent of Total Storage
Texas	25	13,689,000	15.8
Kansas	17	8,556,000	9.9
Oklahoma	17	7,470,000	8.6
Arkansas	9	6,963,000	8.0
Mississippi	5	4,234,000	4.9
Kentucky	14	4,161,000	4.8
Pennsylvania	26	4,066,000	4.7
Arizona	8	3,864,000	4.5
California	29	3,639,000	4.2
Iowa	4	3,476,000	4.0
Minnesota	6	3,466,000	4.0
Ohio	28	3,388,000	3.9
New Mexico	8	3,154,000	3.6
All Others	117	16,376,000	18.9
TOTAL	313	86,502,000	100

Figure 6-8: Cumulative Storage in Corps' Flood Control Reservoirs, 1963-1986



Source: U.S. Army Corps of Engineers, Annual Report of the Secretary of the Army on Civil Works Activities, Appendix A, various years.

Population of Protected Communities. The 1987 performance report presented data on the population of communities that receive some flood control protection from Corps' flood control facilities. This information came from a 1982 Federal Emergency Management Agency (FEMA) report. As this report is published every ten years and the 1992 report has not yet been released (anticipated late July 1993), no updated information is currently available.

Quality of Service

The third component of performance, quality of service in the provision of flood control, can be measured several ways including flood damages averted, deaths due to floods (in lieu of deaths averted), and the relative safety of dams.

Quality measures are not only the most important elements, but also the most difficult to measure when considering the nation's flood control program as a whole. Rainfall and other extreme, but localized, events such as hurricanes or tornados, could skew flood data for the entire year.

Flood Damages Averted. Flood damage prevention is an appropriate quality of service measure because it takes into account such factors as property values within the protected floodplain, weather conditions, streamflow, and design characteristics of each reservoir. From 1982 to 1992, Corps' projects have prevented an estimated $141 billion dollars in potential damages (Figure 6-9).[127]

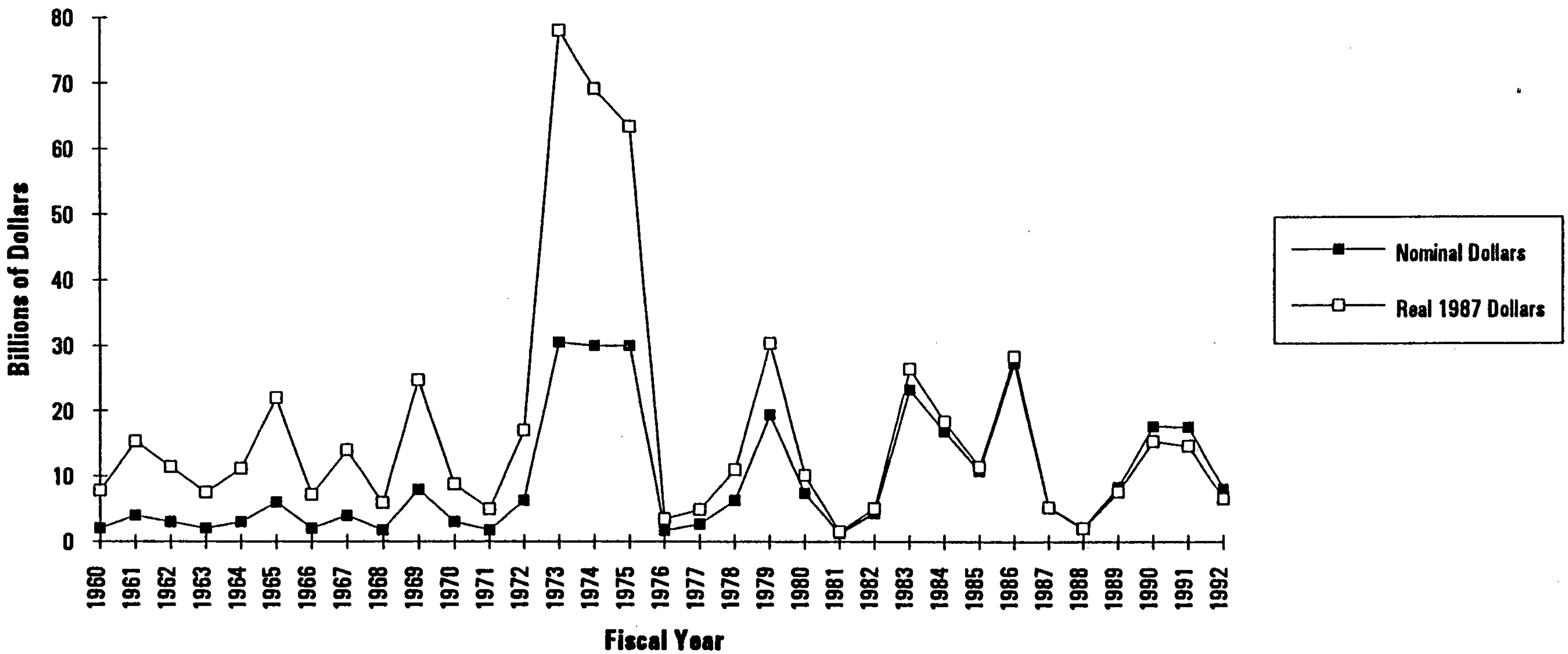
Although the third strongest hurricane of this century, Hurricane Andrew, caused $20 to $30 billion in damages (the costliest natural disaster in U.S. history), flood damages caused by the hurricane were relatively light due to the storm's fast movement over land. It is estimated that Corps flood control projects prevented $12.5 million in damages from this storm.

At the time of this writing, due to a massive and persistent low-pressure weather system stalled over the upper and middle Mississippi River region of the United States, the states of Minnesota, Wisconsin, Iowa, Illinois, and Missouri are experiencing the worst flooding levels of this century. The Mississippi and Missouri Rivers and their tributaries, swollen to 500-year record levels, have overwhelmed hundreds of dikes and levees, causing billions of dollars in damage to crops, businesses, and homes throughout the region. The flooding has not only closed the middle Mississippi to barge traffic, key railroad and highway bridges are closed further shutting down cargo shipping in the middle west. Although reliable flood damage estimates are unavailable at this time, damage is expected to exceed preliminary estimates in the $10 billion range.

An associated measure of the effectiveness of flood control programs is the ratio of damages averted to total damages that would have occurred if there was no flood control program (the sum of damages averted and damages incurred).[128] During most of the time period 1980 to 1992, the Corps' flood control program prevented a large proportion of total damages possible (Figure 6-10). In fact, on average, Corps' dams have prevented an estimated 86 percent of total potential damages. In only one year, 1981, was the total value of actual damages greater than the damages prevented. For the period 1960 to 1979, only in 1972 and 1976 did flood damages exceed damages prevented. This was primarily due to excessive rainfall in regions that had little flood protection.

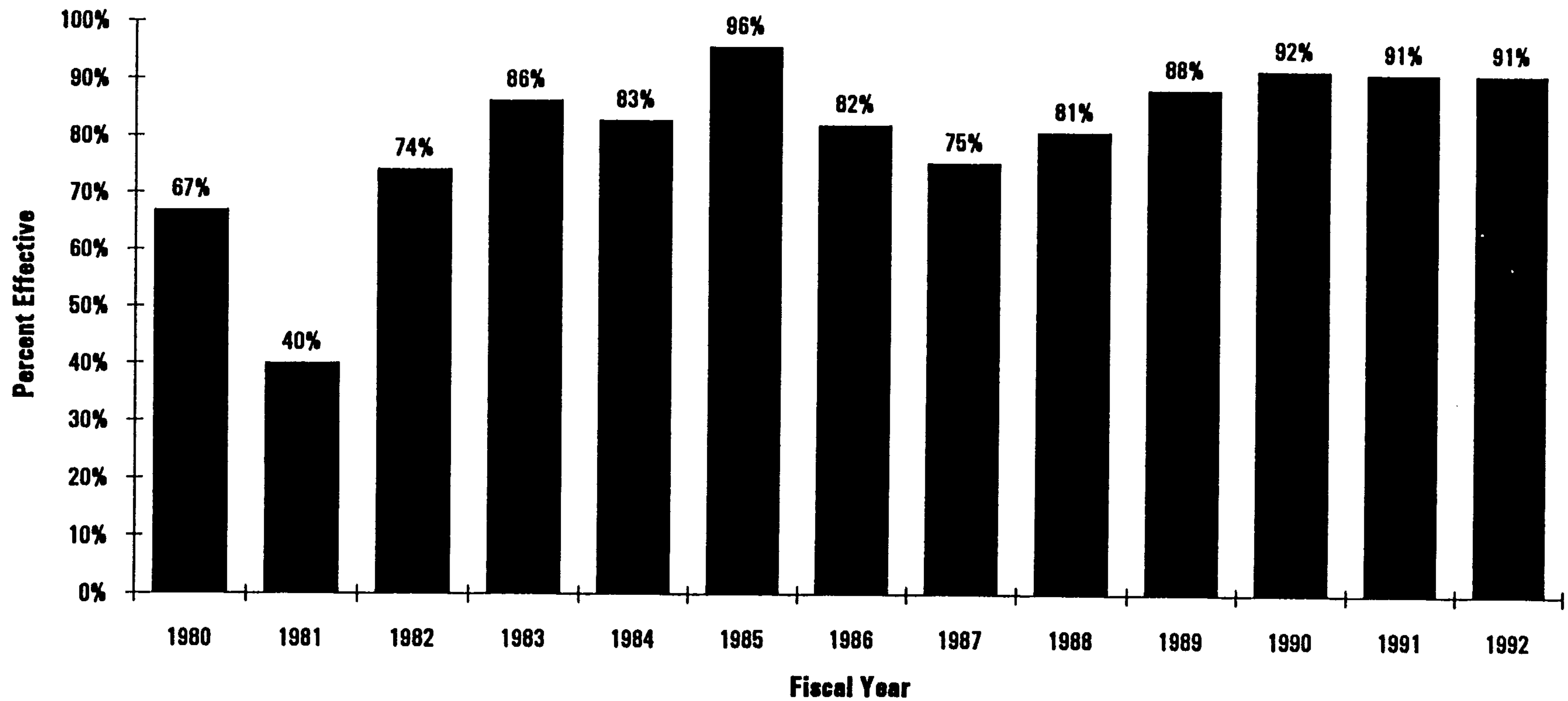
Nevertheless, damages from major floods (in 1987 dollars) have been increasing at an annual rate of about four percent and there is some indication that this rate is accelerating. Figure 6-11 demonstrates

Figure 6-9: Annual Flood Damages Prevented in Real and Nominal Dollars, 1960-1992



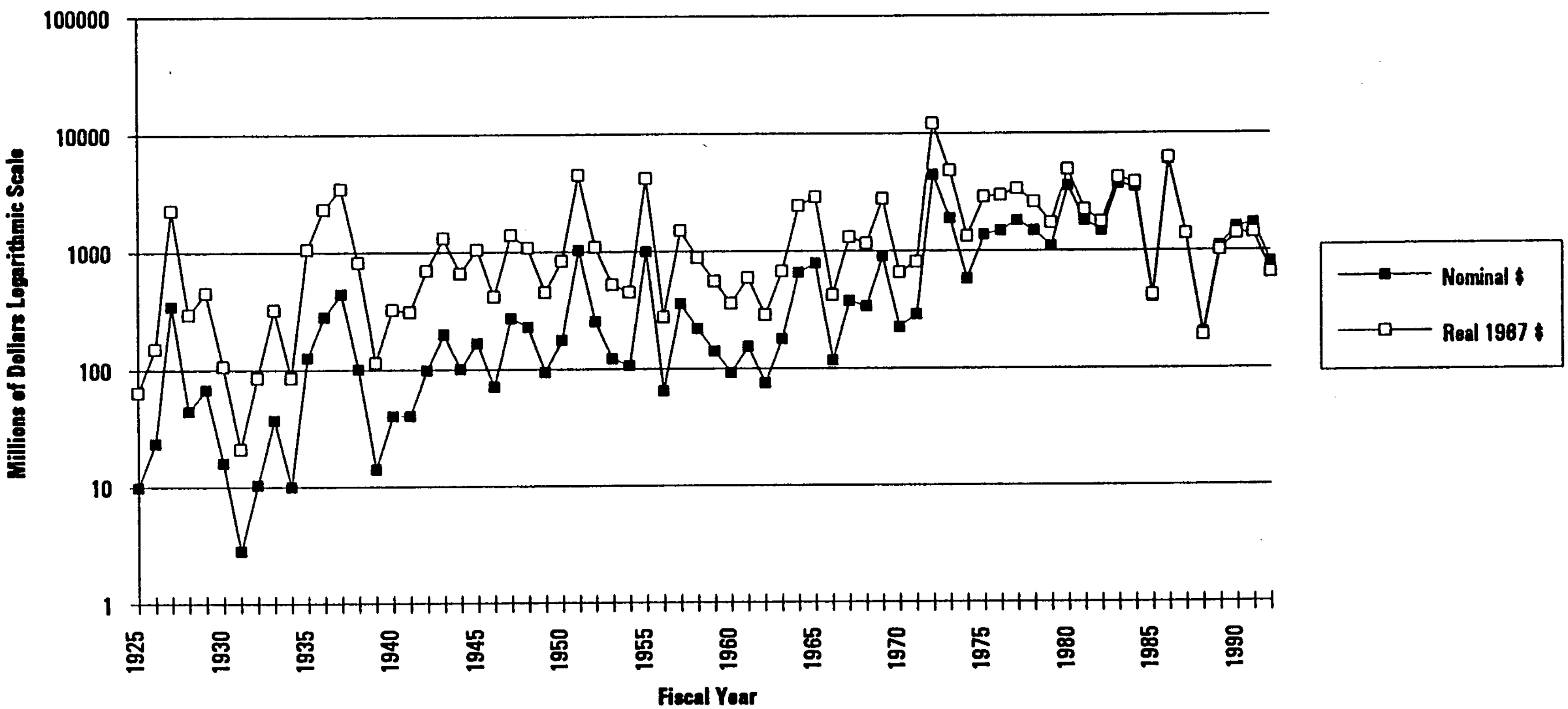
Source: U.S. Army Corps of Engineers, Annual Report to the Chief of Engineers for Civil Works, Statistical Highlights, various years.

Figure 6-10: Annual Damages Prevented as a Percent of Total Possible Damages, 1980-1992



Source: Apogee Research, Inc., from U.S. Army Corps of Engineers, Annual Report of the Secretary of the Army on Civil Works Activities, various years, and U.S. Army Corps of Engineers, Annual Flood Damage Report to Congress, FY 1992.

Figure 6-11: Flood Damages Sustained in the U.S., 1925-1992



Source: Gale Resarch Company, The Weather Almanac, Fifth Edition, 1987, (1925-1975 nominal figures), and U.S. Army Corps of Engineers, Annual Flood Damage Report Fiscal Year 1992, February 1993, (1976-1992 nominal figures).

this trend since 1925. Compared to annual damages averaging some $950 million (1987 dollars) a year in the beginning and middle of this century (1925-1960), annual flood damages averaged $1.6 billion per year from 1985-1992 (Figure 6-12).

Flood-Related Deaths. The number of flood-related deaths provides another rough indication of the quality of the nation's flood control system. Presumably, if flood control structures and non-structural methods are performing adequately, and the nation continues to add such controls on a regular basis, rainfall-adjusted deaths should decline over time. Since 1983 there have been 1,071 deaths due to floods (Figure 6-13). No estimates are available on the number of deaths avoided because of flood control damages.

Flood Control Dam Safety. The final indicators of the quality of nation's flood control works is the safety of the structures themselves. The majority of dams that provide substantial flood control storage are in good condition. The inventory data show that while many (approximately 50) of the 313 Corps flood control reservoirs are over 50 years old, their physical state is sound overall. It also points out that because of their age, physical condition will become increasingly important in the future.

As noted in the previous performance report, attempting to judge the physical condition of channels, floodwalls, or levees is much more difficult. Channels are not considered structures and their performance is primarily based on the frequency of rainfall rather than the lack of maintenance and repair. National data do not exist on the condition and safety of levees or flood walls. Nonetheless, these structures can pose a significant safety hazard similar to dams in the event of failure.

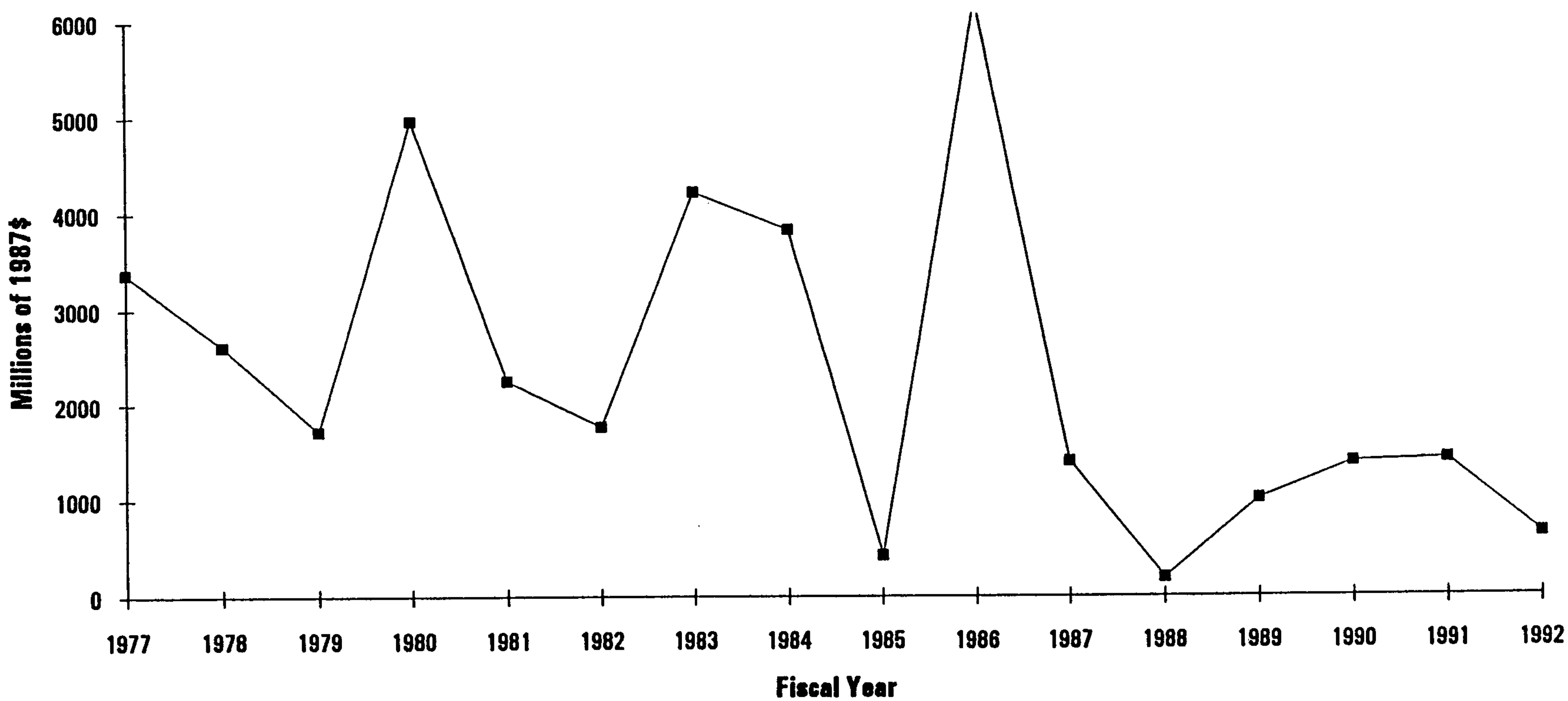
Cost Effectiveness

The fourth aspect of performance is the economic efficiency or cost effectiveness of flood control programs. As discussed earlier, before Congress can authorize any flood control project, the benefits of the project must be demonstrated to be greater than the costs. Without questioning evaluation methods and assuming that all projects are evaluated rigorously, it would follow that all Corps' projects are efficient by definition. But since these studies are performed before the project is put into operation, Corps' benefit-cost ratios rarely reflect the post-project accrual of benefits or the true costs of operation, maintenance, or rehabilitation. It is not unusual for projected benefits to fall short or exceed pre-project estimates.

Another way to view efficiency is the ratio of the annual flood damages averted (the benefits) to the amortized capital expenditures on flood control, aggregated over an historic period equivalent to the average life of a flood control facility. In essence, this would measure the delivery of flood control benefits nationwide by the total capital stock of flood control structures available to deliver these services. Unfortunately, because the useful life of major flood control dams ranges from 50 to 100 years, it was not possible to calculate these ratios within the scope of this study.

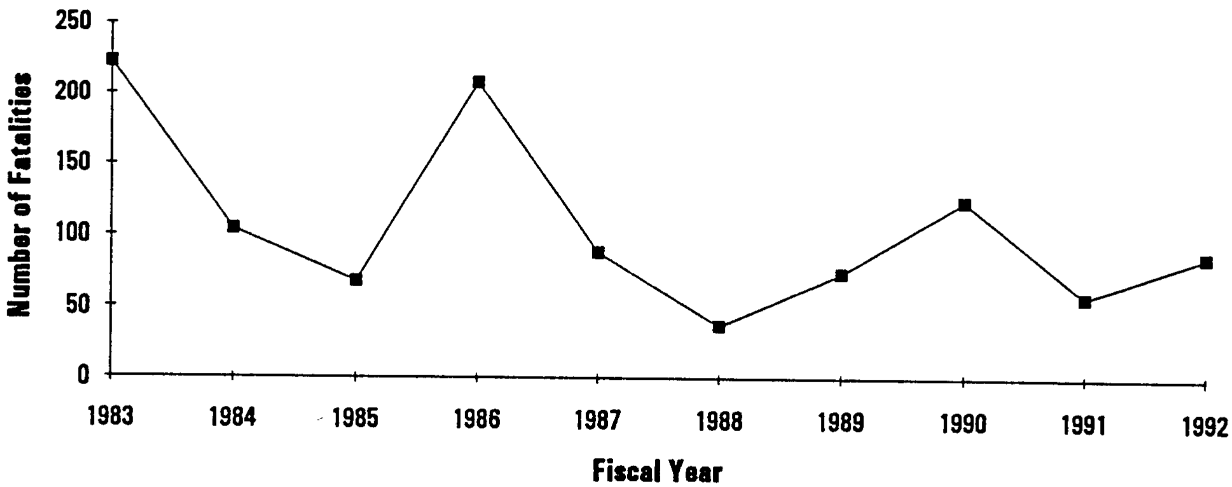
However, it is possible to calculate annual flood damages averted relative to annual program capital costs. If this ratio remains above 2, it is reasonable to conclude that annual benefits exceed the aggregated past costs of providing flood control structures.[129] If it is in the range 1.5-2, the assurance of net benefits is inconclusive. Below 1.5, it would be safe to assume that costs exceed benefits for that year. These ratios, calculated annually over the period 1981-1991, are presented in Figure 6-14.

Figure 6-12: Flood Damages Sustained in the U.S., 1977-1992



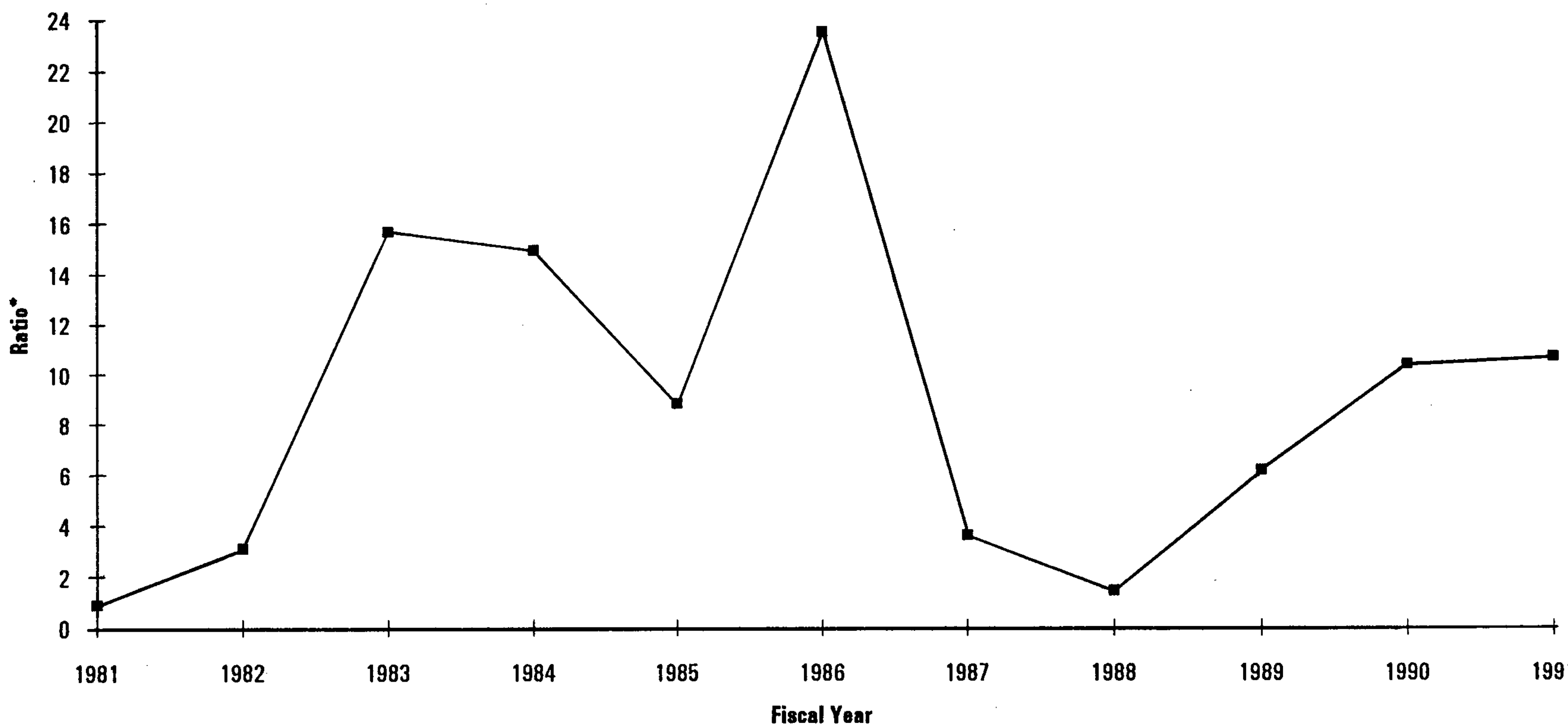
Source: U.S. Army Corps of Engineers, Annual Report of the Secretary of the Army on Civil Works Activities, FY1986, and Annual Flood Damage Report to Congress, FY1992.

Figure 6-13: Flood Related Fatalities in the U.S., 1983-1992



Source: U.S. Army Corps of Engineers, Annual Flood Damage Report to Congress, FY1992.

Figure 6-14: Cost Effectiveness of Flood Prevention Projects



Source: Apogee Research, from Corps Annual Flood Damage Report to Congress, FY1992, and Institute for Water Resources expenditure data.

* Ratio of Damages Averted to Accumulated Ammortized Capital Outlays for Corps Flood Prevention Projects.

OVERALL PERFORMANCE OF THE NAVIGATION PROGRAM

Performance of the nation's navigation system is based on the ability of private and public investments to meet the country's demands for waterborne transport of bulk and containerized goods. Considering this goal, the nation's system appears to have performed moderately well over the past 32 years. In 1991, domestic intercity waterborne commerce (Great Lakes, Rivers and Canals, Coastwise) totaled 1,020 million tons, up from 655 million tons in 1960.[130] This accounted for almost 16 percent of all intercity freight traffic. As stated in the 1987 performance report, and still true today, current concerns include the effects of aging locks on inland waterway performance, congestion at selected facilities, and the need for deeper coastal ports to handle larger ships.

Program Goals

In the early 1800s, the Congress directed the U.S. Army Corps of Engineers to construct: (1) inland waterways to serve emerging agricultural and industrial development in the South and West; and (2) coastal ports to serve foreign trade and national defense. The goals of the nation's inland and coastal navigation program are substantially the same today -- to facilitate the movement of foreign and domestic waterborne commerce in service to U.S. and international markets. National defense has also served to justify both federal regulation in navigation and federal expenditures.

Navigation System Overview and Description

The nation's navigation system incorporates two components: inland waterways and coastal ports. The inland navigation system is comprised of 25,000 miles of inland rivers and intracoastal waterways. The U.S. Army Corps of Engineers is responsible for maintaining the inland waterways, and has constructed 211 lock chambers at 168 lock sites on fuel tax waterways, the majority of which were built before 1940. The Corps also maintains the depth of the inland waterways with periodic dredging and stabilizes channel banks with the construction of revetments.

Historically, the majority of construction, operation, maintenance, and major rehabilitation costs have been financed with federal general revenues. The Inland Waterways Revenue Act of 1978 and the Water Resources Development Act of 1986 established a waterway fuel tax of 4 cents per gallon beginning in 1980, with 2 cent per gallon increases every two years through 1991, totaling 20 cents per gallon by 1991. The revenue from the fuel tax is dedicated to the Inland Waterways Trust Fund. Revenue from the fund must cover half of the operation, maintenance, and major rehabilitation projects authorized from inland waterways. The Inland Waterways User's Board (comprised of the larger towing companies and barge lines) was established under the WRDA of 1986 to advise the administration on the allocation of trust fund revenues.

There are approximately 188 deep draft coastal ports on the Atlantic, Pacific, Gulf, and Great Lakes Coasts. These include ports with a minimum depth of 25 feet for coastal ocean ports and 18 feet for Great Lakes ports. The U.S. Army Corps of Engineers deepens and maintains channel depth at authorized ports through dredging operations and channel stabilization structures such as breakwaters and jetties.

The WRDA of 1986 instituted a harbor maintenance fee of .04 cents per dollar value of imports, exports, and certain types of domestic waterborne commerce. According to the Act, revenues from this fee are dedicated to the Harbor Trust Fund, from which 40 percent of system-wide operations and maintenance costs must be appropriated. The remaining cost is shared by the federal government and the port, depending on the existing channel depth. The WRDA of 1990 and the Omnibus Budget Reconciliation Act of 1990 (P.L. 101-508), contained significant amendments affecting the financing provisions of the WRDA of 1986. The WRDA of 1990 amended the use of funds in the Harbor Maintenance Trust Fund to allow up to 100 percent of costs to be drawn from the trust fund. The Reconciliation Act of 1990 increased the Harbor Maintenance Tax to .125 percent with an effective date January 1, 1991.

Landslide facilities (docks, wharfs, cranes, piers and warehouses) are also an important aspect of the both the inland waterways system and coastal ports. Such facilities are generally provided by individual port authorities, states, local governments, and/or the private sector.

Physical Make-up of the Navigation System

Inland Waterways. Two hundred sixty-four locks and dams have been built by the U.S. Army Corps of Engineers to facilitate the movement of waterborne commerce through 25,000 miles of inland waterways. Although locks and dams are the not the only methods used by the Corps to maintain the nation's waterways (bank stabilization, stream flow, and dredging are also used frequently), these structures represent the major federal investment in inland waterway infrastructure.

The major inland river transportation network of the United States is located along the Mississippi River and its tributaries. This system facilitates traffic moving north and south and includes the Mississippi River, the Ohio River system, the Illinois Waterway, and the Arkansas and Missouri Rivers, among others. This system is comprised of about 7,500 miles of heavily used, improved navigable channels, 85 percent of which have at least 9-foot channel depths.

The second largest inland waterway system is the Gulf Intracoastal Waterway (GIWW). This system parallels the Gulf Coast for about 1,700 miles from St. Marks, Florida to Brownsville, Texas, on the Mexican border. Midway along the coast, the GIWW intersects the Mississippi River at New Orleans. The Atlantic Intracoastal Waterway and the Columbia-Snake Waterway complete the U.S. waterway system. These two systems are comprised of 1,203 and 302 miles of waterways respectively.

Ports. According to the Maritime Administration, there are approximately 188 deep-draft ports located along the Atlantic, Gulf, Pacific and Great Lakes Coasts. The majority of ports are located along the North Pacific Coast (46), followed by the South Pacific (37), North Atlantic (29) and Great Lakes (28).[131] At these 188 ports, there are many public and private commercial facilities, including 1,915 terminals and a total of about 3,180 berths. The highest concentration of terminals is the Gulf (489) followed by the North Atlantic (413), and the Great Lakes (365). The number of berths follows the same pattern as terminals, with the highest concentration in the Gulf (794), followed by the North Atlantic (754), and the Great Lakes (507). It is interesting to note that since 1987 the Gulf region has overtaken the North Atlantic in numbers of terminals and berths. In addition, while the total number of terminals and berths increased from 1987 to 1992, Great Lakes facilities dropped in number.

The Port of South Louisiana, Louisiana handled the largest amount of traffic in 1990 (175 million metric tons). This was followed by the ports of New York/New Jersey (127 million tons) and Houston (114 million tons).[132] The movement of U.S. waterborne commerce is highly concentrated: the top five ports accounted for 30 percent of total waterborne commerce and the top 50 ports handled 87.4 percent.

Government Roles

The development of landslide ports and terminal facilities in the United States is a shared responsibility of state and local governments, and the private sector. Historically, the U.S. government has provided dredging and maintenance of federally authorized shipping channels; construction of breakwaters and jetties; and navigation aids such as lights, channel markers, and buoys. U.S. public port agencies -- usually independent local port authorities -- oversee, coordinate and/or undertake the planning and development of facilities. They also ensure efficient operation of ports. Private ownership accounts for 75 of deep draft seaport and Great Lakes port facilities and 89 percent of inland waterway facilities.[133]

Although the U.S. Army Corps of Engineers has been given responsibility for regulating foreign and domestic waterborne commerce, there are nearly 50 federal, state and local agencies involved in some aspect of navigation. The Corps' role in inland waterways consists of building, operating and maintaining navigation channels, locks and dams, as well as dredging to maintain channel depths. The Corps' main role in ports is the dredging of shipping channels to maintain authorized depths.

Other Federal agencies that have significant roles in navigation include the U.S. Coast Guard, U.S. Customs, and the Department of Transportation. The U.S. Coast Guard funds and administers its aid-to-navigation and search-and-rescue programs. The Maritime Administration's role is to conduct research concerning the promotion of seafaring trade. U.S. Customs Department is responsible for collecting tariffs and duties on foreign trade.

Spending Trends

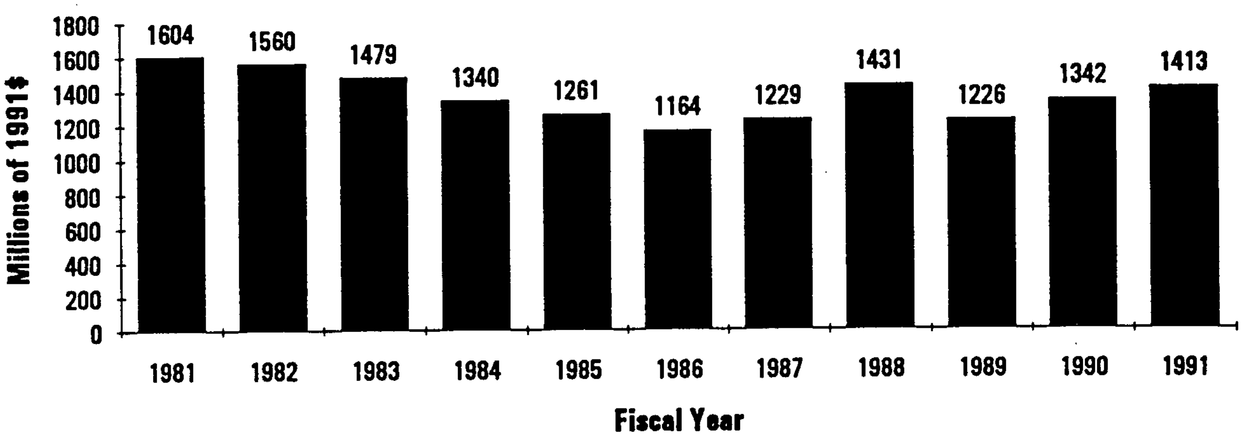
Navigation expenditures by the U.S. Army Corps of Engineers for deep draft ports and inland waterways (1991 dollars) have fluctuated narrowly between about $1.25 billion and $1.5 billion a year since 1981 (Figure 6-15).

Recent federal investment in the navigation system has focused on major rehabilitation and operation and maintenance of an already established system. Corps appropriations for construction have declined over the last decade, while O&M has remained constant in real terms. Corps' construction expenditures have fallen from $852 million in 1981 (1991 dollars) to about $597 million in 1991 (Figure 6-16). Operation and maintenance expenditures have held mostly steady at about $800 million a year: $751 million in 1981; $812 million in 1995; and $816 million in 1991. The large increase in 1988 reflects newly authorized projects resulting from the WRDA of 1986.

INLAND NAVIGATION PERFORMANCE INDICATORS

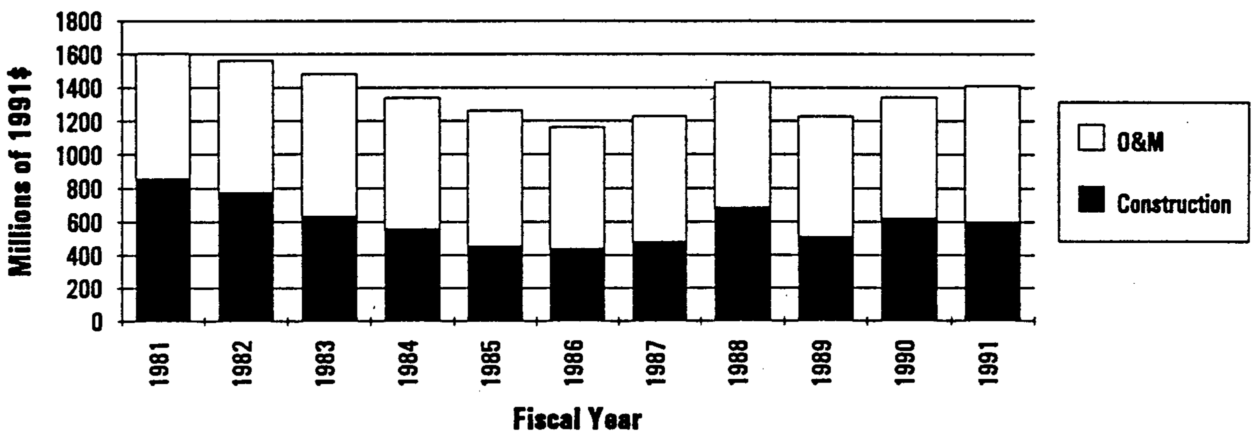
This section presents four performance categories for the U.S. inland waterways: physical assets; service delivery; quality of service; and cost-effectiveness.

Figure 6-15: Total U.S. Army Corps of Engineers Expenditures for Navigation, 1981-1991



Source: U.S. Army Corps of Engineers, Institute for Water Resources expenditures database.

Figure 6-16: U.S. Army Corps of Engineers Navigation Expenditures for O&M and Construction, 1981-1991



Source: U.S. Army Corps of Engineers, Institute for Water Resource expenditures database.

Physical Assets of the Inland Waterways System

Both public and private entities have invested extensively to build the physical assets of the nation's inland waterways system. Federal assets consist primarily of locks and dams, while non-federal assets are comprised of terminals and land-side facilities located at river ports, as well the fleet of barges and tow boats that use the system.

The federal government has invested in 25,000 miles of inland rivers and intracoastal waterways and 168 commercially active sites with 211 chambers in the nine inland waterway segments (fuel tax segments). As of 1992, 85 of these commercial purpose lock chambers were over 50 years old (Figure 6-17). Since 1980, the overall number of lock chambers has grown at a annual rate of about 1 percent.

The current system of locks range in age from less than one year old at Oliver Lock and Dam on the Black Warrior River to over 150 years old on the Kentucky River About 40 percent of the chambers are more than 50 years old.[134] As locks on any given waterway tend to be from the same era, problems that come with aging locks tend to affect many locks at the same time.

Age is an important factor two reasons: older locks generally have smaller chambers that impede processing time; and older locks break down more frequently. The Ohio River system, for example, has the largest number of 50 year old locks. It also has the highest number of locks with processing time over two hours. This is in contrast to the locks on the Lower Mississippi, Middle Mississippi, and Mobile River Segments, which have no locks older than 50 years and no chambers with processing times over two hours (Table 6-2).

Table 6-2: Inland Waterway System Number of Locks and Processing Time by Inland Waterway System, 1990[135]

Inland Waterway System	Number of Locks in System	Number of Locks over 50 Years	Percentage of Locks over 50 Years	Number of Locks with Processing Over 2 Hours
Upper Mississippi	30	25	83 percent	12
Middle Mississippi	3	0	0 percent	1
Lower Mississippi	23	0	0 percent	0
Illinois Waterway	8	7	88 percent	0
Ohio River System	79	36	46 percent	15
Gulf Intercoastal Waterway	13	2	15 percent	5
Mobile River and Trib.	4	0	0 percent	0
Atlantic Intracoastal Waterway	3	3	100 percent	0
Columbia-Snake Willamette	16	1	6 percent	1

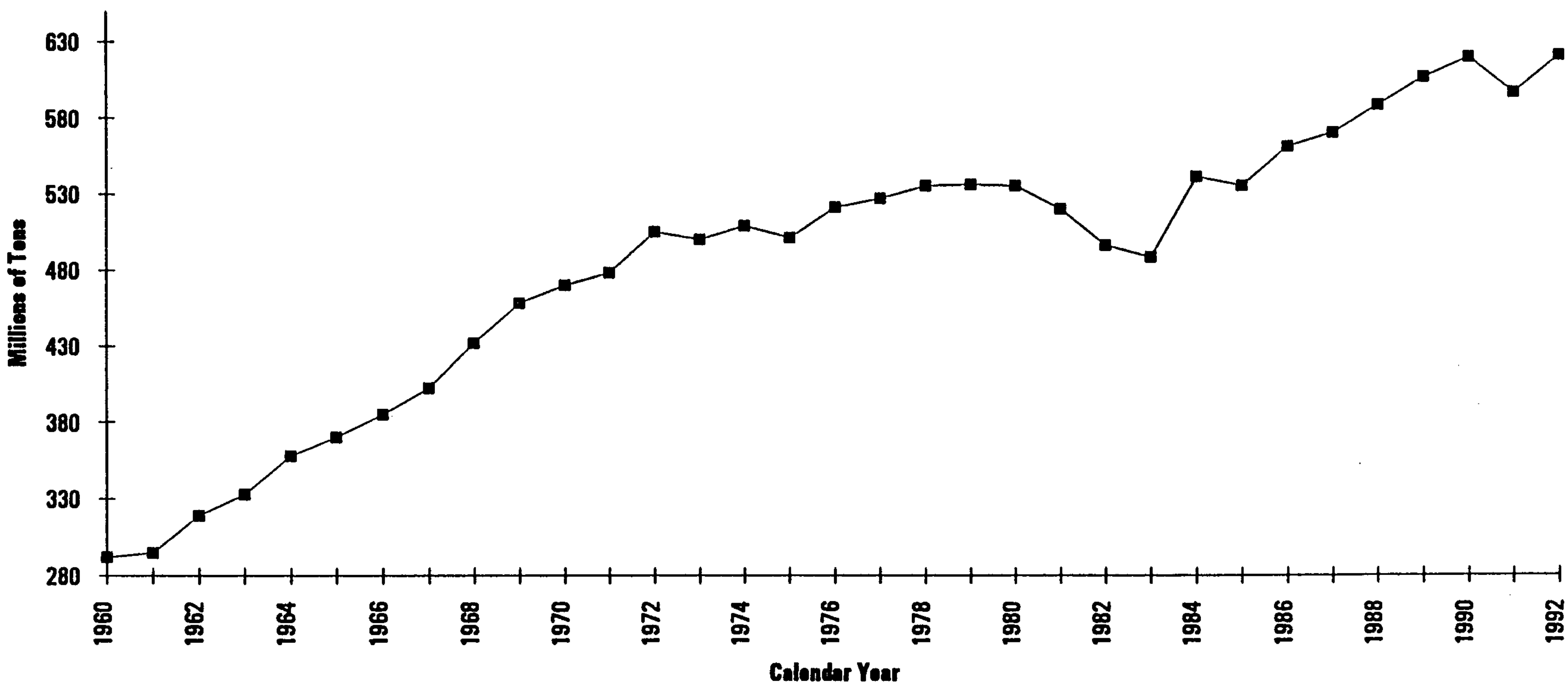
Age alone is not considered a reliable indicator of the condition of a lock, its problems, or its performance. It can be used to generally measure the cumulative effects of various factors, such as operation and maintenance history, traffic volume and environmental factors such as weather.

Investment in river terminal facilities is extensive. Physical assets consist of terminals and other land-side facilities, such as cranes and warehouses. Over 1,700 terminals (up from 1,633 in 1987) and 128 riverports (1987) are scattered along waterways with the highest concentrations found along the Mississippi River and its tributaries (Table 6-3). Illinois has largest number of terminals (252), followed by Kentucky (175), and Pennsylvania (172). The number of river ports is not reported in Table 6-3, as the U.S. Army Corps of Engineers no longer compiles this data.[136]

Table 6-3: Number of Terminals by State, 1990

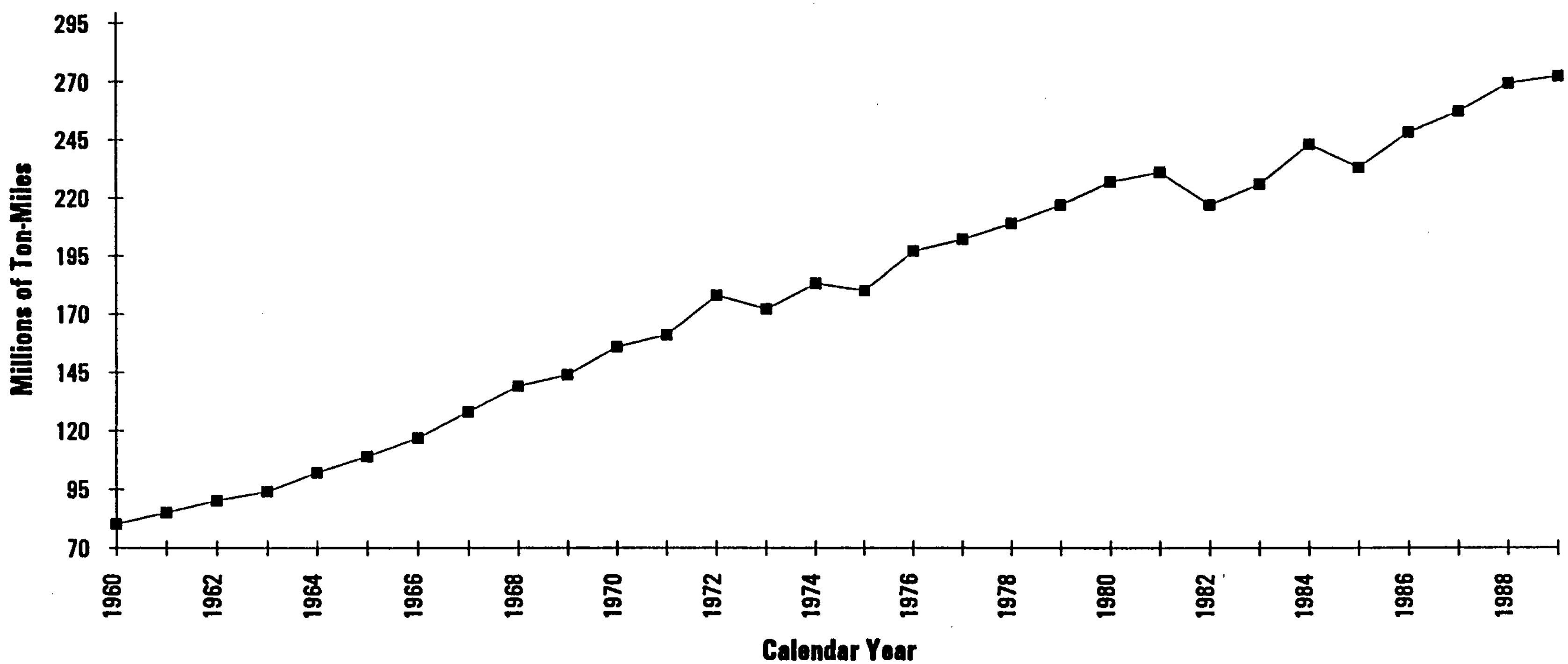
STATE	NUMBER OF TERMINALS
Illinois	252
Kentucky	175
Pennsylvania	172
W. Virginia	150
Alabama	136
Missouri	136
Ohio	123
Tennessee	122
Iowa	81
Arkansas	72
Louisiana	67
Minnesota	62
Mississippi	59
Indiana	53
Oklahoma	27
Wisconsin	18
Nebraska	17
Kansas	8
TOTAL	1,730

Figure 6-18: Tonnage of Internal Traffic Carried on U.S. Waterways, 1960-1992



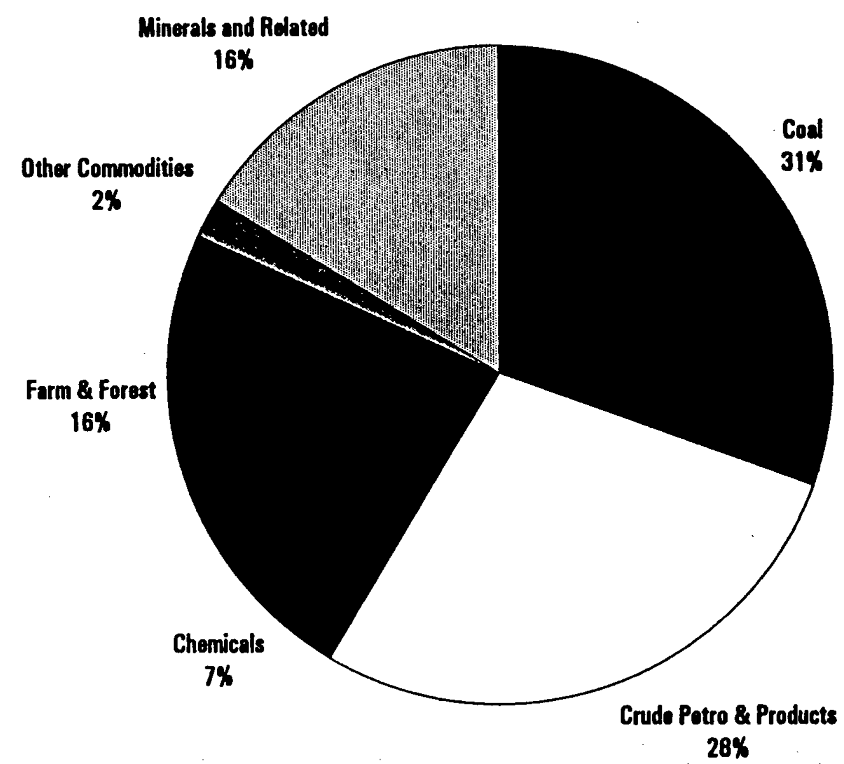
Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Part V - National Summaries, various years.

Figure 6-19: Ton Miles of Internal Traffic Carried on U.S. Shallow Draft Waterways, 1960-1989



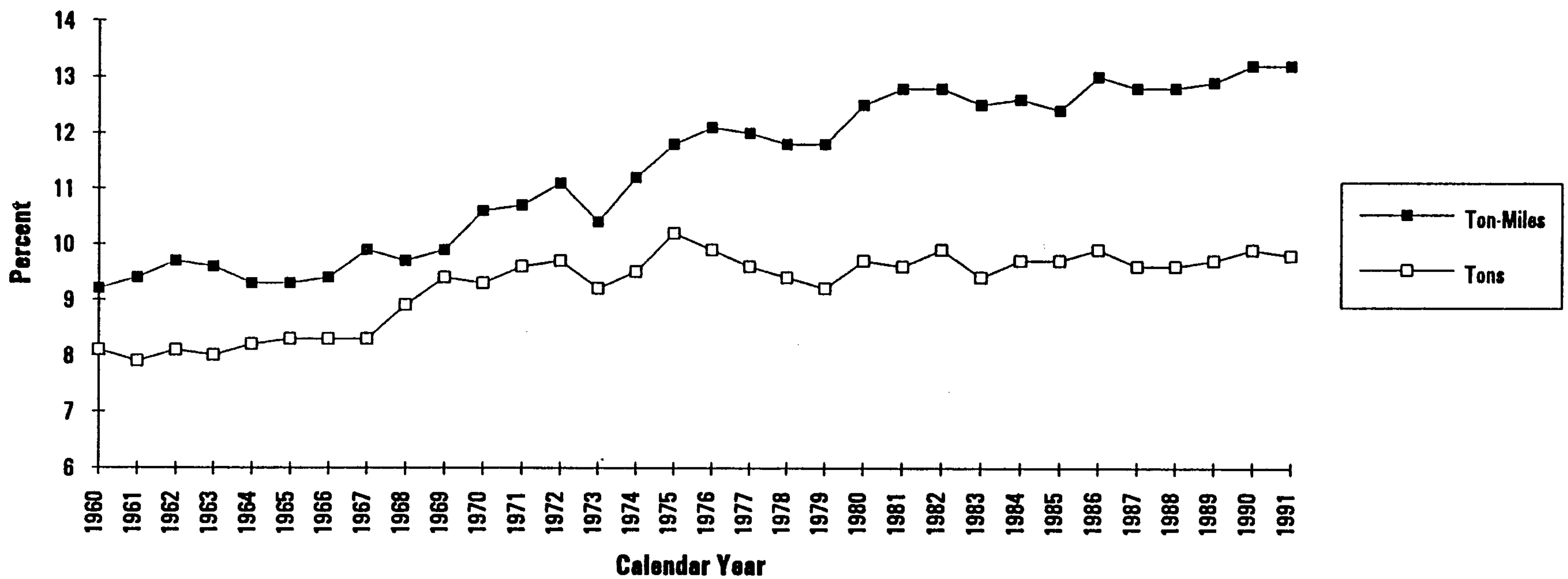
Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Part V - National Summaries, various

Figure 6-20: Waterborne Commodities Transported on U.S. Inland Waterways in 1990



Source: U.S. Army Corps of Engineers, The 1992 Inland Waterway Review, Institute for Water Resources, October 1992.

Figure 6-21: Percentage of Intercity Tons and Ton-Miles Carried on U.S. Inland Waterways, 1960-1991



Source: ENO Transportation Foundation, Inc., Transportation in America, 1992.

Delays. The average delay per tow -- a measure of the congestion or system breakdown -- is a good overall indicator of system performance. This measure is defined as total time spent waiting in queues, plus total time spent waiting during lock stalls each year, divided by the total number of commercial vessels transiting the lock. In 1990, the majority of delays occurred on the Ohio and Mississippi Rivers, where a total of 21 locks have an average delay time of two hours.[139] Over the nine river segments, average delays among locks ranged from no delay to over 10 hours in 1990.

As noted in the 1987 performance report, delays depend greatly on the traffic and condition of the lock. The Ohio and Upper Mississippi River Segments not only have the oldest and smallest locks on the system, they carry the most traffic, factors which contribute to a large number of delays on these segments. Atlantic Intracoastal Waterway and the Mobile River and Tributaries, on the other hand, had short average delays mostly because traffic was relatively light on these segments. The heavily travelled Lower Mississippi segments have relatively short delays despite high traffic. This is mostly due to the availability of modern high-capacity facilities.

The five locks with the longest average delays in 1990 were Guntersville 5 (609 minutes), Pickwick 5 (573), and Wheeler 5 (474) on the Tennessee River, Inner Harbor on the Gulf Intracoastal Waterway (516), and Winfield 1 (324) on the Kanawha River. Average delay for all 198 Corps' locks was just under 1 hour.

Processing Time. Processing time, an indicator of technology, represents the total time spent by a vessel or tow at a lock, and is shown as average processing time for individual locks.[140] Processing time, therefore, is a combination of wait, stall, and processing time.

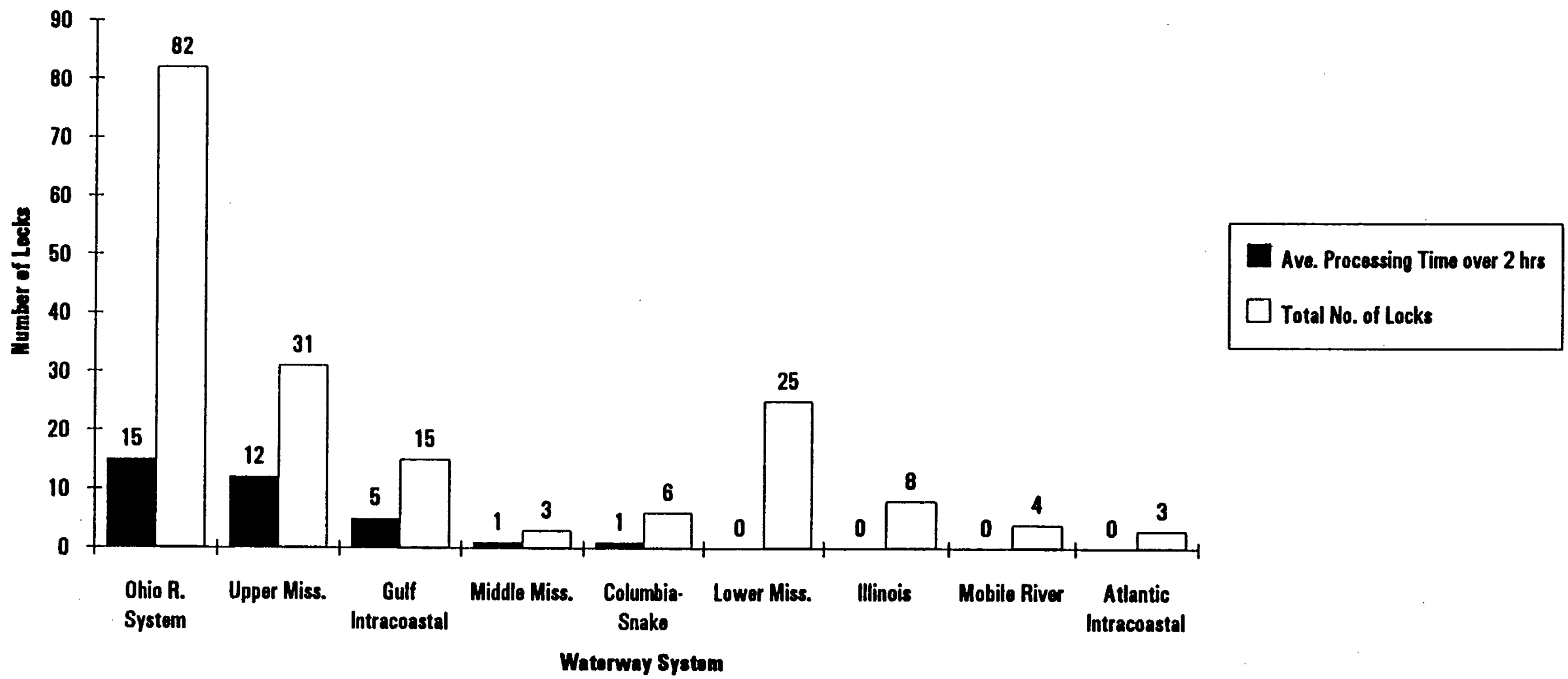
In 1990, 34 locks had an average processing time of more than two hours. Average lock processing time ranged from 5 minutes to 630 minutes on locks, with the lowest average times found on the Atlantic Intracoastal Waterway, Mobile River and Tributaries, and the Lower Mississippi (Figure 6-22). The five locks with the longest average processing time in 1990 were Guntersville 5 (630 minutes), Pickwick 5 (606), and Wheeler 5 (492) on the Tennessee River, Inner Harbor on the Gulf Intracoastal Waterway (550), and Winfield 1 (453) on the Kanawha River. Not surprisingly, these same five locks had the longest delay time as well. Overall average processing time has changed little since 1987, although there have been some improvements in certain areas such as Illinois, where the number of locks with an average processing time of more than two hours decreased from six in 1987 to zero in 1990.

Downtime. Another indicator of the quality of inland navigation services is the failure rate of locks, or simply downtime. Downtime is defined as the number of hours per year a lock is unable to operate or is stalled. This measure provides an indication of the structural soundness of a lock. There are three main reasons why a lock becomes stalled: lock conditions (lock equipment failure); natural conditions (weather); and tow (malfunction) and other conditions (accidents).

In 1990, 93 commercially operated locks had less than 50 hours of downtime with a range from zero to over 16,000 hours (almost 700 days). The four locks that had the highest stall times were Port Allen on the Gulf Intracoastal (16,532 hours), Guntersville 5 (7,030), Pickwick 5 (6,797), and Wheeler 5 (6,738) on the Tennessee River.

Utilization. Lock utilization rates help explain delays and downtime. In general, the locks with the highest utilization rates experience the most delays and significant downtime. Conversely, a lack of

Figure 6-22: Total Number of Locks and Number of Locks with 2 or More Hours Processing Time by Waterway System in 1990



Source: U.S. Army Corps of Engineers, The 1992 Inland Waterway Review, October 1992.

traffic usually results in less downtime. The lock utilization rate (expressed as a percentage) is simply the time a lock is in actual use, divided by the amount of time the lock is available in a given year. According to the 1992 Inland Waterway Review, a one percent increase in utilization for an average lock during the 1980s resulted in an additional 109 hours of delay per lock.

The data indicate that a great number of locks are in use much of the time. In 1990, 57 locks were used at least 50 percent of the time they were operational, 83 locks were used at least 40 percent of the time, and 128 locks were used at least 20 percent of the time. Locks with highest utilization rates in 1990 were the Inner Harbor (93 percent) and Algiers (88 percent) both on the Gulf Intracoastal Waterway, and Lock and Dam 16 (88 percent) and 17 (18 percent) on the Upper Mississippi. The reason these locks handle relatively low volumes of traffic yet have high utilization rates is probably due to a large amount of recreational use.

Cost Effectiveness

The cost effectiveness of the inland waterways system can be measured in terms of federal investment to maintain the system and private expenditures to use and access the system on a per unit basis. Federal investment to maintain the inland waterways system is typically measured in terms of costs per ton-mile where costs include only operation and maintenance and do not reflect depreciation of capital stocks. Since 1977, nominal unit costs for fuel taxed waterways have increased from $0.0010/ton-mile in 1977 to $0.0013/ton-mile in 1982 and $0.0016/ton-mile in 1990. In real 1987 dollars, unit costs declined slightly, from $0.0015/ton-mile in 1982 to $0.0014/ton-mile in 1990, an annual decline of 2.65 percent.

However, this overall average masks large variations in cost per ton-mile among certain segments. The Atlantic Intracoastal Waterway is one of most expensive segments to maintain, averaging in 1990, $.0293 per ton-mile. This compares to the Lower Mississippi segments, which have average maintenance cost rates of $0.0006 per ton-mile.[141]

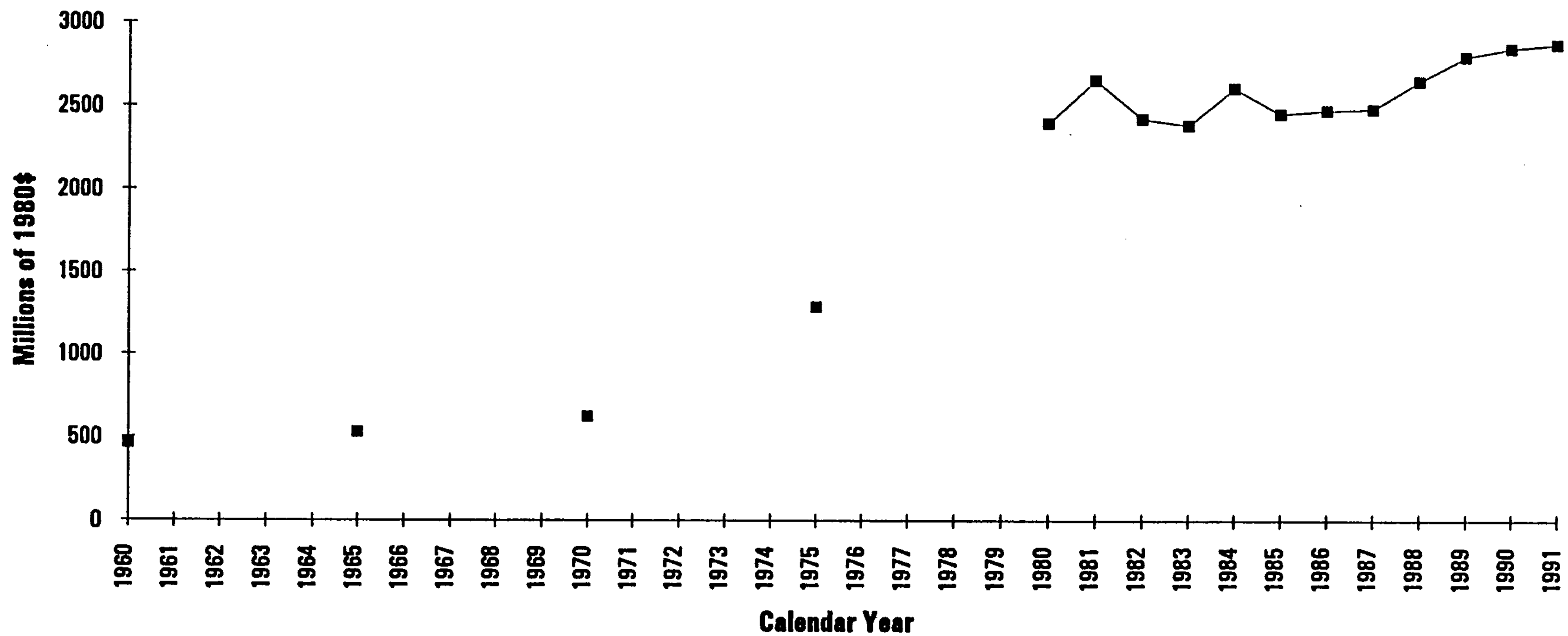
Private cost effectiveness is much harder to measure. One indicator -- the nation's inland waterways' freight bill -- measures the price consumers pay for waterborne transportation of goods and services. The nation's inland waterway freight bill increased (in 1980 dollars) from $461 million in 1960 to $2,843 million in 1990 (Figure 6-23). The trend indicates a general leveling-off of since 1980 (prior to 1980, the data are available only in five year increments).

PORTS AND HARBORS PERFORMANCE INDICATORS

This section presents four performance categories for the Corp's port dredging program: physical assets; service delivery; quality of service; and cost-effectiveness.

Most of the U.S. Army Corps of Engineers dredging budget is directed toward maintenance as opposed to new work (Figure 6-24). New work peaked in 1963 at $402 million (1987 dollars), declining to $94 million in 1992. Much of the recent increase in dredging expenditures has benefitted private dredging contractors (Figure 6-25). Since the late 1970s, the Corps has increasingly contracted out dredging to private industry. In 1975, for example, Corps dredging accounted for about 40 percent of

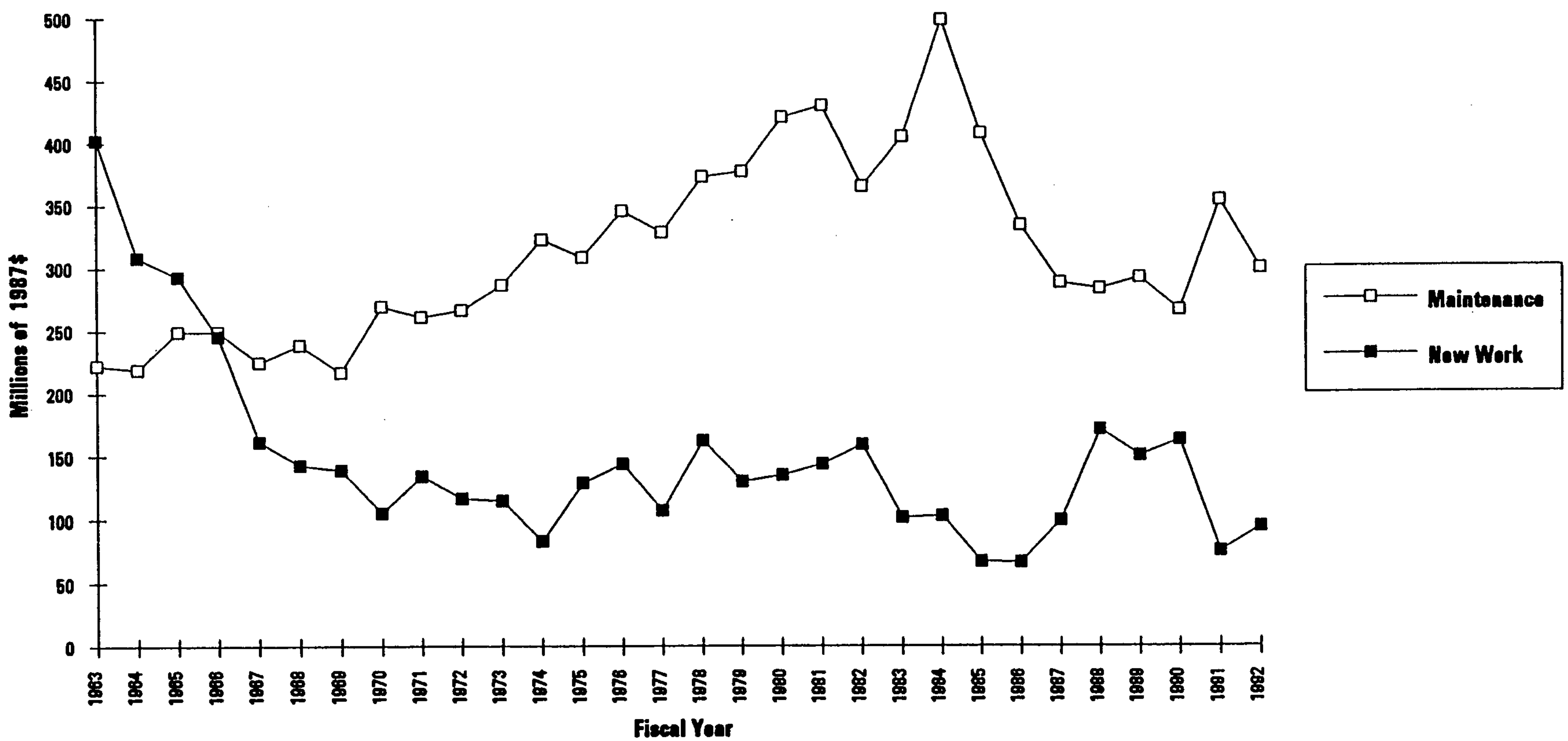
Figure 6-23: The Nations Inland Waterways Freight Bill, 1960-1991



Source: ENO Transportation Foundation, Inc., Transportation in America, 1992

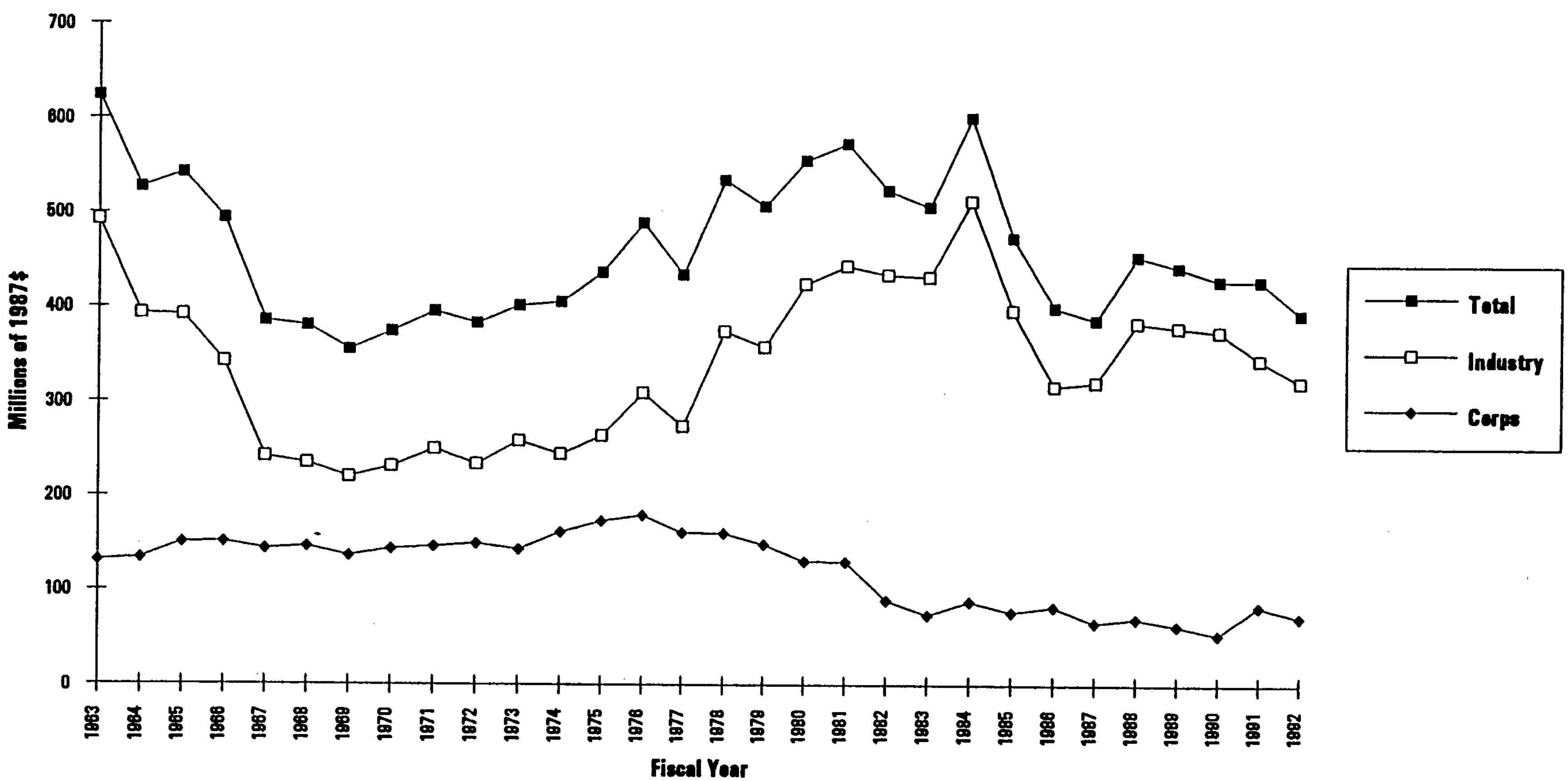
Note: Prior to 1980, data available only in 5-year intervals.

Figure 6-24: Dredging Expenditures by the U.S. Army Corps of Engineers (Corps and Industry Combined), 1963-1992



Source: U.S. Army Corps of Engineers, Navigation Office.

Figure 6-25: Dredging Expenditures by the U.S. Army Corps of Engineers and Contracted Industry, 1963-1992



Source: U.S. Army Corps of Engineers, Navigation Office the total. Presently (1992), all deepening work, and more than 80 percent of all maintenance dredging is performed by private industry.

Physical Assets

There are approximately 188 deep draft ports along the coastal United States and the Great Lakes. Investment in coastal ports is in deepening channels and maintenance dredging and non-federal investments are in landslide facilities and floating stock (vessels). However, locks are often constructed to allow ease of entrance into harbors, especially on the Great Lakes.

Landslide facilities are the responsibility of the states, local governments, and the private sector. Investment in such facilities include terminals, piers, warehouses, cranes and other loading/unloading equipment, and highway and railroad connections. A total of 1,915 terminals supported by 3,180 berths are found at U.S. ports across the nation (Table 6-4). The distribution of terminals among the four seacoasts, the Great Lakes, and the Gulf is fairly even: Gulf (26 percent); North Atlantic (22 percent); Great Lakes (19 percent); North Pacific (13 percent); South Pacific (12 percent); and South Atlantic (10 percent). General cargo make up the largest portion of terminal type (37.6 percent), followed by dry bulk (23 percent), liquid bulk (20 percent), passenger (3 percent) and other types (18 percent).[142] This distribution has changed little since 1986.

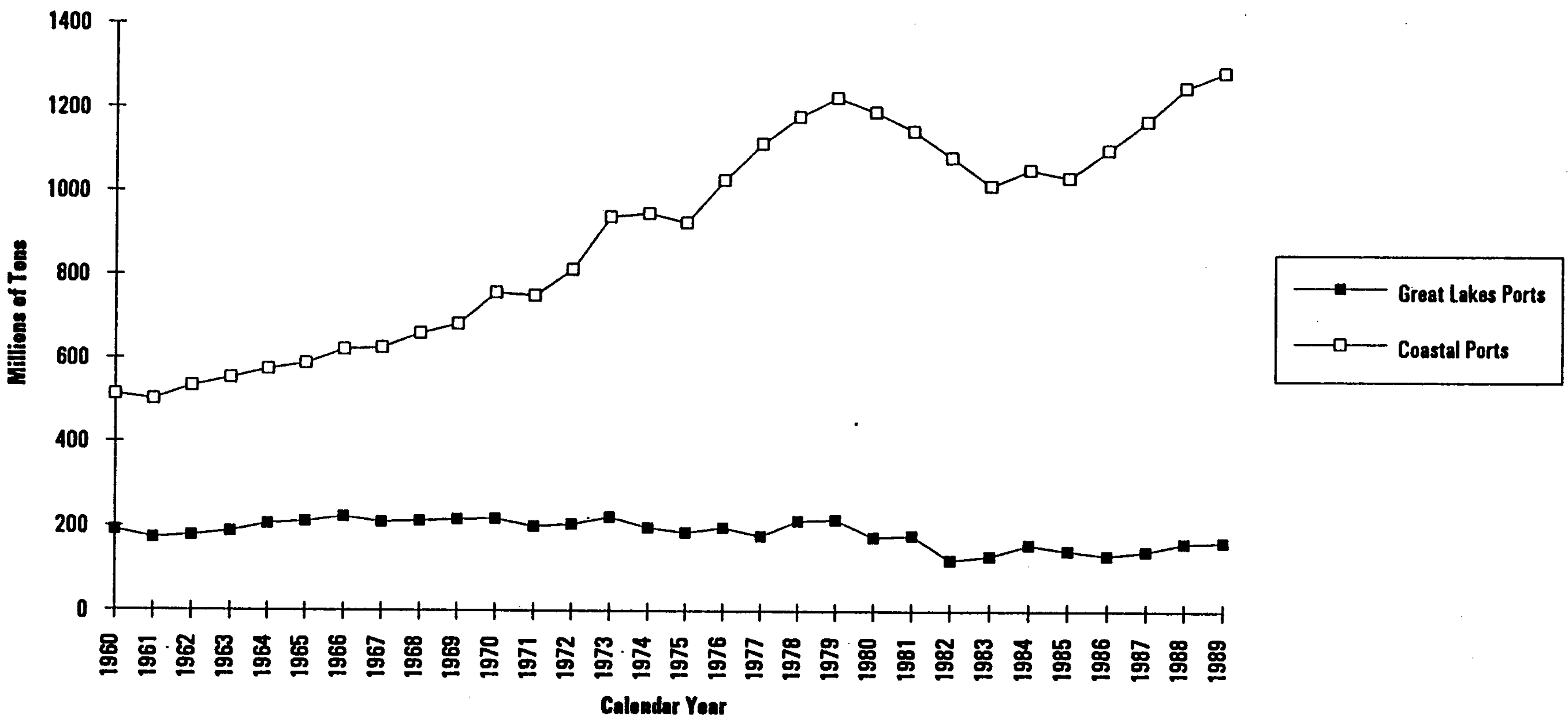
Table 6-4: U.S. Seaport Terminals by Coastal Range

Coastal Range	Number of Ports			Number of Terminals			Number of Berths		
	1982	1986	1990	1982	1986	1990	1982	1986	1990
North Atlantic	27	29	na	285	408	413	651	753	754
South Atlantic	24	24	na	103	159	184	256	290	339
Gulf	30	24	na	322	424	489	558	657	794
South Pacific	37	37	na	240	240	222	433	441	405
North Pacific	43	46	na	223	241	242	398	388	381
Great Lakes	28	28	na	283	369	365	643	516	507
Total	189	188	188	1,456	1,841	1,915	2,939	3,018	3,180

Service Delivery

The most common measure of use of the nation's ports is cargo tons handled by ports. Since 1960 the tonnage handled by U.S. ports has more than doubled, from 550 million tons to 1,500 (Figure 6-26). The decrease in tonnage from 1973 to 1976, and 1979 to 1983 was due largely to world-wide economic recession. Since 1984, total tonnage has increased through 1989 (the last year accurate data are available) at a rapid rate, reflecting U.S. economic recovery during this period. The long-term increase in tonnage

Figure 6-26: Total Tonnage of Cargo Handled by U.S. Great Lakes and Coastal Ports, 1960-1989



Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Part V, National Summaries, 1989.

has occurred at the coastal ports rather the on the Great Lakes. In fact, tonnage has actually decreased on the Great Lakes.

Quality of Service

The quality of service provided by coastal ports is based on the cargo they attract. Two possible indicators of the quality of service include: (1) maintenance of necessary channel depths (to avoid grounding); and (2), loading/off loading services. Unfortunately, very little data are available to characterize the ports in terms of either quality measure.

Maintaining channels at their authorized depths is crucial. The weakest part of a vessel, especially a tanker, is its bottom hull area. Because of this, possible damages resulting from grounding or simply striking a submerged object can be devastating. Fortunately, this type of accident rarely occurs within dredged harbor areas of major ports. This is one indication that the U.S. Army Corps of Engineers adequately maintains channel depths where necessary alerts shipping interests when channels are unsafe. It is rare that a ship cannot dock due to poor channel maintenance.

Terminal operations have a much larger impact on quality of services. These factors consist of terminal productivity, capacity, labor, and intermodal access to rail and highway transportation facilities.

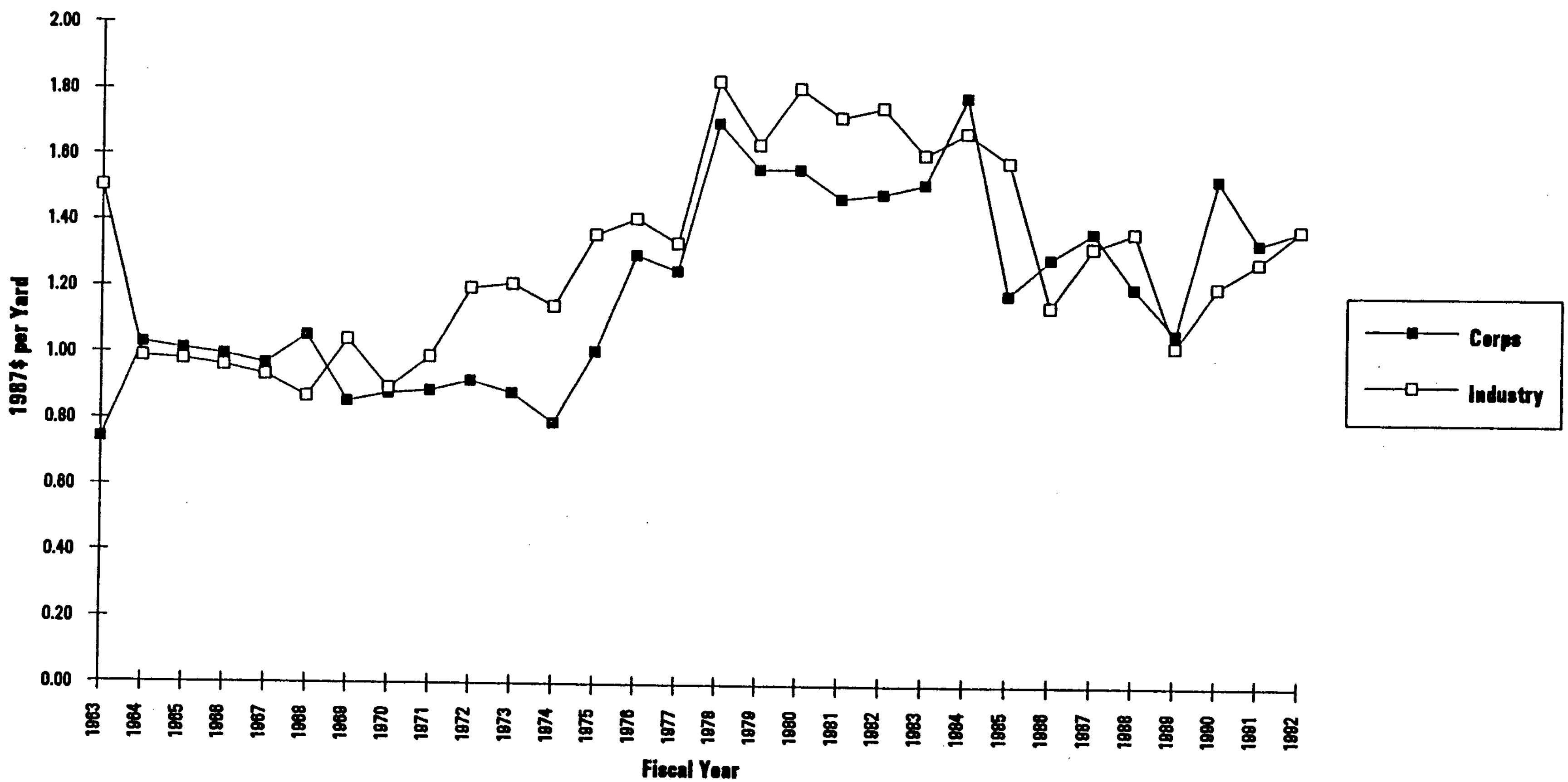
As noted in the 1987 performance report, in order to measure such factors, information would be needed on equipment failure rates, ship waiting times, crane lifts per hour, cargo damages and theft as well as output per man-hour. Since ports are largely independent authorities these data are not centralized and system-wide analysis is nearly impossible. Also, for competitive reasons, ports often are unwilling to publish such data although many shipping lines often request it. In some sense however, port services and efficiency are self-policing because inter-port competition is fierce. If delays become a problem at one port, shipping lines can simply switch to another port (subject to crowding and availability of specialized handling equipment). This is especially true in the West Coast where many ports are concentrated in the same area.

Cost Effectiveness

Measuring cost effectiveness of the Corps dredging program is difficult because natural ports require minimal dredging, while man-made ports may require constant maintenance. Although deeper ports generally have larger dredging requirements, hydro and geographic factors greatly influence dredging requirements.

To account for these differences, cost effectiveness can be measured as unit cost to dredge a cubic yard of sediment (Figure 6-27). The unit cost (1987 dollars) to dredge one yard of material increased from $0.74 in 1963 to $1.39 in 1992 (Corps dredging). Dollars per yard increased rapidly during the 1970s, before stabilizing and slightly falling in the 1980s and early 1990s. Although a time-series of cost to dredge one cubic yard of sediment may suggest a trend in cost effectiveness, dredging costs vary widely depending on the dredged material make-up, geographic location, type of disposal (open water, confined facility, etc.), type of dredging equipment used, and environmental concerns. Unit costs should, therefore, be cautiously interpreted.

Figure 6-27: Unit Costs for Maintenance Dredging (Corps and Industry), 1963-1992



Source: U.S. Army Corps of Engineers, Navigation Office.

CHAPTER VII: WASTEWATER TREATMENT

GOALS OF WASTEWATER TREATMENT

Wastewater treatment facilities remove wastes from water used by individuals and by commercial and industrial establishments before release of the water to its natural environment. Construction of wastewater treatment facilities began in major U.S. cities in the latter part of the 19th century. The primary goal was protection of human health and the elimination of public nuisances. The resulting improvement in the natural environment supported economic development and aesthetic values.

The national interest in wastewater treatment was not given statutory recognition until 1948. Since 1956, federal grants have been made available to localities to defray a portion of the cost of building treatment facilities. In 1972, the Federal Water Pollution Control Act was amended to enunciate the national goals of attaining sufficiently pure ambient water quality to protect and propagate fish and wildlife and provide for recreation in and on the water by 1983. Congress set a longer term goal of eliminating entirely the discharge of pollutants into navigable waters. Federal construction grants were authorized for up to 75 percent of the cost of publicly owned wastewater treatment plants.

Since 1987, federal grants have been made available to states to capitalize State Revolving Fund (SRF) programs. Under these programs, states loan monies to municipalities or regional authorities to finance upgrades to, or new construction of, wastewater treatment facilities. The amount of future funding for the SRF program and the construction grant program will be determined by the reauthorization of the Clean Water Act in 1993 or 1994.

OVERALL PERFORMANCE OF WASTEWATER FACILITIES

Analysis of the nearly 15,700 wastewater treatment facilities indicates that in general, these facilities continue to provide wastewater treatment that complies with national standards. However, compliance with national standards does not necessarily result in an improvement in water quality. Natural degradation or runoff from farm land and city streets may so degrade waterways that properly operated municipal treatment plants do not result in cleaner rivers or streams.

IMPROVING PERFORMANCE REPORTING IN THE FUTURE

EPA's biennial Needs Survey continues to be the most complete source of asset data on the nation's sewage treatment plants. The most current Needs Survey was completed in 1988; a Needs Survey was completed in 1990, but the scope of the 1990 survey was scaled down from previous efforts resulting in data and analysis that is not directly comparable to those in previous surveys. For this reason, the 1988 Needs Survey is the latest source of available information for most performance indicators. The 1992 Needs Survey, available in August 1993, uses the same survey methodology as the 1988 Needs Survey and will be an invaluable source for future performance updates.

Since the last report, information on the characteristics of wastewater conveyance systems is still not available. Very little is yet known about the relationship between operations and maintenance expenditures (O&M), fee structures, and sewage treatment plant performance. Moreover, there are little data linking the construction and operation of treatment facilities to water quality improvements. The collection of such information could sharpen investment priorities at the local, state, and federal government levels.

OVERVIEW OF WASTEWATER MANAGEMENT

Wastewater treatment plants can be characterized by their size and type of service. Size is a function of treatment capacity in millions of gallons per day (mgd). Type of service is dependent on the processes employed to treat the waste. Plants provide either primary treatment (40 percent to 50 percent removal of pollutants prior to discharge), secondary treatment (85 percent removal), or advanced treatment (greater than 85 percent removal). Another small category of treatment plants do not discharge to a receiving water body.

Since the 1987 performance report, there has been little change in the number and performance of wastewater treatment facilities. The number of treatment plants in operation increased by less than one percent from 15,438 to 15,591 facilities, and national flow capacity increased by 2.9 percent (Table 7-1). Large capacity plants that discharge more than 10 mgd continue to account for most (91 percent) of total national flow capacity (37,639 mgd). Most (81 percent) facilities continue to be small capacity facilities with discharge of less than one million gallons per day (mgd). In both 1986 and 1988, the amount of wastewater treated to advanced levels is roughly comparable to flows treated to secondary levels. Since 1986, there has been a small (2 percent) decrease in the total flow receiving less than secondary treatment. This follows as more treatment facilities are constructed or upgraded to meet national standards.

Government Roles

Decision making in wastewater management takes place in all three levels of government: federal, state, and local. Each group, however, plays a fundamentally different role in the process.

Federal Government. The federal government enacts laws, promulgates regulations, and develops procedures and guidelines for managing water quality. The Environmental Protection Agency sets national policy affecting the types of technologies that will qualify for grants and the processes that constitute cost-effective planning. EPA has managed a Construction Grant Program since 1972 that provides financial assistance for the construction of wastewater treatment facilities. Federal wastewater capital grants are apportioned among the states based on population and a joint EPA/state estimate of state "need". The Water Quality Act of 1987 replaced the Title II Construction Grants Program (scheduled to be phased out by the 1990s) with the State Revolving Fund (SRF) program. SRFs are loan programs with initial capital provided through federal seed money and state contributions. States use the fund to provide a range of loan assistance to local governments, and as loans are repaid, the fund is replenished. All 50 states and Puerto Rico have established SRF Programs and have received at least one grant.[143]

Table 7-1: Distribution of Wastewater Treatment Facilities in the United States By Size and Level of Treatment

SIZE (mgd) AND LEVEL OF TREATMENT	NUMBER OF PLANTS IN OPERATION IN 1988	FLOW CAPACITY (mgd)	PERCENT OF TOTAL FLOW
SIZE (mgd)			
0.01 to 0.10	5,983	259	.9
0.11 to 1.00	6,589	2,307	8.0
1.01 to 10.00	2,427	7,178	25.0
10.01 and above	446	18,992	66.1
Other *	146	8,903	NA **
TOTAL	15,591	37,639	100.0
LEVEL OF TREATMENT			
Less Than Secondary	1,789	5,030	13.3
Secondary	8,536	16,087	42.7
Greater Than Secondary	3,412	15,488	41.2
No Discharge	1,854	1,034	2.8
TOTAL ***	15,591	37,639	100.0

* Flow data were unavailable for these facilities.

** Percent of flow capacity based on 28,736 facilities; unknown facilities not included.

*** There are an additional 117 raw discharge facilities serving 1,367,172 people (0.6% of population). Raw discharge facilities are considered collection, not treatment facilities.

Source: U.S. Environmental Protection Agency, 1988 Needs Survey Report to Congress: Assessment of Publicly Owned Wastewater Treatment Facilities in the United States, (February 1989).

The transition into SRFs recognizes the broader context of restoring and protecting water quality, by including as eligible projects not only the construction of municipal wastewater treatment facilities, but also the implementation of non-point source control programs, groundwater protection strategies, and estuarine resource conservation and protection plans. The Federal SRF capitalization grant program is authorized only through 1994, but may be extended through the year 2000 as part of the reauthorization of the Clean Water Act in 1983 or 1984.

State Government. State governments provide financing for wastewater facilities and operate water quality management programs which involve setting water quality standards, determining effluent limits, issuing effluent limitation permits, and enforcing compliance with the permits. States also ensure local compliance with state water quality plans and minimum design and construction standards. With the SRF program, state governments have taken a much larger role in wastewater treatment as they must continuously plan for water quality management, operate the SRF program, and loan monies to finance the construction of wastewater treatment facilities. When accepting the capitalization grants for SRFs, the states must agree to enter into binding agreements with municipalities, to issue loans or other funding assistance for 120 percent of each quarterly grant payment not later than one year after each payment is received.

Local Government. In general, local governments plan, finance, construct, operate, and maintain wastewater treatment facilities. Local governments are responsible for the design, timing, cost effectiveness, and final selection of facilities. Localities also oversee construction and operation of treatment facilities, with user fees and sometimes general tax assessments supporting operations.

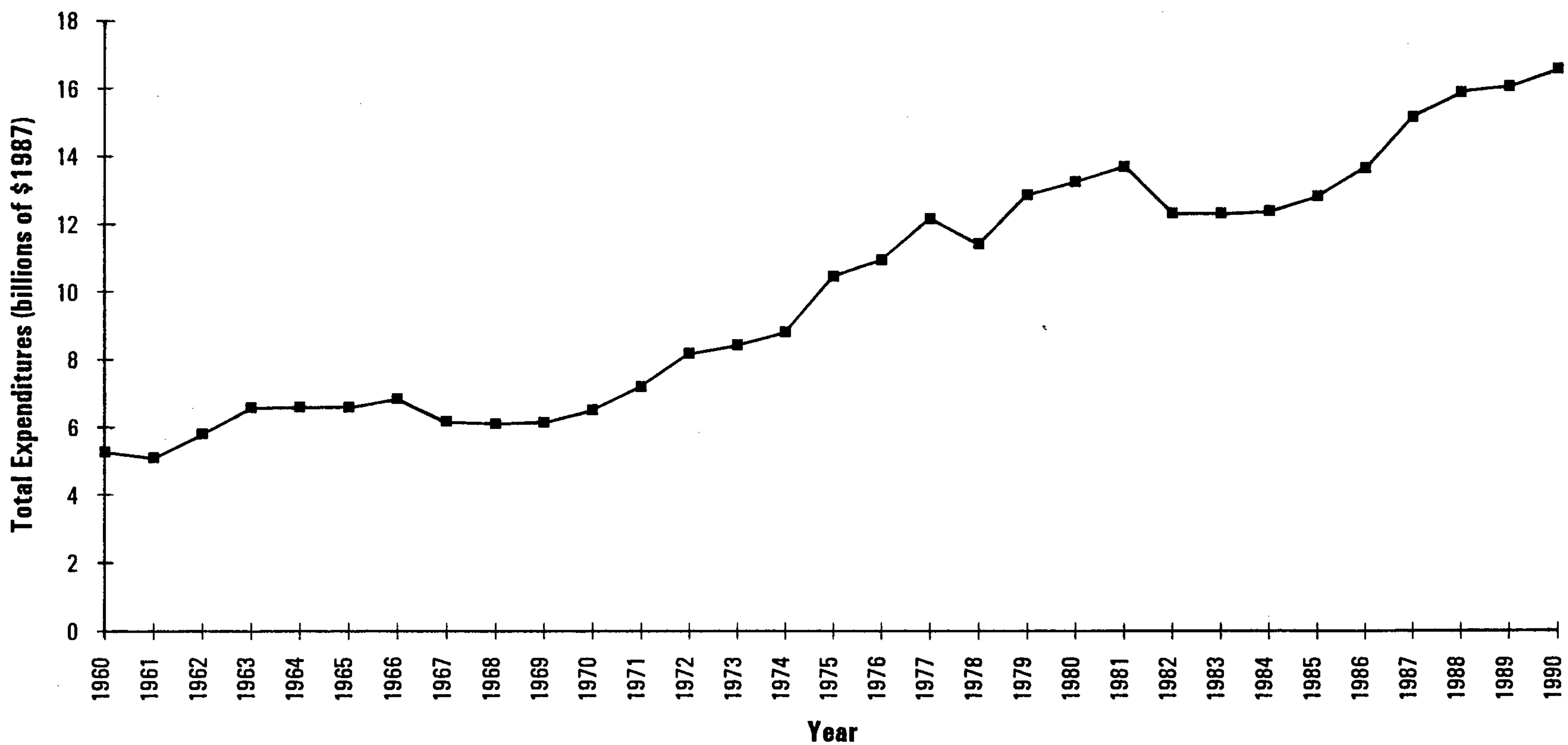
Recent Spending Trends and Financial Condition of Facilities

Total public spending for wastewater treatment has continued to increase annually. Since 1984, real total government expenditures (1987 dollars) have increased by 4.7 percent a year - from $12.4 billion in 1984 to $16.6 billion in 1990 (Figure 7-1). During this period, the largest increase in public spending occurred between 1986 and 1987 when total public expenditures increased by 9.9 percent a year from $13.6 billion in 1986 to $15.1 billion in 1987. This sharp increase corresponds with the initiation of the State Revolving Loan Fund (SRF) Program. If total government expenditures continue to increase by 4.7 percent a year, total public spending would approach $27 billion in 2000.

There continues to be two general trends driving wastewater treatment expenditures. First, while real total capital spending has declined from its peak of nearly $8.6 billion in 1981, real operating costs show no sign of levelling off (Figure 7-2). From a relatively low $1.2 billion a year in 1960, outlays for O&M have increased steadily by about 6.4 percent a year to $8.8 billion in 1990. This growth in aggregate operating expense has stemmed from growth in the number of treatment plants, miles of sewers in service, and number of households served by these facilities. A recent survey of 50 large wastewater systems found that O&M expenses increased by 35 percent, on average, between 1983 and 1986.[144]

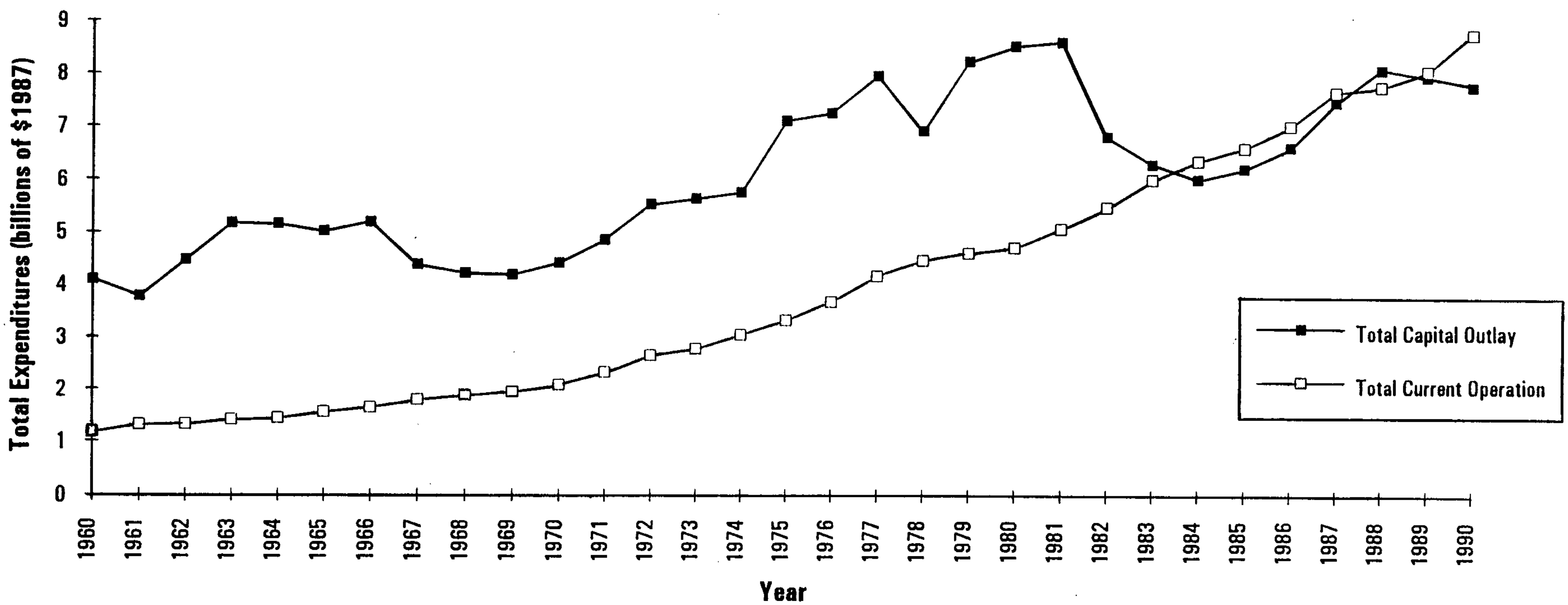
The second underlying trend is the substitution of Federal capital spending for state and local capital outlays. Prior to the onset of EPA's Construction Grants program in the early 1970s, state and local real capital spending ranged between $3 billion and $5 billion a year, and comprised approximately 75 percent of total public spending. But, as Federal capital grants expanded rapidly in the mid- to late-1970s, state and local capital outlays decreased to only 34 percent of total public expenditures. This

Figure 7-1: Total Government Expenditures for Wastewater Treatment, 1960-1990



Source: Bureau of the Census, Government Finances data series.

Figure 7-2: Total Capital Outlay and Current Operation Expenditures for Wastewater Treatment



Source: Census Government Finances data

relative decline in state and local capital spending has continued throughout the 1980s; by 1990 state and local capital expenditures comprised only 47 percent of total capital expenditures.

PERFORMANCE OF MUNICIPAL WASTEWATER MANAGEMENT FACILITIES

This section discusses performance indicators at five levels: physical assets; service delivery; quality of service; external effects; and cost effectiveness. Data are generally available for most of these indicators on a biennial basis from 1980 to 1988.[145]

As in all public works categories, the choice of performance measures is critical to the conclusions drawn about overall modal performance. In wastewater treatment, there is considerable uncertainty over the link between the provision of physical facilities and the achievement of national water quality goals. Only limited statements appear justifiable, therefore, regarding the overall performance of this category.

Physical Assets

Two broad categories of physical assets for which national data are available include: sewer systems (number of systems in operation nationwide) and wastewater treatment facilities (the total number of treatment facilities, their total design capacity, and the total population served, all by treatment level). By themselves, asset data are not adequate indicators of the performance of wastewater treatment systems, but do provide valuable support for the other measures of performance that follow. Physical assets represent the most direct measure of the extent to which the nation is meeting the literal statutory mandate for minimum wastewater treatment facilities.

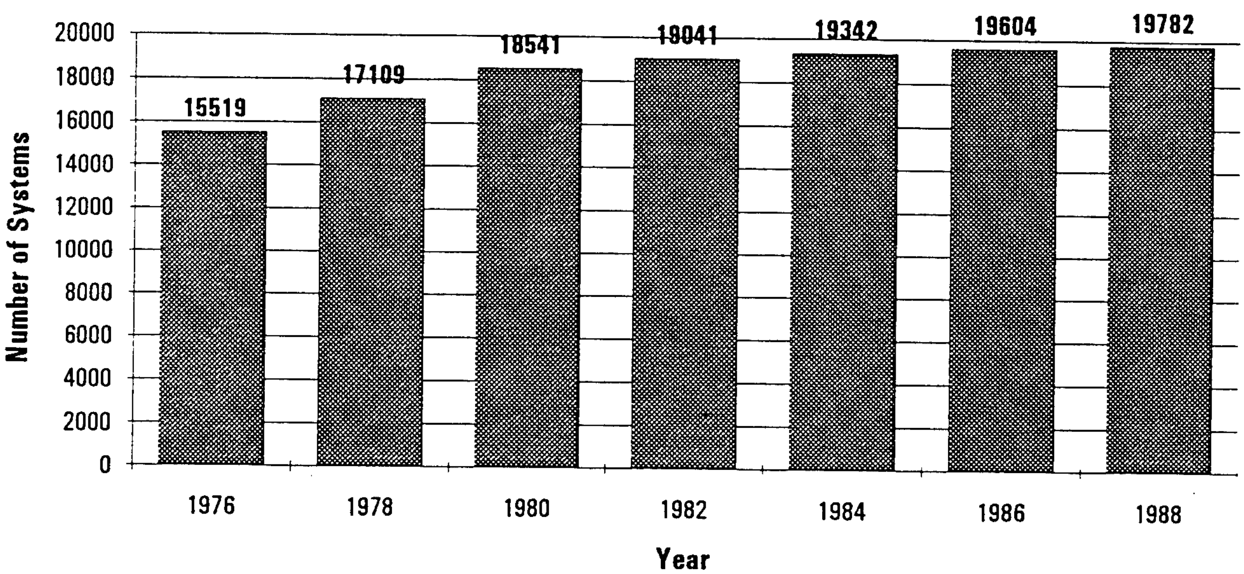
Sewer Systems. The total number of collection systems continues to increase, with a one percent increase between 1986 and 1988. From 1978 to 1988, the number of sewer systems has grown by about 22 percent (Figure 7-3). This corresponds with similar growth trends in the number of treatment plants and treatment plant capacity. The number of sewer systems only roughly tracks total growth in wastewater treated since a single system can convey varying wastewater flows depending upon pipe diameter. Also multiple sewer systems can serve a single treatment plant.

Treatment Facilities. The total number of treatment plants has grown by about 15 percent between 1976 and 1988 (Figure 7-4). There continues to be an increase in the number of secondary and above treatment plants relative to the number of below secondary treatment plants. This trend toward more and more secondary treatment corresponds with the implementation of the Clean Water Act.

Overall capacity of treatment plants grew by approximately 16 percent over the period 1978-1988 (Figure 7-5). From 1980 to 1988, growth has averaged only one percent a year. There is also a steady increase in the capacity of secondary treatment plants relative to below secondary treatment plants.

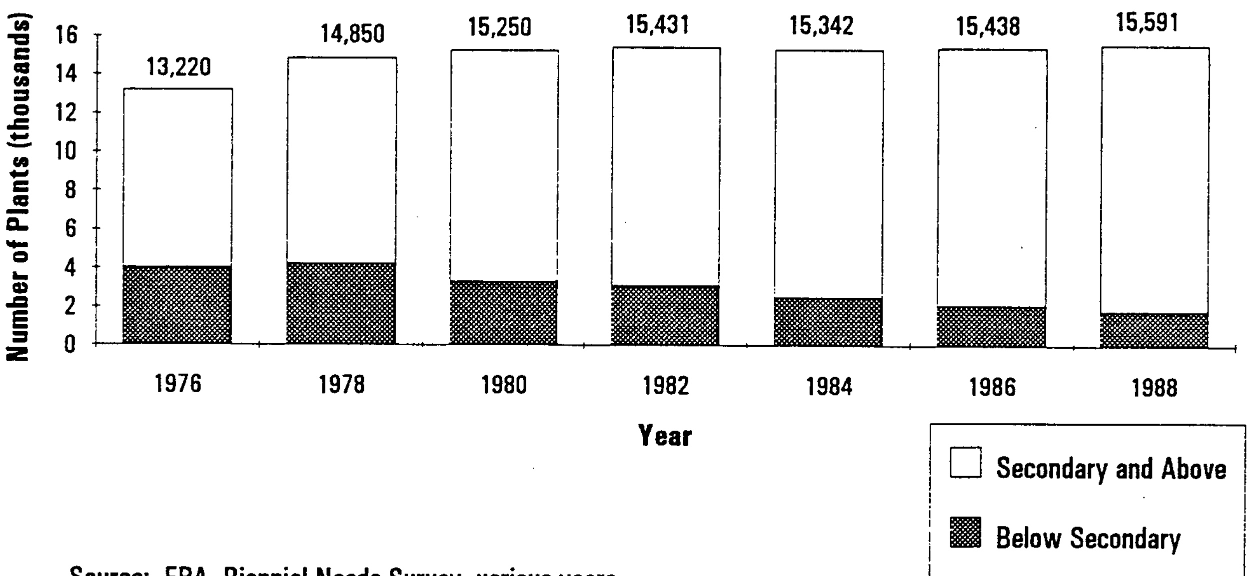
While both the total number and capacity of treatment plants has been increasing over time, the number and capacity of treatment plants that treat waste only up to the primary level has been declining. This result is consistent with the national goal of bringing all treatment plants to the level of secondary treatment or better.

Figure 7-3: Number of Collection Systems, 1976 - 1988



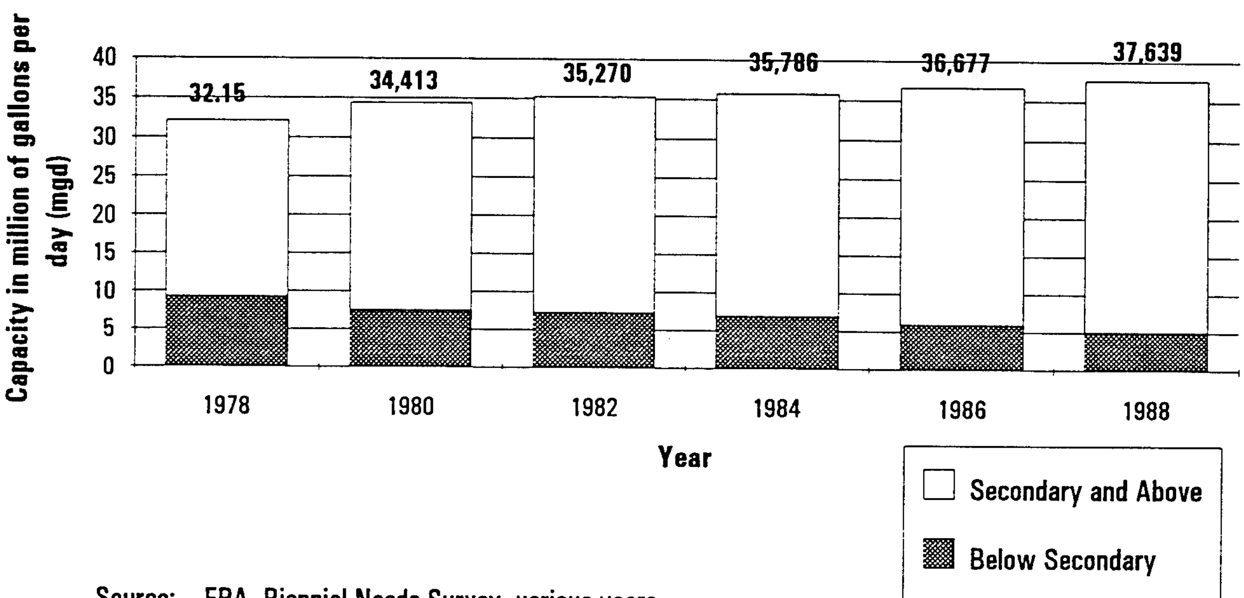
Source: EPA, Biennial Needs Survey, various years.

Figure 7-4: Total Number of Treatment Plants By Level of Treatment, By Year, 1976-1988



Source: EPA, Biennial Needs Survey, various years.

Figure: 7-5: Capacity of Treatment Plants By Level of Treatment, By Year, 1978-1988



Source: EPA, Biennial Needs Survey, various years.

Population Served. Another way to view the increasing demand for wastewater treatment and the system's ability to meet that demand is the population served by centralized treatment. The proportion of the U.S. population served by centralized wastewater treatment facilities increased each year from 1986 through 1988 (74.9 percent and 77.3 percent respectively) (Figure 7-6).

Net Capital Stock. Net capital stock of wastewater treatment facilities grew steadily by 3.5 percent a year, from a little over $52.1 billion in 1960 to $144.6 billion in 1990 (Figure 7-7). Growth averaged 4.0 percent from 1970 to 1980, slowing to 2.2 percent between 1980 and 1990. The continued positive trend over the period 1960 through 1990 signifies that new additions to wastewater treatment capital stock (treatment plants plus conveyance facilities) has outpaced the depreciation of existing plant and equipment.

Service Delivery

Service delivery measures include the volume of wastewater treated and the reserve capacity available to serve future populations.

Volume of Wastewater Treated. The historical trend in the volume of wastewater treated is exhibited in Figure 7-8. Volume (in mgd) is given for each two-year period from 1976 to 1988. The volume of wastewater treated continues to increase each two-year period and grew by roughly 11 percent over the 12 year time frame (from 25,535 mgd in 1976 to 28,736 mgd in 1988). This is largely an intuitive result, considering that the number and overall capacity of treatment plants as well as the population served by treatment plants has risen during the same ten-year period.

Reserve Capacity. Reserve capacity is simply the difference between design capacity and the actual volume of wastewater treated. Available reserve capacity is an important concept because it signifies the degree to which municipalities are planning for future increases in demand. The large increase in reserve capacity from 1978 through 1988 bodes well for the ability to meet future demand for wastewater treatment, although it may be an indication of over investment.

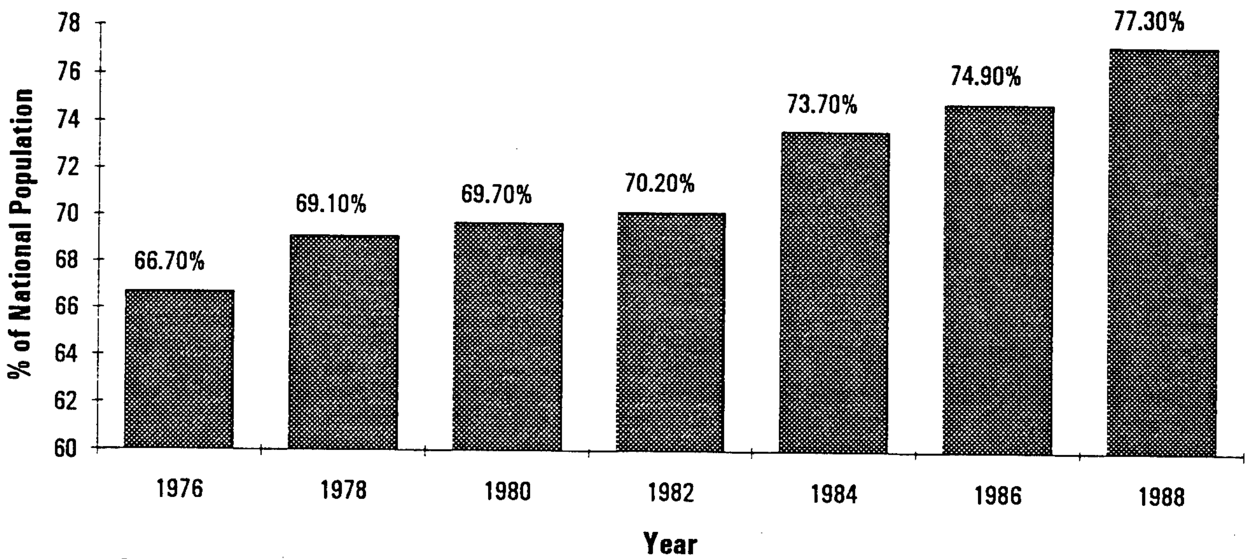
Figure 7-9 examines the reserve capacity available in each two-year period since 1978. In 1988, reserve capacity as a percentage of total flow treated was 35 percent, indicating no statistically significant change in reserve capacity since 1980. Between 1980 and 1988, reserve capacity has remained steady at around 33 percent. The data indicates that the Clean Water Act amendments in 1981 that restricted the use of federal grants for reserve capacity after 1985 have not resulted in a decrease in reserve capacity, although more recent data is needed before further conclusions can be made.

Quality of Service

Quality of service is made up of two interrelated but distinct components: quality of service to the direct users; and quality of service to the "rest of the world", as measured by system externalities.[146]

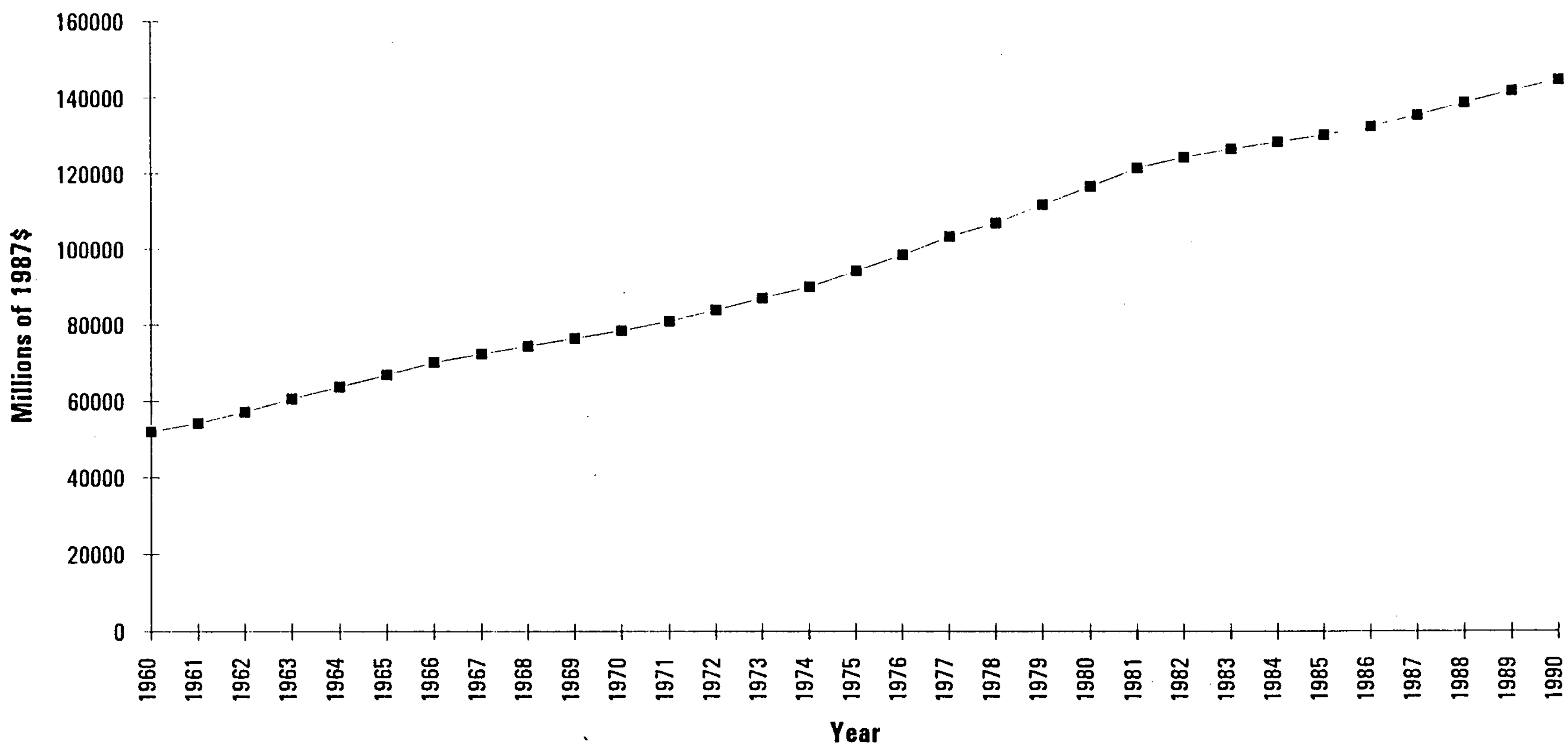
Quality of service to users is a broad category that includes concerns for reliability, health, safety, environmental impacts, and progress toward meeting national goals. Unfortunately, many measures are difficult to link to wastewater treatment facilities alone because of other sources of water pollution. Comprehensive data are not available on the contamination of water supplies (both surface water and

Figure 7-6: Percentage of National Population Served by Centralized Treatment Plants, 1976-1988



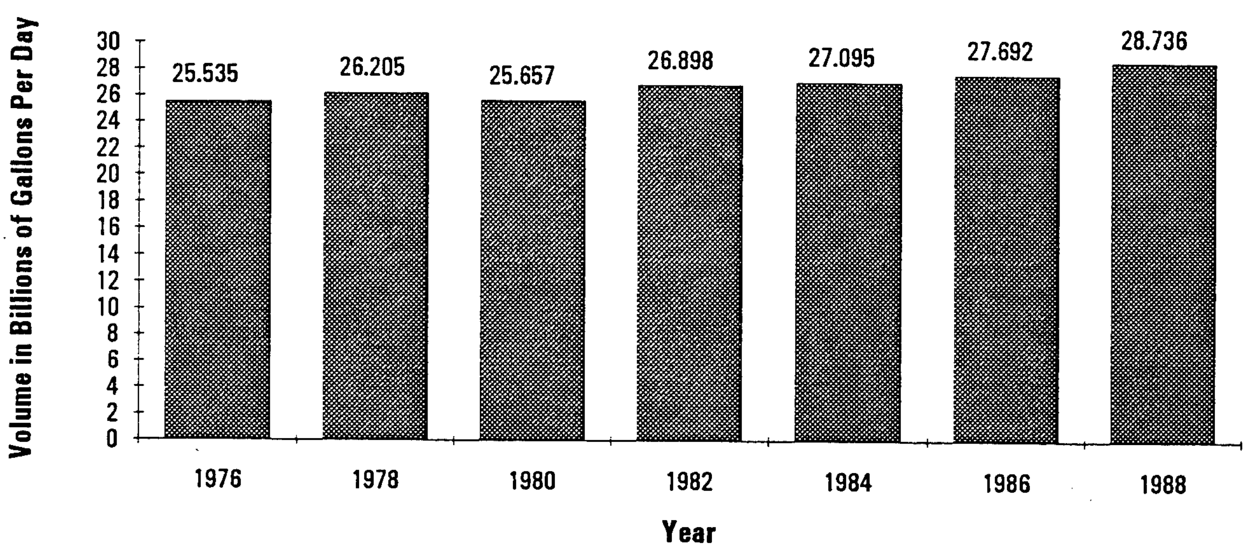
Source: EPA, Biennial Needs Survey, various years.

Figure 7-7: Net Wastewater Treatment Capital Stock



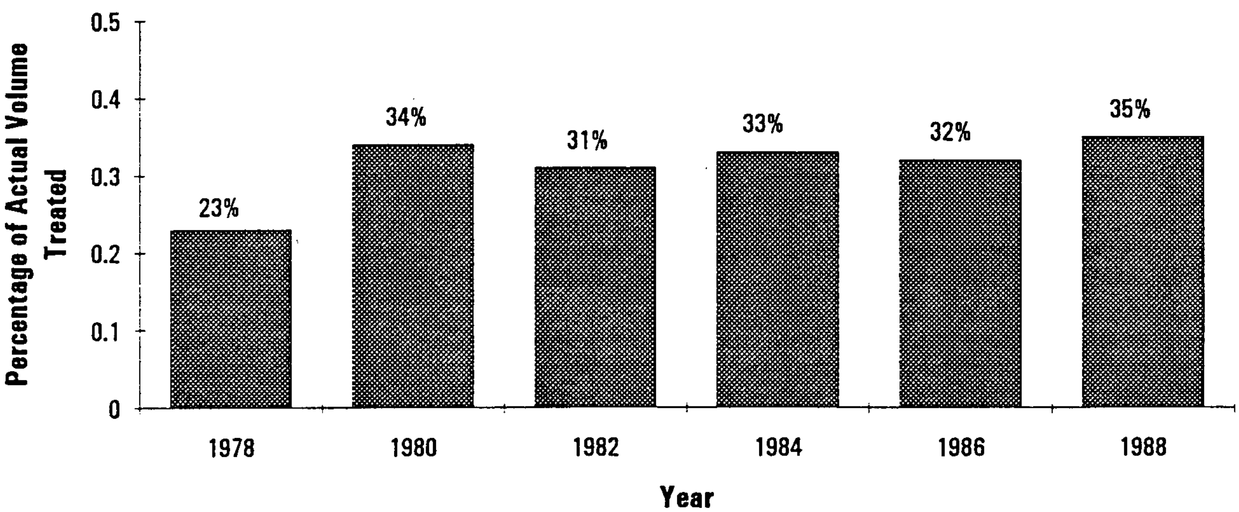
Source: Apogee Research from Census Government Finances data

Figure 7-8: Volume of Wastewater Treated By Year, 1976-1988



Source: EPA, Biennial Needs Survey, various years.

Figure 7-9: Reserve Capacity as a Percentage of Treated Volume, 1978-1988



Source: EPA, Biennial Needs Survey, various years.

groundwater) and the impairment of public health from wastewaters, aerosols, and sludges. Statistics do not exist covering the reliability of either wastewater treatment or collection systems at the national level.

Three measures of quality for which data do exist include ambient water quality reviews, facility compliance with effluent limits, and worker safety.

Ambient Water Quality. Important progress has been made since the 1972 Clean Water Act to reduce the impact of conventional (i.e. non-toxic) pollutants from traditional point sources, such as wastewater treatment facilities. Although wastewater treatments continue to cause localized water quality problems, they are no longer leading causes of pollution in the United States. Instead, pollution from nontraditional sources such as farmlands, city streets, construction sites, and mines adversely affects more waters. Toxic pollutants which are both difficult and expensive to detect and control also continue to impair our water resources.

Two nationwide sampling networks permit nationally consistent analyses of long-term water quality trends at more than 300 locations on major U.S. rivers. These networks -- The National Stream Quality Accounting Network (NASQAN) and the National Water Quality Surveillance System (NWQSS) -- are operated by the U.S. Geological Survey. Together, they provide an indication of the progress toward meeting national water quality goals.

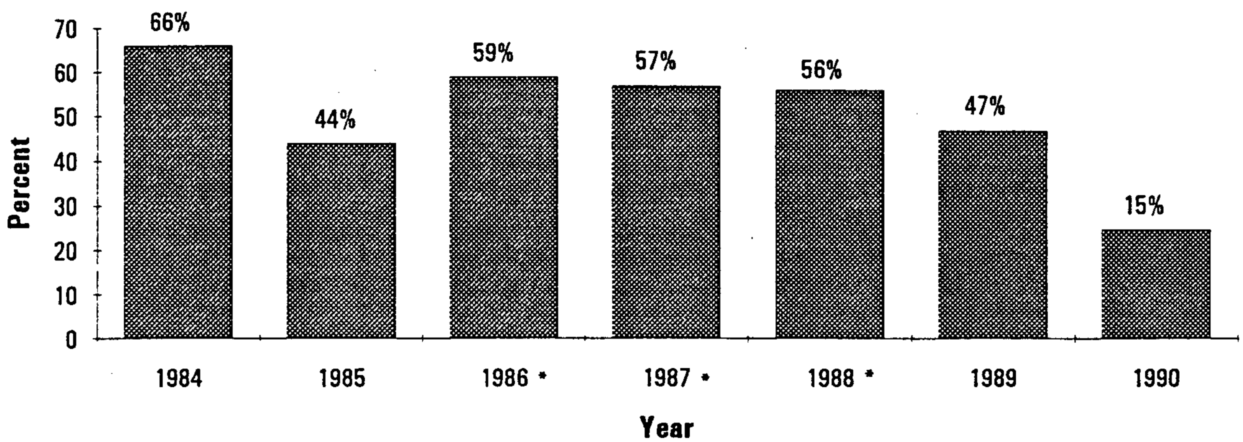
Overall, stream water quality data continue to be far from conclusive in measuring the progress toward attaining national clean water goals. Although there is more water quality data available since the last performance report was published, difficulties still remain in isolating the effects of wastewater treatment plants to water quality improvement since water quality is influenced by a number of other factors including agricultural run-off, water temperature, and water flow. Despite these inherent difficulties EPA reported to Congress in 1992 that municipal discharges effect 16 percent of all impaired river waters.[147] In a similar study, the Government Accounting Office (GAO) modelled the linkages between ambient water quality and Construction Grant expenditures in four case study areas. In three of the four case studies, GAO found a linkage between wastewater treatment improvements and water quality.[148] Before broad conclusions can be drawn from this study, additional work needs to be done.

Compliance With Effluent Limits. Reliable data on a national scale are available from 1985 to 1990. Figure 7-10 shows the rates of significant noncompliance based on statistics maintained by EPA from June 1984 through October 1990. This figure indicates a general trend toward greater compliance. However, effluent limits are generally not subjected to a systematic risk/cost analysis and therefore, may not be economically or environmentally justified. As such, compliance with these limits may be a misleading or inappropriate performance standard.

The large decrease in noncompliance rates in 1990 (from 47 percent in 1989 to 15 percent in 1990) may be due in part to a change in data collection methods. The 1990 rate was calculated by EPA directly from its automated Permit Compliance System (PCS) database. This database consists of periodic measurements of different discharge parameters such as municipal treatment plant violations of BOD, suspended solids, nitrogen, and phosphorus for all of the major facilities (greater than 10 mgd) operating in the country.[149]

Worker Safety. The level of safety for wastewater treatment and collection systems covers the occurrence and seriousness of injuries to maintenance workers.[150] The frequency of injuries is a rough

Figure 7-10: National Composite Rates of Municipal Treatment Facilities in Significant Non-Compliance (Percent) 1984 - 1990



(*) - reflects NPDES rule change

Source: U.S. Environmental Protection Agency, National Water Quality Inventory: 1990 Report to Congress, prepared by the Office of Water. Washington D.C. (1992).

indicator of the quality of sewerage structures and more to the point, the quality of labor associated with sewer system maintenance. The injury frequency rate is the number of worker injuries occurring per million man-hours of labor; the severity rate is equal to the number of days lost from work per million man-hours or labor.

From 1968 to 1986 the trend in injury frequency rates is generally upward with a high of 61.64 injuries in 1981 and a low of 28.30 injuries in 1968 (Figure 7-11). Howe ɜr, from 1986 to 1988, the overall injury frequency rate was down 18.6 percent from 50.93 injuries per million man-hours worked to 41.48 in 1988. Severity rates continue to remain relatively constant for the period 1978 to 1988 (Figure 7-12). The two most recent surveys in 1987 and 1988 have revealed a severity rate in the high 600s (691 in 1987, 689 in 1988).

Lower rates for injury frequency from 1986 to 1988 could be due to the stabilization in construction activity and fewer new wastewater treatment facilities coming on-line. This data may also indicate that the work force is maturing, becoming more professional, and has begun to master its trade. The need no longer exists for large numbers of unskilled and untrained workers. Increased awareness of safety and health issues may have also contributed to this encouraging downward trend in injury rates. If these premises hold true, then injury rates should continue to decline during the 1990s.

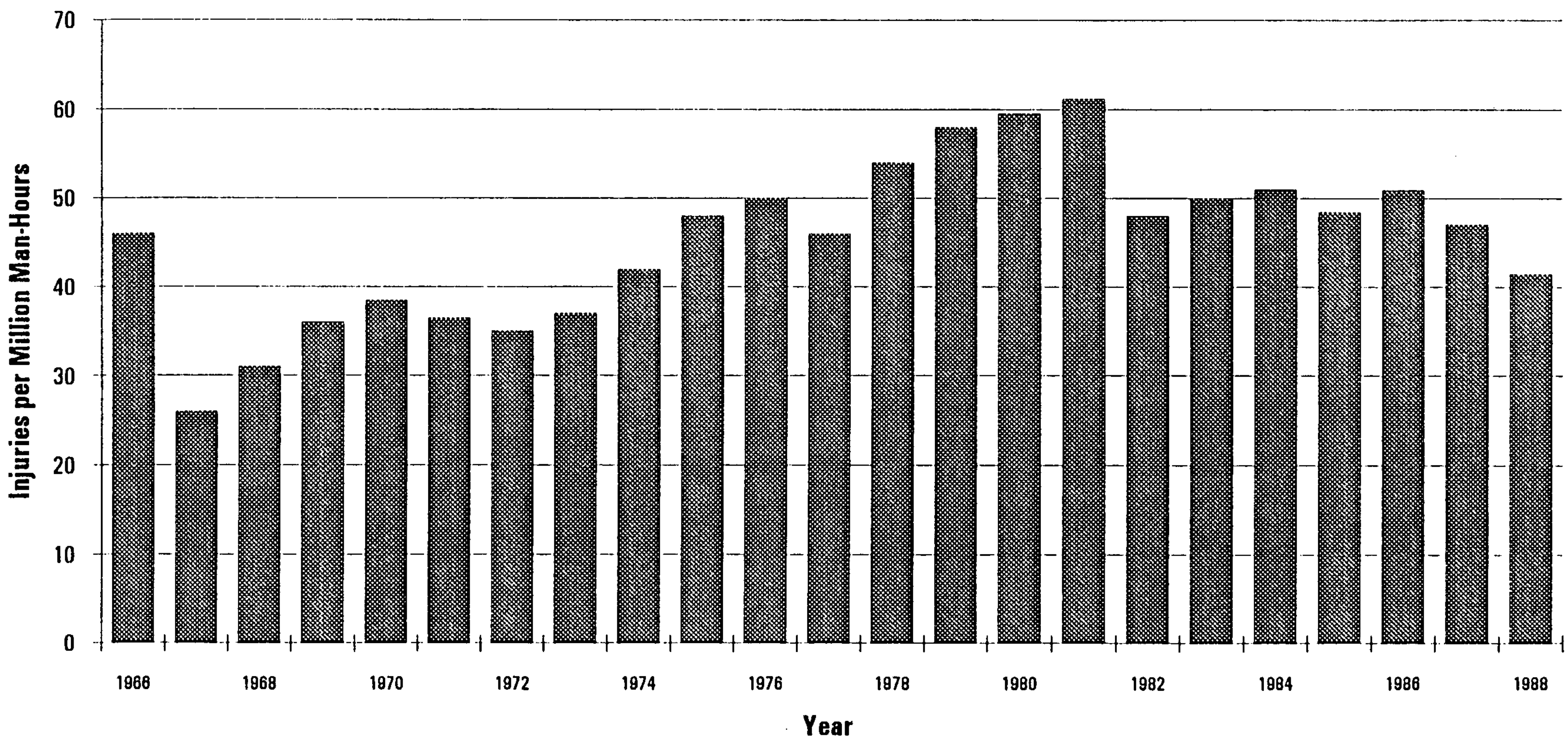
Lower rates for both injury frequency and severity in the past four year period (48.4 injuries on average with severity rates in the high 600s) could suggest a reduction in the use of labor intensive processes, thereby decreasing the chance of injury. Another possible explanation could be that employee training programs and increased safety measures are having a positive effect on the occurrence and severity of injuries.

Cost Effectiveness

One measure of cost effectiveness in wastewater treatment is the volume of output achieved per dollar invested in a given project. The previous performance report specified two types of unit cost measurements: capital; and operations and maintenance (O&M).[151] Because of changes in the data collected for the EPA Biennial Needs Survey, it is impossible to update the available data on national capital costs. However, updated data is still available on unit O&M costs. As in the previous report, aggregated national data is not available to allow for our unit O&M cost calculations to control for both level of treatment (greater levels of removal are associated with higher unit costs) and for size of facility (larger facilities demonstrate economies of scale with lower unit costs).

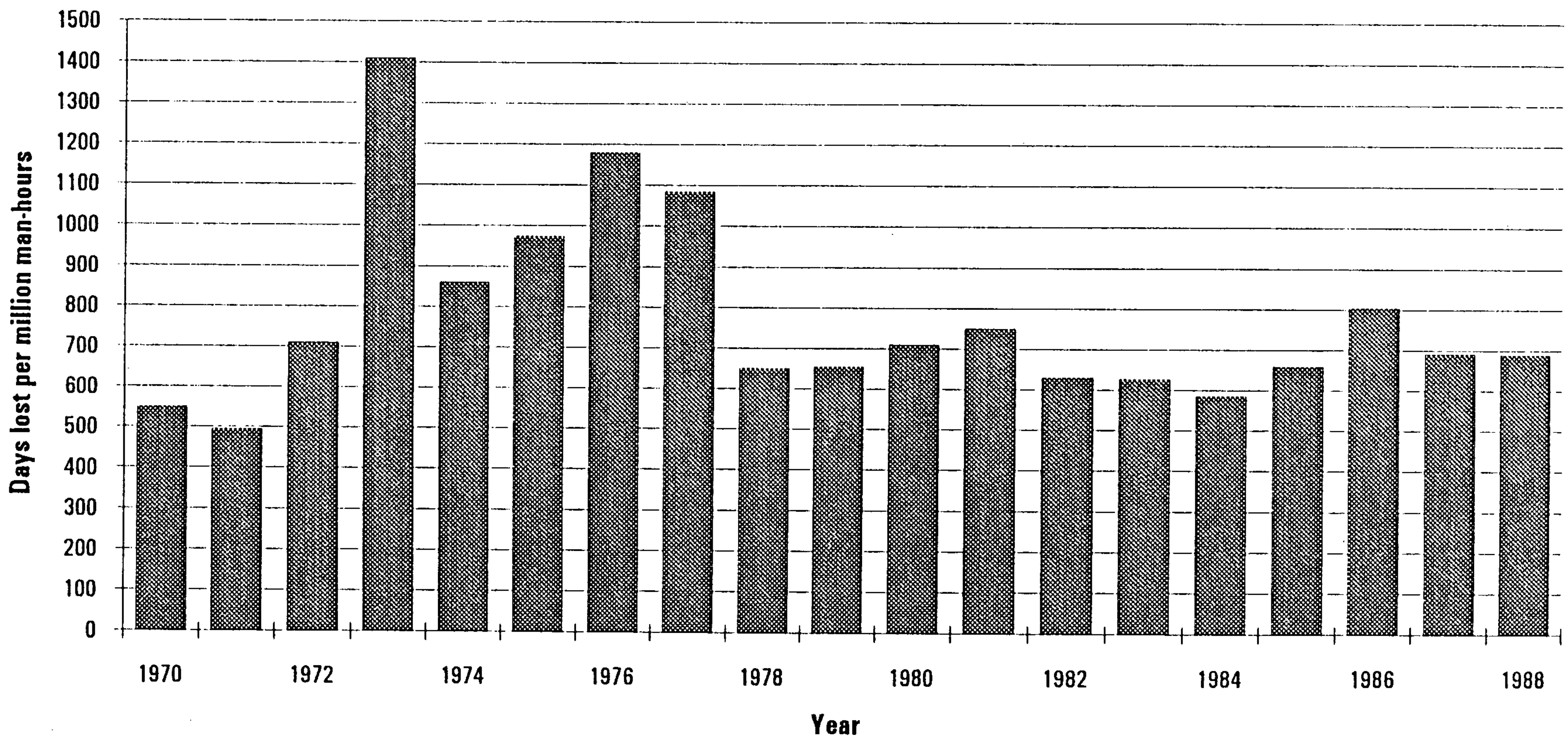
Unit O&M costs (constant 1987 dollars) have increased since 1976. The national average cost to operate and maintain treatment facilities increased from 14 cents per gallon per day in 1976 to about 27 cents in 1988 (Figure 7-13). This 88 percent increase could be attributable to plants operating well below capacity or to an increase in chemical- and energy-intensive systems.

Figure 7-11: Sewer System Maintenance Injury Frequency Rate, 1966 - 1988



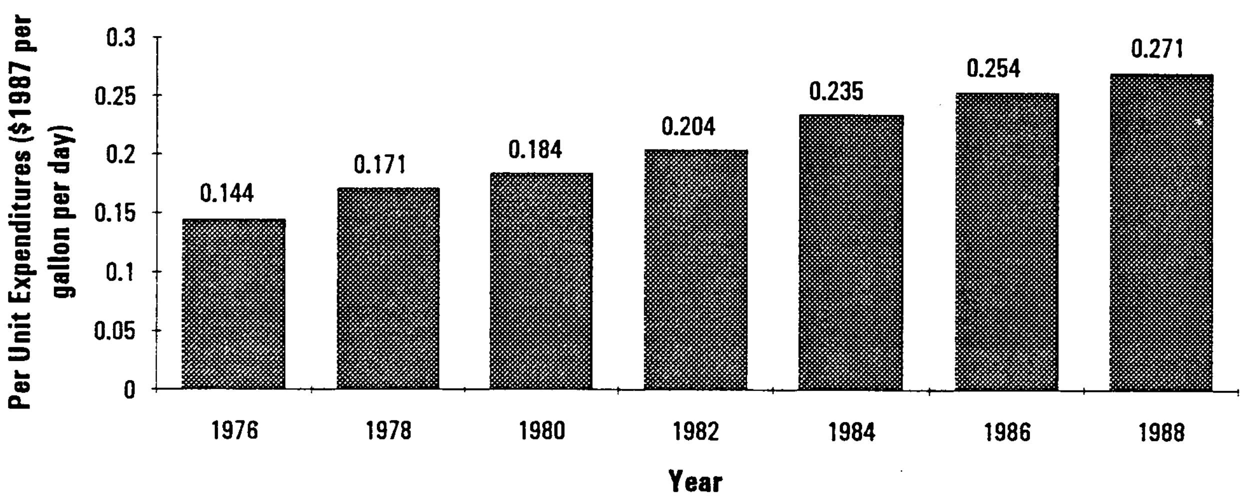
Source: Water Pollution Control Federation, Safety Survey, various years.

Figure 7-12: Injury Severity Rate for Sewer System Maintenance Workers, 1970 - 1988



Source: Water Pollution Control Federation, Safety Survey, various years.

Figure 7-13: O&M Expenditures Per Unit Volume Treated, 1976-1988



Source: Apogee Research from Biennial Needs Survey and Bureau of Census, Government Finances series.

CHAPTER VIII: PUBLIC WATER SUPPLY

GOALS OF PUBLIC WATER SUPPLY

The goals of public water supply have remained basically the same as described in the 1987 performance report. Municipalities regard an adequate supply of water as an essential service to ensure public health and safety, economic growth, and community well-being. Although individual systems may vary greatly with respect to their engineering sophistication and complexity of operation, they all deliver the same product and rely on similar treatment, storage, and distribution technologies. As such, there are two overall goals of a water supply system, whether public or private:

- Deliver sufficient quantities of water at suitable pressure at the minimum cost for consumption and fire protection; and

- Deliver sufficient quantities of water that meet the levels of quality mandated or acceptable for its various uses, such as residential, commercial, and industrial applications.

These overall goals are the basis by which all changes in performance indicators in this chapter are measured.

OVERALL PERFORMANCE OF WATER SUPPLY SYSTEMS

There continues to be relatively little data and few analyses available to evaluate the performance of community water facilities on a nationwide basis. Those few statistically significant samples of the nearly 60,000 water systems reveal a largely self-sufficient cross-section of publicly and privately owned utilities, the majority of which produce a high-quality product at reasonable cost.

Yet, there continues to be certain regional and country-wide problems that could affect future performance. One such regional concern is the deterioration of storage and distribution systems within older cities, especially in the Northeast. Public water systems in all regions of the country face potential financial difficulties arising from such factors as: (1) controlled prices; (2) cost of compliance with increasingly restrictive water purity standards, particularly for small systems with limited funds; and (3) acute or chronic source contamination, particularly among groundwater users. In addition, a recent Natural Resources Defense Council (NRDC) report indicates widespread noncompliance with the Safe Drinking Water Act (SDWA), under-reporting of violations and deceit regarding the level of water contamination, and EPA's failure to enforce violations.[152]

IMPROVING PERFORMANCE REPORTING IN THE FUTURE

Performance reporting continues to be strongest at the local level, and may be expected to remain so because local governments bear final responsibility for service delivery. Nonetheless, there is some evidence that water supply managers are increasing the frequency and scope of documentation in an effort to enhance efficiency in resource use and allocation. Moreover, it is becoming increasingly difficult to justify rate increases without detailed data supporting local performance.

There have been few changes in performance reporting at the state level since the last report. As before, state involvement in water supply issues is primarily due to their growing role in implementing the Safe Drinking Water Act, the relationship between water supply planning and land use planning -- an area in which states are becoming increasingly active, and their role as regulators of investor-owned water utilities.

The federal role in water supply is more broadly supportive, consisting of standardizing water purity regulations, conducting research and disseminating information, and providing limited funding assistance to needy communities. Should nationwide information be required, the maintenance of relatively standardized databases at the state level will permit aggregation of data for a national evaluation. The federal government could develop an effective role establishing a standardized performance reporting format and assisting financially in the initial years of data collection.

OVERVIEW OF PUBLIC WATER SUPPLY

There is no single mission at the national level for the provision of public water supplies. Water supply is provided at the local or regional level by a series of disparate entities. These community and regional systems are developed, owned, and operated by various government (public) agencies, investor (private) groups, and ancillary (special) organizations (Figure 8-1).

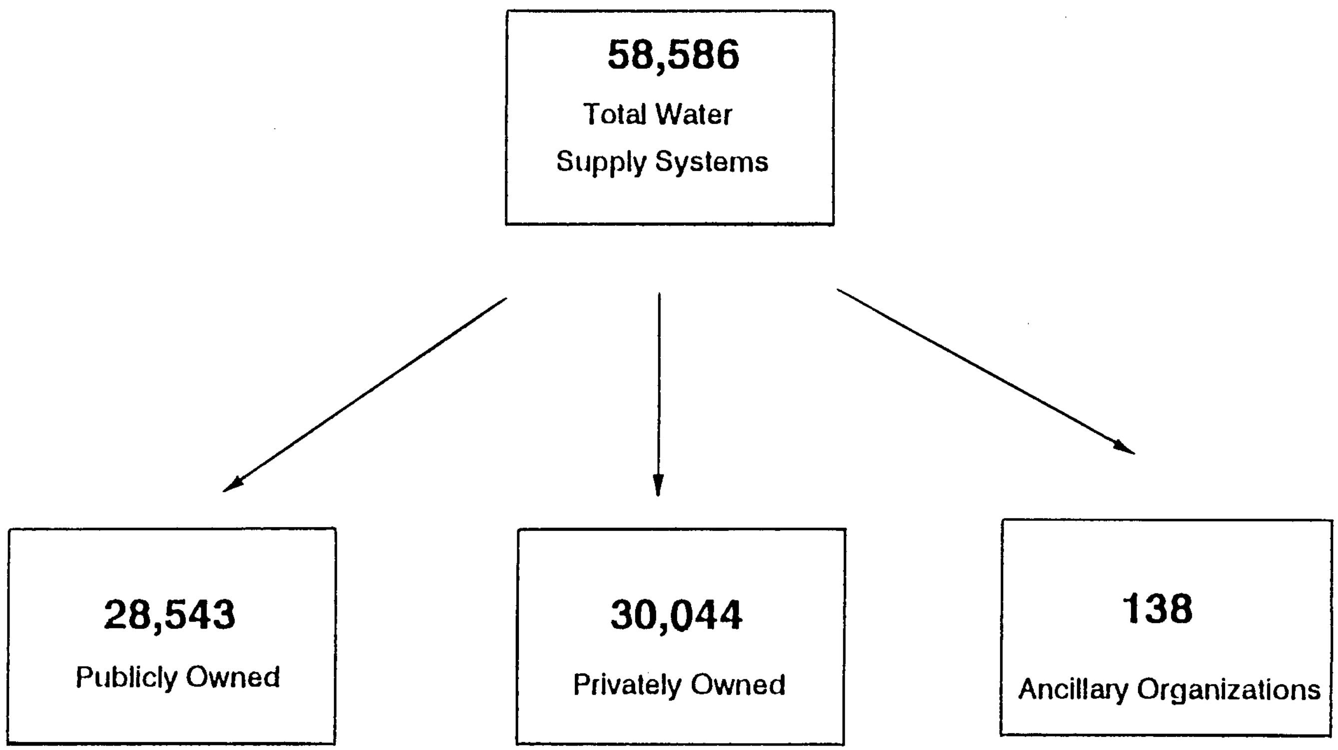
Total assets used for public water supply provision continue to vary substantially from system to system. The 1986 EPA survey reported mean assets ranging from $490,000 for systems serving less than 100 people to $650 million combined for systems serving more than one million people. The majority of these assets (about 75 to 80 percent) are concentrated in water distribution systems.[153]

Government and Private Roles

<u>Local Government</u>. Historically, public water supply has been a local government service delivery function. There are four types of local government ownership categories: municipal government/township, water district/board/commission, county government, and special regional authority. The federal Water Supply Act of 1958 formalized this policy by declaring that the primary responsibility of developing water supplies for domestic and industrial purposes be left to state and local interests. As a result, local governments have traditionally planned, financed, built, and operated autonomous water delivery systems. Now, however, there is a trend to regionalize services. Regionalization of services has helped address water allocation problems, water quality problems, revenue shortfalls, and system expansion or rehabilitation requirements.

Figure 8-1: Water Supply Systems Profile

Total Water Supply Systems



Source: EPA Office of Ground Water and Drinking Water, Federal Reporting DataSystem as of July 8, 1992.

State Government. State governments provide varying degrees of oversight and regulation of public water supply systems, although they are rarely involved in ownership or operation. The state role continues to increase over time as the federal Safe Drinking Water Act is fully implemented.[154] Overall, the major responsibilities of state government continue to be the administration and allocation of water rights and the development and maintenance of a generally favorable operating climate.

Federal Government. Historically, the federal role has focused on development of large multipurpose water projects, development of primary drinking water standards, research to support regulations, and funding support for very small communities. Over the past decade, however, the federal government's involvement in water supply development and funding support has been steadily decreasing (Table 8-1). On the other hand, the 1986 Safe Drinking Water Act significantly strengthened the federal role in setting minimum drinking water quality regulations, planning for the protection of groundwater recharge areas, protecting aquifers that are the only drinking water source for a community, and preventing the contamination of groundwater from injection of industrial hazardous waste.

Table 8-1: Federal Spending for Water Supply By Federal Agency, Fiscal Years 1986-1988 (in millions of current dollars)

	CURRENT POLICY	
Federal Agency	1986 Outlays (Actual)	1990 Outlays (Actual)
FmHA		
Loans[a]	170	238
Grants	120	128
HUD Community Development Block Grants	200	178
Economic Development Administration	15	48
Appalachian Regional Commission	10	12
TOTAL	515	604

Source: Apogee Research from published and unpublished agency documents.
[a] New loan obligations

Private Sector. In 1992, there were roughly 30,044 private (investor-owned) water utilities; nearly one-half of these utilities served less than 100 persons. Their average size is about a third as large as the average public system. These utilities perform the same functions as municipalities that provide water to service populations, with one significant exception -- the rates charged by private utilities are regulated by state public utility commissions.

Description of Financial Trends and Conditions

Since the previous performance report, there have been no significant changes in water supply finance. During the period, local governments provided about 90 percent of total expenditures on water supply, state governments about 3 percent, and the federal government about 7 percent. Real state and local capital spending (1987 dollars) have remained relatively steady between $3.8 and $5.8 billion a year since 1970. After adjusting for inflation, expenditures for operations and maintenance (O&M) have grown rapidly -- about 4.2 percent a year -- from about $6.2 billion in 1977 to $10.9 billion in 1990, largely a result of population growth and the increasing real costs of energy and chemicals (Figure 8-2). If O&M expenditures continue to grow at this rate, they will approach $16.4 billion by the year 2000.

The financial status of the nation's water supply service may be estimated through a comparison of revenues and costs among various individual systems. The EPA has noted that two major factors influencing a water system's economics are: size, due to economies of scale; and local conditions, such as varying water rates, energy costs, and operating costs.[155]

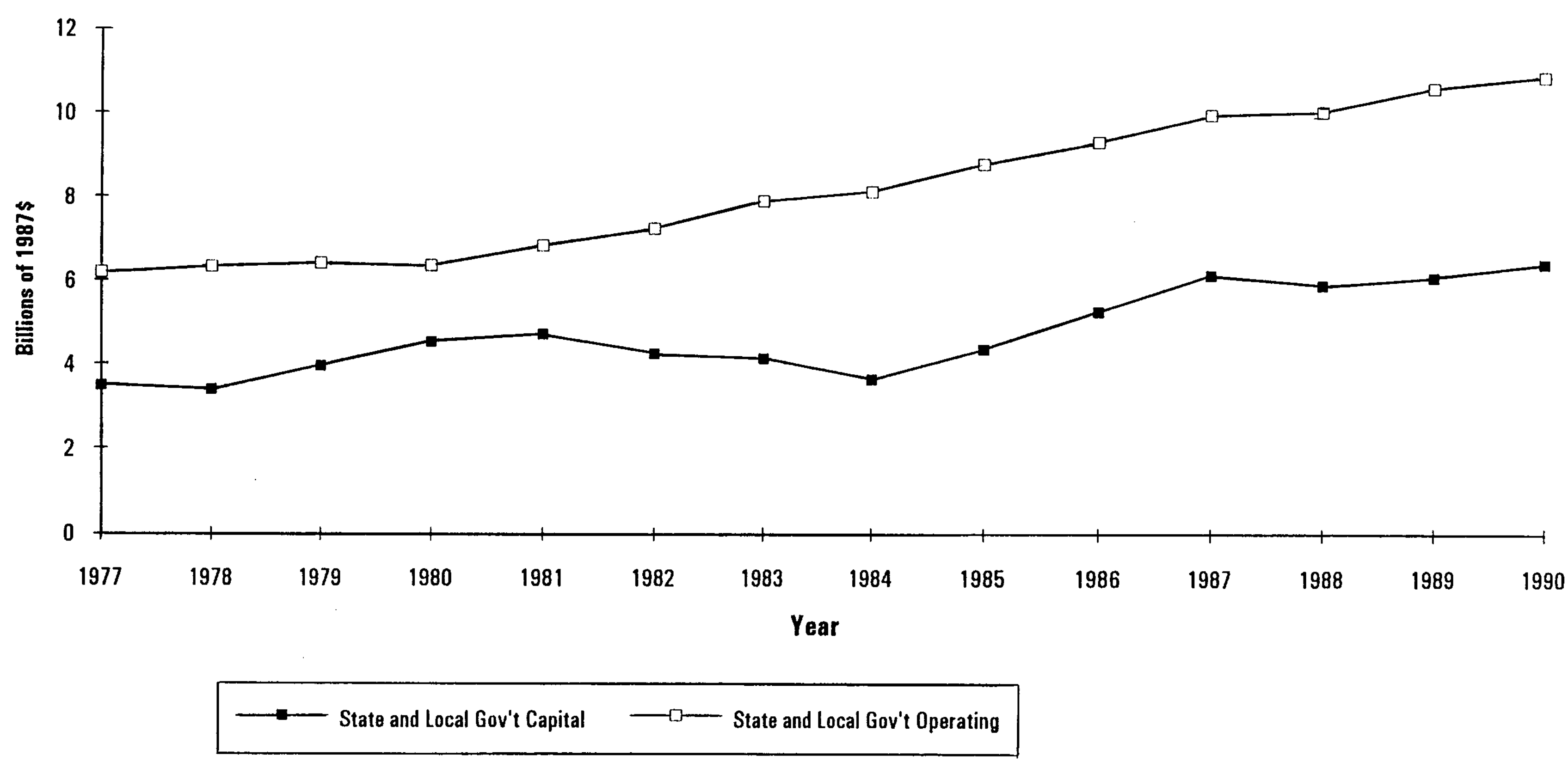
Overall, industry revenues continue to display a pattern of declining mean revenue rates with increasing system size. A 1990 survey of 1,097 public and private/investor owned utilities estimates that range to extend from approximately $1.66 per thousand gallons produced for the smallest systems (10,000 to 25,000 service population) to $1.17 for the largest systems (100,000 or greater service population).[156]

Operating expenses consist of direct and indirect costs of producing water and maintaining the water system, such as labor, fuel, electricity, chemicals, repairs, depreciation charges, and taxes or payments in lieu of taxes. There continues to be clear evidence of economies of scale in total system operating expenses. A 1992 American Water Works Association survey indicated that total operating expenses ranged from $1.47 per thousand gallons produced by systems serving 10,000 - 25,000 persons to 98 cents for systems serving over 100,000 persons.[157]

The bill for water service continues to be one of the smaller items in a typical family budget. According to a recent industry survey in 1990, the cost per 1000 gallons of water ranged from an average of $1.76 for water systems serving between 10,000 and 25,000 people to $1.56 for a water system serving 100,000 or more people. The average residential bill for water service was $182 or $1.66 per 1,000 gallons.[158]

Of course, water rates vary depending on the quantity of water used; the price of water decreases as more water is purchased. The average purchase cost for 3,750 gallons of water is $2.50 per 1000 gallons, while the average cost of 60,000 gallons decreases to only $1.30 per 1000 gallons.[159]

Figure 8-2: State and Local Government Expenditure for Water Supply, 1977-1990



Source: Census Government Finances data

PUBLIC WATER SUPPLY PERFORMANCE INDICATORS

Physical Assets

Despite their simplicity, physical assets of water systems are difficult to evaluate at the national level. They vary greatly from one system to another in terms of quantity or size, strength, age, and relative efficiency. Good records are kept only at the community, or utility, levels. At the aggregate national level, readily measurable indicators include number of systems, net capital assets, estimated miles of distribution systems, treatment plant capacity in million gallons per day (mgd) per 1,000 persons served, and distribution storage capacity, also in mgd per 1,000 persons served.

Numbers of Systems. Not surprisingly, the number of water systems and the population served has not changed significantly since the last performance report. In 1992, the EPA Office of Drinking Water and Ground Water estimated that there were 58,724 community water supply systems in the nation. Community water systems are defined as systems supplying water to a significant number of year round residents. These community water systems serve approximately 226 million persons or 91 percent of the population. Most of the population not serviced by community water systems receives their water from individual wells.[160] Figure 8-3 presents the distribution of both the number of water systems and the populations they serve. While the vast majority of systems continue to be small in size -- 87 percent of all systems serve less than 3,300 people each -- these small systems serve only 11 percent of the total population who receive their water from public sources. A very small majority of systems (0.5 percent) provide water to more than 43 percent of the publicly served population.

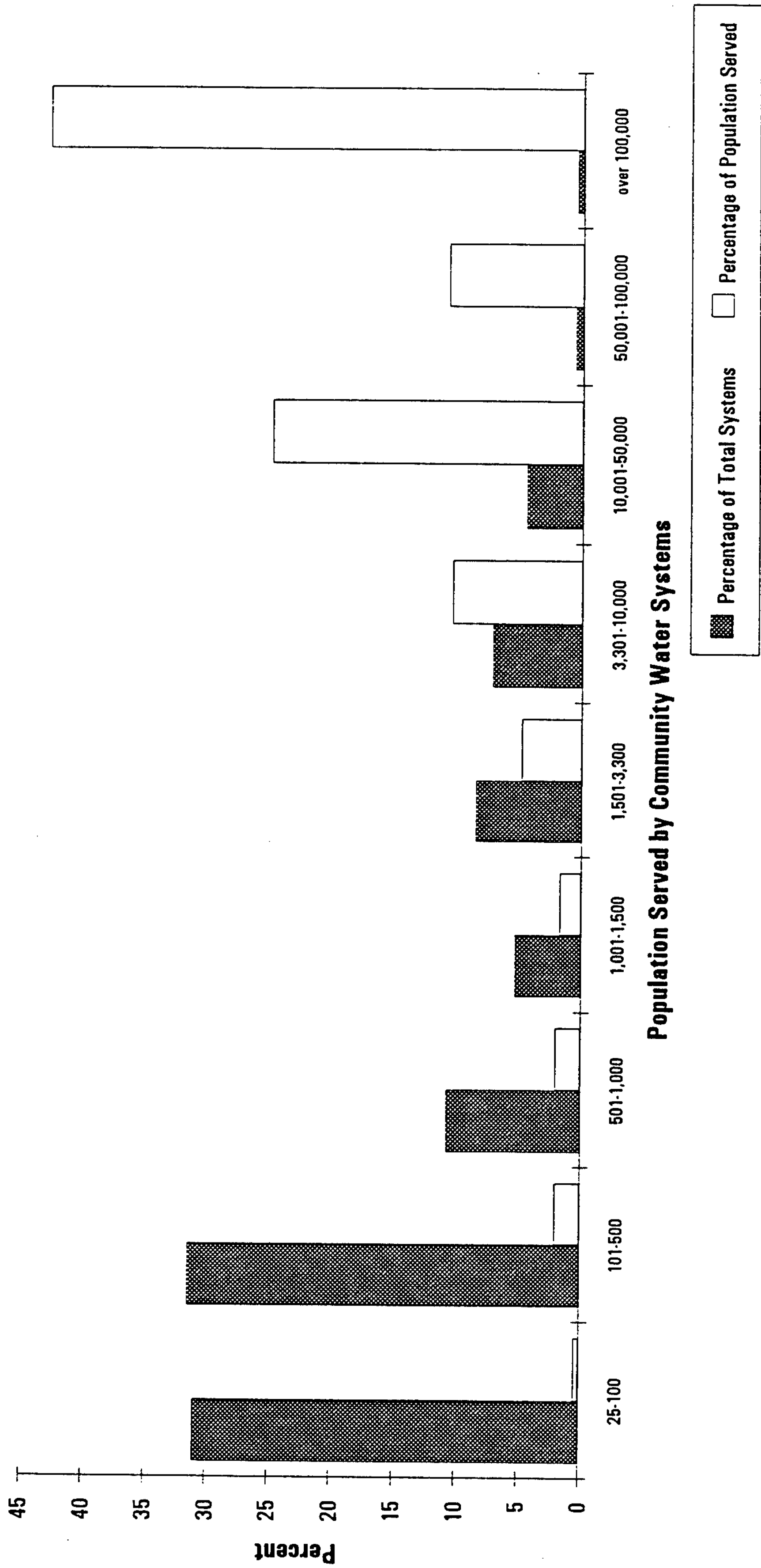
Net Capital Stock. Net capital stock of water supply facilities grew slowly from 1970 to 1980, increasing an average of 0.71 per year, from $82.8 billion to $88.9 billion (Figure 8-4). This slow rate of growth continued through the mid-1980s, averaging 0.65 percent from 1980 to 1985. However, from 1985 to 1990, the rate of growth has risen to 2.1 percent. Net capital stock has risen from $91.8 billion to $101.9 billion during this period, indicating an increased emphasis on additions to public water-supply facilities.

The NRDC report identifies an outdated and decaying water supply infrastructure as a contributing factor in a decline in water quality. According to the report:

> The vast majority of the drinking water systems in the United States rely upon drinking water treatment systems developed before World War I. Most surface water systems fail to protect from pollution the watersheds from which they draw their water; hundreds do not filter their water before it is used as some water systems have done since the 1800's. Moreover, advanced water treatment technology, such as membrane filters and granular activated carbon, has been installed in only a relative handful of water systems even though it is clearly economically and technically feasible, particularly for larger systems. Finally, the water mains and service lines in the nation's cities are decaying and millions of Americans are served by lead pipes in their service lines, which contribute to lead-contaminated drinking water.[161]

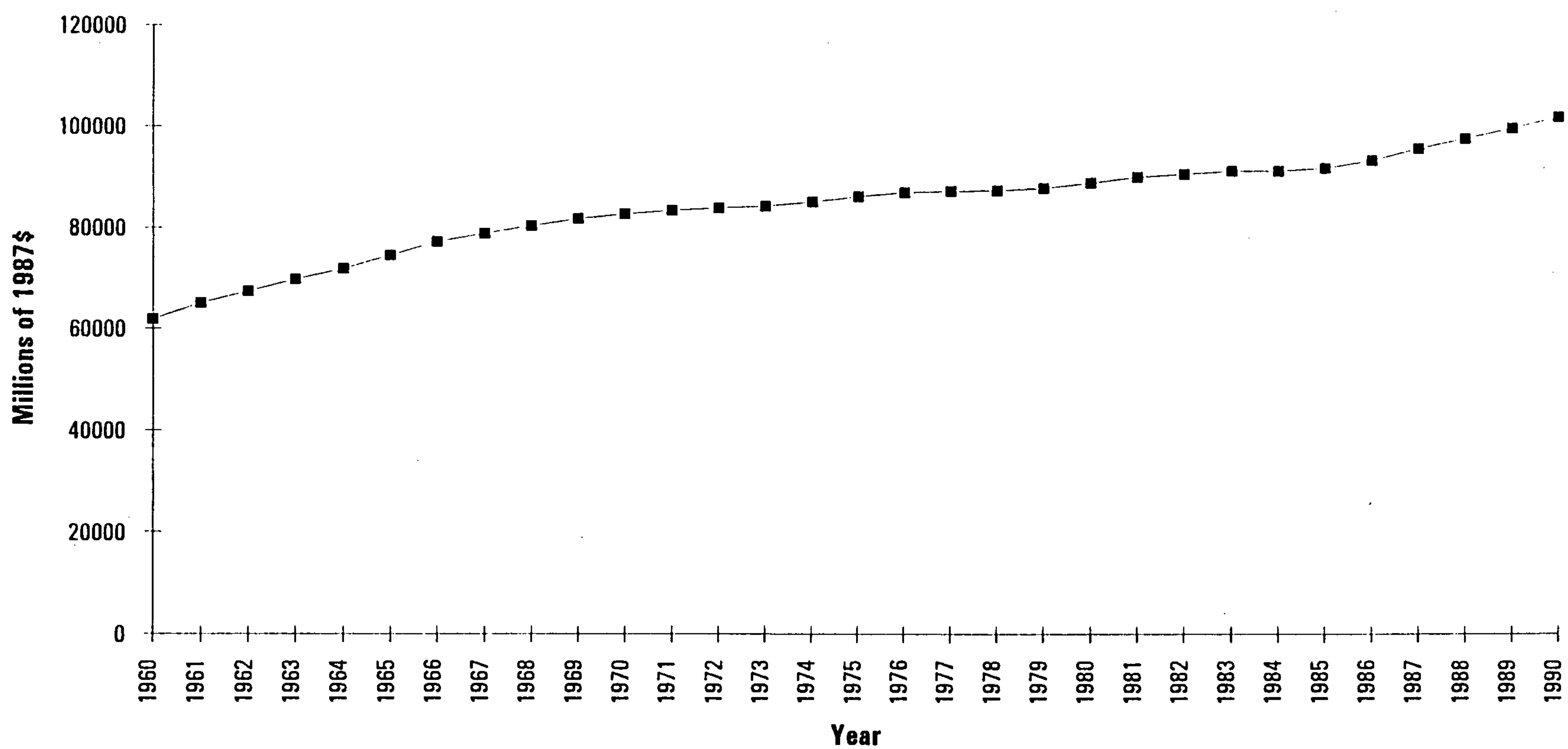
The report recommends a significant effort to invest in water supply infrastructure. As the growth trend in water supply capital stock indicates, this renewed effort may have recently begun.

Figure 8-3: Distribution of Number of Systems and Population Served, By Size of System, 1992



Source: EPA Office of Drinking Water and Ground Water

Figure 8-4: Water Supply Net Capital Stock



Source: Apogee Research from Census, Government Finances data

Miles of Distribution Systems. The total number of miles of water mains in the U.S. is not known. It can be estimated, however, based on the ratio of population served to total miles of distribution system in a sample population. According to a 1992 survey of 600 systems serving a population of 50,000 or more, and 2,400 medium-sized firms serving 10,000 to 50,000 persons conducted by the American Water Works Association (AWWA), an average of 250 persons were served by one mile of water main.[162] A larger number of 260 persons per mile was obtained from the 1985 AWWA survey of 211 water systems that included several larger systems, thus indicating an increasing density of population per square mile served by the larger systems.

According to the U.S. Geological Survey, the total population served by water systems in 1990 was 210 million.[163] A 1980 Geological Survey indicates that 55 percent of the total population is served by the 430 largest water systems with an average of 336 miles of water main per person.[164] Assuming that this ratio still holds true today, there are about 344,000 miles of pipeline for this larger group. If we also assume that the smaller systems serve the remainder of the population, reflecting a density of 150 persons per mile of distribution line, then the total number of miles of distribution line may approach 974,000 miles. This is a 13.8 percent increase in the estimated distribution line miles from the estimated 856,000 miles in the last performance report. This large increase is attributable in part to population growth and the geographic expansion of areas serviced by municipal water systems.

Treatment and Distribution Capacity. Treatment plant capacity measures the capability of water systems to meet the overall needs of service area populations. Distribution storage capacity is a measure of readily accessible reserves of finished water, which are important for dealing with unexpected, intensive water requirements such as fire fighting or alleviation of hazardous material spills. Generally, the Congressional Budget Office estimates that the average system can deliver 20-40 percent more water than current demands require.[165]

Treatment plant and distribution storage capacity estimates were calculated for 1981, 1984, 1985, and 1990 (Table 8-2).[166] The capacity of the nation's water treatment facilities dropped between the years 1985 and 1990, although it is impossible to predict if this is a long term trend or an anomaly due to small sample size. Storage capacity has remained about the same between 1981 and 1990 (the small decline is statistically insignificant considering the sample sizes).

Service Delivery

Service delivery may be defined in terms of water production and delivery. According to a 1990 American Water Works Association Survey, 1,097 utilities in 50 states produced a combined annual total of 14,605,000 million gallons of water, or approximately 205 gallons of finished water per person served. This is a 14 percent increase from the 1984 AWWA Survey of 430 utilities in 50 states that produced a combined total of 6,683,505 million gallons or water, or 176 gallons of finished water per person.

Delivery statistics are still not readily available due to the difficulty of estimating delivery in unmetered areas. In absolute terms, insufficient service delivery is not a problem at the national level or even at the state level. Delivery failures result from the disruption of individual systems and may affect all or part of the related service area.

Table 8-2: Treatment Plant and Distribution Storage Capacity in 1985 and 1990 (millions of gallons per day per 1,000 persons served)

	1981[a]	1984[b]	1985[c]	1990[d]
Treatment Plant Capacity				
Average	0.403	0.395	0.466	0.295
Highest	1.170	0.740	1.169	2.733
Lowest	0.180	0.100	0.012	0.590
Storage Distribution Capacity				
Average	0.39	0.19	0.260	Not Available
Highest	2.09	0.55	2.910	
Lowest	0.01	0.05	0.003	

Source: American Water Works Association, 1985 Water Utility Operating Data (1986); and American Water Works Association, 1990 Water Utility Operating Data (1991).

[a] Sample size = 1,397 observations
[b] Sample size = 430 observations
[c] Sample size = 189 observations for treatment plant capacity; 193 observations for storage distribution capacity
[d] Sample size = 1,095 observations

Quality of Service

One of the most important factors underlying the quality of the water supply service in the U.S. is the continuity of supply. Water is essential to many human activities, and the assurance of continued supplies is paramount. Interruptions in supply, measured by frequency, duration, cause, and number of persons affected, would provide indicators of the overall quality of service. Unfortunately, this information cannot yet be sufficiently evaluated at the national level.

Water systems do not lend themselves easily to an overall quality measurement.[167] As for most public infrastructure, there is no single, all-encompassing measure, rating, for judging the quality of water systems. Nor are there federal or state guidelines for distribution system performance as there are for sewer and water treatment facilities. Sophisticated diagnostic tests of the specific elements of water distribution systems, such as pipe carrying capacity, leakage rates, or internal corrosion can be carried out but most cities do not employ them routinely.

This section examines five indicators of the quality of water supplied in this country:

- Purity, as measured in terms of compliance with drinking water standards;
- Outbreaks of disease associated with water systems;
- Amount of water produced but unsold, or unaccounted for;
- Leakage rates; and

- Number of water-main breaks in distribution systems.

Compliance With Drinking Water Standards. National drinking water standards were established in 1974 with the passage of the Safe Drinking Water Act (SDWA). The Environmental Protection Agency (EPA) issues the drinking water regulations, which are then enforced by the states; if a state does not adopt and enforce EPA's rules, the EPA must provide the enforcement. In 1986, the SDWA was updated and substantially strengthened.

While the SDWA requires EPA to regulate all public water systems, EPA distinguishes between community and noncommunity water systems. Community systems serve a year-round population, while noncommunity systems serve their customers only part of the time, e.g., hospitals, resorts, and schools. Figure 8-1 shows the distribution of community systems; yet there are nearly 140,000 noncommunity water systems serving over 22 million persons.[168] Most of EPA's drinking water standards apply only to community water systems. In setting drinking water standards, the EPA establishes Maximum Contaminant Levels (MCLs), the maximum amount of a contaminant allowed in drinking water, for a broad number of contaminants. Water systems are required to test their water for contamination and report their findings to federal or state officials.

Between 1981-1986, there was no substantial change in water purity levels. In 1986, 87 percent of the 58,000 water systems in the United States were in compliance with SDWA MCLs. In fiscal year 1985, 72 percent of all public water systems met EPA's monitoring and reporting requirements. Approximately 89 percent of all public water systems met all national microbiological MCL standards, while nearly 95 percent were in full compliance with turbidity MCLs. Fewer than three percent of water systems were found to be "persistent violators" of turbidity and microbiological MCL requirements. A persistent violator is one who has been out of compliance with federal standards for four months of longer during the year.[169]

Since 1986, according to the EPA, there has been essentially no change in the compliance rate for community water systems. From 1986 to 1992, between 70 and 72 percent of the community water systems were in full compliance with EPA's regulations. In 1992, approximately 92 percent of all public water systems met EPA's microbiological standards, a 3 percentage increase since 1985.[170] The new regulations under the SDWA substantially increasing compliance and monitoring costs for public water systems. The 1986 amendments to the Safe Drinking Water Act required EPA to issue MCLs for at least 82 more contaminants, substantially increasing compliance and monitoring costs for public water systems. The 1992 AWWA survey indicates that annual laboratory equipment purchases are expected to increase 35 percent and commercial laboratory expenses are expected to increase 75 percent over a three year period.[171]

NRDC reports the number of drinking water violations of the SDWA by all systems (community and noncommunity) has risen from 101,000 in fiscal year 1987 to approximately 150,000 in fiscal year 1992 (the FY1992 value is approximated from NRDC's figure).[172] This represents a total increase in the number of violations of almost 50 percent, or about 8.2 percent per year. As NRDC notes, this increase is due in part to an expansion and strengthening of EPA's drinking water standards between 1989 and 1992.

Incidence of Disease. There has been tremendous progress in the quality of our water supply, as 100 years ago contaminated drinking water was the number one health problem in the country.

However, during the 1971-1992 period, there were 85,000 reported cases of disease from bacteriological contamination of drinking water. An analysis of these cases showed that 49 percent were the result of treatment deficiencies and nearly one-third were found to stem from defective distribution systems. These figures represent a slight increase over previous years, but most experts attribute this apparent increase simply to more active surveillance.[173] The Centers for Disease Control, in collaboration with the Environmental Protection Agency, has tabulated data on waterborne-disease outbreaks since 1971. The data indicate that for the two-year period 1989-1990, 16 states reported 26 outbreaks of illness from drinking water, resulting in an estimated national total of 4,288 persons. The extent to which this represents a decrease in the number of reported outbreaks (from a high of 53 in 1980) and not simply a reporting artifact is again not known.[174]

There are also increased concerns about industrial chemicals in drinking water that may cause cancer or other long-term health effects. This concern is especially strong in the case of ground water which is often taken straight from a well without being treated. Other water-borne contaminants that pose immediate and long-term health concerns identified by NRDC include bacteria, viruses, and other pathogens; trihalomethanes and other disinfection by-products (DBPs), related to chlorine, and other chemical additives; arsenic; lead; and radioactive contamination.

Unaccounted-For Water. Unaccounted for water is the difference between the amount of water produced by a utility and the amount of water sold to customers, as registered by meters. Unaccounted for water should not be interpreted as an indicator of efficiency alone because while it is primarily due to leakage and meter under-registration, it also includes water used for firefighting, streetwashing, sewer flushing, and other unmetered public services. Systems having 10 to 15 percent unaccounted for water are generally agreed to be performing well, and distribution system losses of 10 to 20 percent are considered reasonable.[175]

The amount of unaccounted for water continues to be well within the range acceptable to the water industry. In the 1981 AWWA survey of 573 water utilities, unaccounted for system losses averaged 13 percent of total water produced. In the 1992 AWWA survey, the 1,097 systems reported in the survey had an average of 15 percent unaccounted for water. Of the 15 percent unaccounted for water, 1.9 percent was water provided free of charge to municipal buildings and parks, 3.1 percent was used for firefighting, street cleaning, and hydrant flushing, and 10 percent was due to leaks, breaks, and failed meters.

Water Leakage. This indicator is a better measure of declining capital facilities, but most cities can only estimate actual leakage. Except for very large leaks, the amount and location of leaks can only be determined by thorough analyses of all water mains and service connections, and this process is both costly and time consuming. Leakage rates are usually expressed as leaks per mile of distribution system. Table 8-3 summarizes the results from a AWWA study of five U.S. cities.

Estimated leakage rates for these cities range from a high of 39 percent in Mamaroneck, New Jersey to a low of 4.5 percent in Boston. Studies performed in the early 1980s reported similar results from a high of 19 percent in Philadelphia to no leakage at all in Kansas City.[176]

Water Main Breaks. Although the terms are often used interchangeably, water main breaks differ from leakage in that main breaks involve circumferential and longitudinal separations in the main itself while leaks occur at joints connecting the mains. In the AWWA survey of five cities, leaks in water mains comprise 15 to 77 percent of all leaks and are the greatest source of water loss, as measured in terms of mean leakage rate (gallons per minute) (Table 8-3). A main breakage rate expressed as the number of breaks per 1,000 miles of distribution line is frequently used to compare systems of varying sizes.

Table 8-3: Water Leakage and Water Main Breaks in Five U.S. Cities

	Mamaroneck[a]	Atlanta	Boston	Louisville[b]	New York
Miles of main in system	190	1070	1075	2490	6660
Number of leaks (all)	75	232	48	753	302
Leakage rates per mile of distribution system	39 %	22 %	4.5%	30%	4.5%
Percentage of Total Leaks Occurring @ Main	52%	15%	23.5%	77%	71.5%
Mean Leakage Rate (expressed in gallons per minute):					
Main	36	6.2	49	38	103
All Leaks	11	2.7	15	21	38

[a] Westchester Joint Water Works in Mamaroneck NJ

[b] Louisville Water Company in Louisville KY

Source: Moyer, Ellen D., "Economics of Leak Detection: A Case Study Approach", published by the American Water Works Association (1985).

There is no evidence indicating a significant increase in water main breaks over the last 15 years. In a study of 34 cities over the three year period, 1978-1980, there was an average of 229 breaks per 1000 miles of main.[177] According to the 1992 AWWA survey, there was an average of one emergency main break per year of every 3.7 miles of pipe. This translates into 270 breaks a year per 1000 miles of main. Fewer emergency main breaks were reported for the larger systems than the smaller systems. One break every 3.4 miles for systems serving 100,000 people or more (sample size 225) versus one break every 4.8 miles for systems serving a population of 10,000 to 25,000 (sample size 352).

A large number of breaks indicates a problem but does not indicate that the system is uniformly weak. The causes of breaks include severe weather, rapid changes in seasonal temperatures, ground movement, corrosive soils, and damages resulting from other utility or construction activities. Main failures do not always increase with the age of the system, although the literature is inconclusive on this issue.

Cost Effectiveness

Due to the varied nature of water system ownership and operation, there are few indicators that may be readily collected and evaluated at the national level. Typically, factors that indicate the economic status and relative efficiency of U.S. water supply systems must be estimated by generalizing survey responses, which introduces unavoidable biases and inaccuracies. For the purposes of this report, water systems will be evaluated on the basis of total annual revenues and total annual expenses.

Data from the 1984 AWWA survey were analyzed to determine state-level values for each of the four indicators listed above and these values were then aggregated to the national level. Total annual expenses were subtracted from total annual revenues to obtain an indication of overall financial health. Data from the 1992 AWWA survey was also analyzed in a similar fashion. In 1992, of the 952 utilities responding to the survey, 16 percent (155 utilities) reported an annual deficit. The smaller systems reported the largest number of deficits, in part because of the economies of scale in water supply services. Table 8-4 summarizes the survey results.

Table 8-4: Percentage of Utilities with Annual Deficits

Population Served (Thousands)	10 - 25	25 - 50	50 - 100	100 +
Utilities Responding	323	205	194	230
Percentage of Utilities Reporting Annual Deficits	21.4	18.5	11.3	11.3

Such analyses should be conducted with a larger number of utilities and over a longer time frame in order to obtain more meaningful measurements, although our results do not indicate any significant change since the last performance report.

CHAPTER IX: SOLID WASTE MANAGEMENT

GOALS OF SOLID WASTE MANAGEMENT

Municipal solid waste management is responsible for collection, transportation, and disposal of nonhazardous residential, commercial, and industrial waste in a safe, cost-effective manner. Federal, state, and local governments are involved in the regulation and provision of solid waste management services to protect public health and welfare from unsanitary collection and management practices in the U.S. Local governments and the private sector are primarily responsible for the provision of solid waste management services.

This chapter examines the management of municipal solid waste as defined by the U.S. Environmental Protection Agency (EPA) and does not include performance data on the management of all nonhazardous wastes. There are no comprehensive data on municipal sludge, industrial, small quantity generator, construction and demolition, agricultural, oil and gas, and mining waste. For the most part, these wastes are managed on-site by private sector generators.[178]

OVERALL PERFORMANCE OF SOLID WASTE MANAGEMENT SERVICES

The solid waste management market has changed rapidly during the last few years due to new environmental regulations, technological innovation, and evolving waste management priorities and economics. Since 1987, almost every state and many local governments have introduced legislation to reduce solid waste generation through source reduction, reuse, and recycling. In addition, more stringent federal and state regulatory requirements on municipal solid waste landfills and waste-to-energy facilities are changing the structure of the solid waste disposal market. These new regulatory requirements have improved the quality of municipal waste management in the United States by facilitating the development of environmentally sound technologies and practices. Performance highlights include:

- Municipal solid waste (MSW) generation increased from 164.4 million tons in 1985 to 195.7 million tons in 1990. By the year 2000, MSW generation is projected to be 222 million tons.[179]

- Recovery of MSW for recycling and composting increased from 10 percent of total MSW in 1985 to 17.1 percent in 1990. The number of curbside recycling programs rose from 3,955 in 1991 to 5,404 in 1992.[180]

- In 1984, the U.S. EPA identified 9,284 MSW landfills; today, there are approximately 5,386 MSW landfills[181], a decrease of 42 percent. Landfill capacity, however, may have increased during this time period because smaller, municipal landfills were replaced with larger, regional facilities.

- There were 142 waste-to-energy facilities and 34 incinerators without energy recovery operating in the U.S. in 1992.[182] These facilities process approximately 34 million tons of MSW annually.

- Per ton management costs have increased the last five years due to more stringent environmental regulations on disposal facilities and the gradual shift from land disposal to alternative waste management techniques such as waste-to-energy and recycling.

- Remaining challenges for solid waste management planning include difficulties associated with siting a disposal facility, weak demand for recyclables, and lack of cost data regarding the specific components of waste management.

IMPROVING PERFORMANCE REPORTING IN THE FUTURE

Performance reporting in solid waste management does not exist within the federal government and is inconsistent within state and local governments. There is substantial room for improvement at both the project and program levels. Separate concerns and types of decisions are made at these two organizational levels, suggesting that each has a different set of data needs.

Project Level

Since local governments are responsible for all phases of service delivery in solid waste, these practitioners are the logical focus of project-level performance data. Indeed, many local waste management agencies already collect a vast array of performance indicators that they use for program planning, budget justification, and rate changes. While the needs of the individual management authorities may be served by their own performance monitoring, these data are not readily transferable from one locality to another. As in other categories of public works, one prerequisite for performance evaluation is the ability to compare one system to another. Uniform performance reporting conventions would enable practitioners to benefit by the successes and avoid the failures of their counterparts across the nation. Of course, putting such a system in place could be costly and would require an institution to accumulate, analyze, and disseminate locally gathered information.

One piece of information not widely collected at the project level that would likely be useful to managers is the distance that solid waste is hauled for disposal. In recent years, with the closure of many local landfills, localities face options of higher costs for longer hauls, reducing waste streams through source reduction, recycling, and composting, or building new waste disposal capacity within their jurisdictions. Better cost data of the various components of solid waste management (collection, hauling, transportation, recycling, composting, waste-to-energy, landfilling) could improve local decisions on future investments in facilities and/or waste management programs. This type of information is critical in developing and implementing a cost-effective integrated solid waste management plan.

Program Level

Solid waste programs are administered at both the state and federal levels. It is unclear whether performance reporting is a common component within most state programs, but there is no evidence that the federal government collects any valuable performance information. This is not surprising since the federal presence in solid waste management has only recently escalated beyond nominal regulations.

There are at least three reasons for program level analysis, although none argues for federal level involvement. First, like other utility models of public works (water supply, wastewater treatment) solid waste management lends itself to regional service provision. In order to effectively plan for such regional facilities, some institution must take a broad perspective of service delivery. A multi-county planning agency is probably the most localized group that could perform this function adequately. Although they remain a minority, a growing number of states have taken the lead in regional waste facility planning. In solid waste, Connecticut, Rhode Island, Maryland, and Delaware have active regional programs in operations, technical assistance, and/or finance. With the changing economics of solid waste disposal, effective regional planning may ensure that waste generators take advantage of the economies of scale of modern waste disposal facilities.

Second, improving local service delivery may depend, at least in part, on the inter-system comparison of performance. Solid waste technologies are changing rapidly and levels of future investment are expected to escalate. As with any changing market, information may hold the key to an efficient transition. Data on quality of service, externalities, and cost effectiveness could improve the local selection of technology and lower costs to consumers of adequate waste management services. Again, some institution must take a broad perspective on these issues, aggregate local data, analyze it, and report findings back to local decision makers. This would appear to be an appropriate state government function. Alternatively, a joint federal/state effort would further broaden perspectives.

A final program level concern is the question of safety performance versus service performance. In the context of solid waste management, these two concepts are often at odds. Prior to the environmental protection statutes of the 1970s and 1980s, the public appeared satisfied with service alone. However, recent protective mandates introduced safety as a parallel concern. Promoting the dual goals of service and safety (freedom from contamination of the environment) has resulted in sharply higher costs of solid waste management. Balancing safety and service at the lowest cost acceptable to the public would appear to be a proper function of state governments. In order to serve in this capacity, however, data on the performance of individual systems seems essential.

OVERVIEW OF SOLID WASTE MANAGEMENT

Today, municipal solid waste management includes a variety of techniques for managing solid waste such as recycling, waste-to-energy, landfilling, composting, and source reduction. Until recently, municipal solid waste was managed in local disposal facilities, primarily in unlined landfills and incinerators with no pollution control equipment. Waste disposal was relatively inexpensive because of the local nature of the disposal market and the lack of environmental controls. These disposal facilities, however, were responsible for serious ground and surface water contamination and air pollution. For example, there are currently 230 municipal solid waste landfills on the Superfund National Priority List.[183]

Governments and the public have focused their concerns regarding solid waste management in three areas. First, state and local governments are acting, with public support, to reduce the demand for disposal capacity by encouraging source reduction, recycling, and reuse. Forty-two states have official waste reduction/recycling goals, and participation in curbside recycling programs has grown rapidly. Second, federal and state regulations have imposed stringent capital and operating requirements on municipal solid waste landfills and waste-to-energy facilities, which will result in environmentally sound waste disposal. Finally, because of growing public environmental concern, it is increasingly difficult to site either a landfill or a waste-to-energy facility. The siting process for a waste disposal facility is expensive, time-consuming, and risky. If this trend continues, waste disposal costs will continue to increase as regional capacity shortfalls develop. Local government and the solid waste management industry need to cooperate to educate citizens on the technological and economic characteristics of modern waste disposal facilities in order to site capacity where it makes environmental and economic sense.

Environmental performance of waste management has improved in the last decade with the shift in waste management priorities at the expense of higher waste management costs. The remainder of this section evaluates performance of solid waste management infrastructure in the United States for the following categories:

- Federal, state, and local roles in solid waste management;
- Trends in municipal solid waste generation, management, market share, and expenditures;
- Collection of recyclables and solid waste;
- Recycling;
- Landfilling; and
- Combustion.

Government Roles

Municipal solid waste management generally requires the following three public works services: collection, transportation, and disposal of municipal refuse. The primary responsibility for solid waste management varies significantly from state to state. However, the various levels of government have been involved to some degree.

Federal Government. The federal government establishes and implements solid waste regulations intended to protect the environment and public health. Since passage of the Resource Conservation and Recovery Act (RCRA) in 1976, the federal government has slowly withdrawn financial and oversight support, leaving program management largely to state and local governments. Subtitle D of RCRA addresses municipal solid waste. Recent federal regulations on solid waste disposal facilities, to be discussed in more detail below, include new Subtitle D requirements and 1990 Clean Air Act Amendments (CAAA). In addition, both houses of the U.S. Congress are now considering legislation to reauthorize RCRA, which may have a major impact on solid waste management in the United States. Important issues that may be addressed include mandatory state waste reduction, recycling and recycled-content requirements, interstate waste bans, and ash management regulations for combustion facilities.

State Government. For the most part, states are providing the regulatory framework under which local governments must deliver solid waste management services. The level of state involvement, however, varies significantly from state to state. While most states serve in an advisory or regulatory capacity, a growing number of states are adopting stringent regulatory standards for landfill siting, design, operation, and monitoring. Connecticut, Delaware, and Rhode Island, for example, have created state authorities to develop and implement solid waste disposal facility plans.

On the regulatory side, thirty-nine states and the District of Columbia have passed some form of statewide recycling law.[184] Forty-two states have official recycling or waste reduction goals, with a variety of targets and timetables. Most states have mandated disposal bans for certain types of waste. For example, 41 states have banned the disposal of lead-acid batteries. On the demand-side for recycling, 24 states, representing two-thirds of U.S. newsprint consumption in 1990, have recycled-content requirements for newspapers. In addition, 27 states now have tax incentives for recycling, which vary widely from state-to-state.[185]

Local Government. The ultimate responsibility for all three facets of solid waste management -- collection, transportation, and disposal -- most often rests with municipalities, counties, or regional authorities. Municipal solid waste collection is generally performed by one or a combination of the following:

- The public works department of the local government entity;
- A private hauler under contract with the local government;
- A private hauler operating in a franchise area contracting directly with residential or commercial waste generators; or
- Private haulers operating in unfranchised areas where two or more competing haulers collect waste in the same area.

Many local governments are required to submit solid waste management plans to state agencies, outlining plans for meeting state-mandated waste reduction and recycling goals and finding adequate disposal capacity. In order to implement these plans, local governments may impose mandatory recycling requirements, mandate flow controls to finance the construction of a waste disposal facility, or ban the disposal of specific materials.

Trends in Municipal Solid Waste Generation, Management, Market Share, and Expenditures

In 1990, 195.7 million tons, or 4.3 pounds per person per day of municipal solid waste (MSW) were generated. After materials recovery for recycling and composting, discards were 3.6 pounds per person per day. The amount of waste generated is projected to reach 208 million in 1995. By the year 2000, waste generation is expected to reach 222 million tons, or 4.5 pounds per person per day. This projection suggests a substantial slowing in the rate of increase of MSW generation. This slow down in growth will depend on demographic changes, economic factors, consumer preferences, and the success of source reduction efforts in reducing MSW generation. Table 9-1 has a state-by-state breakdown of MSW generation and management for 1992.[186]

Table 9-1: State-by-State MSW Generation and Management

State	Solid Waste (tons per year) (000s)	Percent Recycled	Percent Combusted	Percent Landfilled
Alabama	5,200	12	8	80
Alaska	500	6	15	79
Arizona	4,147	7	0	93
Arkansas	2,154	10	5	85
California	44,535	11	2	87
Colorado	3,500	26	1	73
Connecticut	2,900	19	57	24
Delaware	790	16	19	65
D.C.	919	30	59	11
Florida	19,400	27	23	49
Georgia	6,000	12	3	85
Hawaii	1,300	4	42	54
Idaho	850	10	0	90
Illinois	14,140	11	2	87
Indiana	8,400	8	17	75
Iowa	2,088	23	2	75
Kansas	2,400	5	0	95
Kentucky	4,650	15	0	85
Louisiana	3,484	10	0	90
Maine	1,246	30	37	33
Maryland	5,000	15	17	68
Massachusetts	6,600	30	47	23
Michigan	13,000	26	17	57
Minnesota	4,270	38	35	27
Mississippi	1,400	8	3	89
Missouri	7,500	13	0	87
Montana	744	5	2	93
Nebraska	1,400	10	0	90
Nevada	2,300	10	0	90
New Hampshire	1,138	10	26	64
New Jersey	7,513	34	21	45
New Mexico	1,487	6	0	94
New York	22,800	21	17	62
North Carolina	7,788	4	1	95
North Dakota	466	17	0	83
Ohio	16,400	19	6	75
Oklahoma	3,000	10	8	82
Oregon	3,350	23	6	71
Pennsylvania	8,984	11	30	59
Rhode Island	1,200	15	0	85
South Carolina	5,000	10	5	85
South Dakota	800	10	0	90
Tennessee	5,800	10	8	82
Texas	14,469	11	1	88
Utah	1,500	13	7	80
Vermont	550	25	3	72
Virginia	7,600	24	18	58
Washington	5,708	33	2	65
West Virginia	1,700	10	0	90
Wisconsin	3,352	24	4	72
Wyoming	320	4	0	96
Total	291,742			

Source: 1993 Nationwide Survey, The State of Garbage, BioCycle

Figure 9-1 provides a breakdown by weight of the materials generated in MSW in 1990. It shows that paper and paperboard products are the largest component of municipal solid waste by weight (37 percent of generation) and yard trimmings are the second largest component (about 18 percent of generation). Five of the remaining materials in MSW -- glass, metals, plastics, wood, and food wastes -- range between 6 and 9 percent each by weight of total MSW generated.

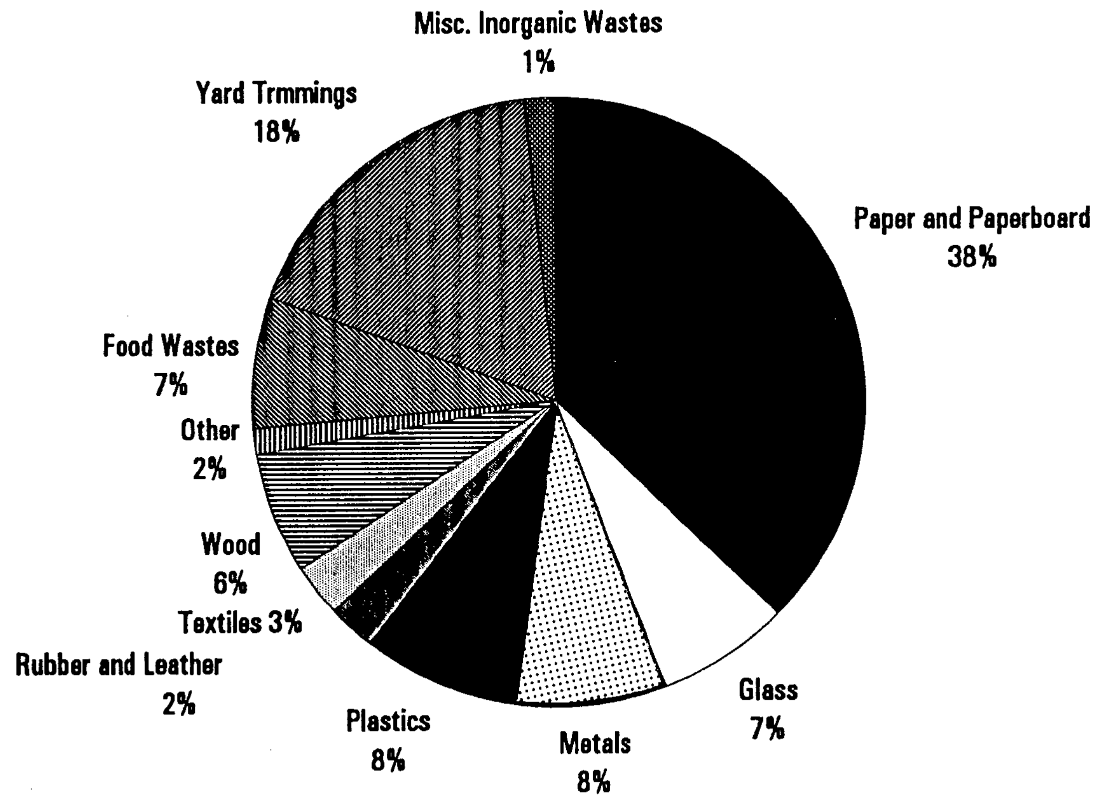
Figure 9-2 presents historical data as well as projections of generation and management of MSW in the United States. Recovery has increased gradually from roughly 7 percent of MSW generated in 1960 to 17 percent in 1990. Projected scenarios for recovery are between 20 and 30 percent in 1995 and 25 and 35 percent in 2000. Combustors handled an estimated 30 percent of MSW generated in 1960, most of them with no energy recovery or air pollution controls. As these older incinerators were shut down in the 1970s, combustion dropped steadily, reaching a low of less than 10 percent of MSW generated by 1980. Since 1980, combustion of MSW has increased to 32 million tons (approximately 16 percent of MSW generated) in 1990. EPA estimates that 35 million tons of MSW will be combusted in 1995, and 46 million tons will be combusted in 2000. Landfill use fluctuates with changes in the use of alternative solid waste management methods. For example, when the use of combustion for MSW management declined in the 1970s, the MSW percentage sent to landfills increased. Approximately 130.4 million tons of MSW (66.6 percent of the total) was managed in landfills in 1990.

Solid waste management is a $25-30 billion industry.[187] In 1991, collection and landfill disposal accounted for almost 85 percent of the estimated $26 billion industry, and the remainder was divided equally between burning for energy recovery and recycling.[188] In the $22 billion collection and disposal market, publicly traded firms had a collective market share of 40 percent, while private firms and local governments each had about a 30 percent market share.

As discussed earlier, local government and the private sector are primarily responsible for the provision of solid waste management infrastructure in the United States. From 1981 to 1990, private sector spending on solid waste management rose from $9.4 billion to $13.7 billion, in 1987 dollars, an increase of almost 46 percent.[189] During the same time period, local government expenditures for solid waste management increased almost 80 percent from $4.57 billion to $8.23 billion (Figure 9-3).[190] Capital expenditures by local governments have increased from $576 million in 1981 to $1.4 billion in 1990. In the late 1980s, several state governments also reported expenditures on solid waste management infrastructure, increasing from $237 million in 1988 to $800 million in 1990. The majority of state funds are invested through state empowered waste management districts. This increase in state expenditures is expected to continue as state governments become more involved in the implementation of solid waste management plans. Government expenditures increased dramatically in the late 1980s in response to more stringent regulatory requirements and the shift to alternative waste management techniques.

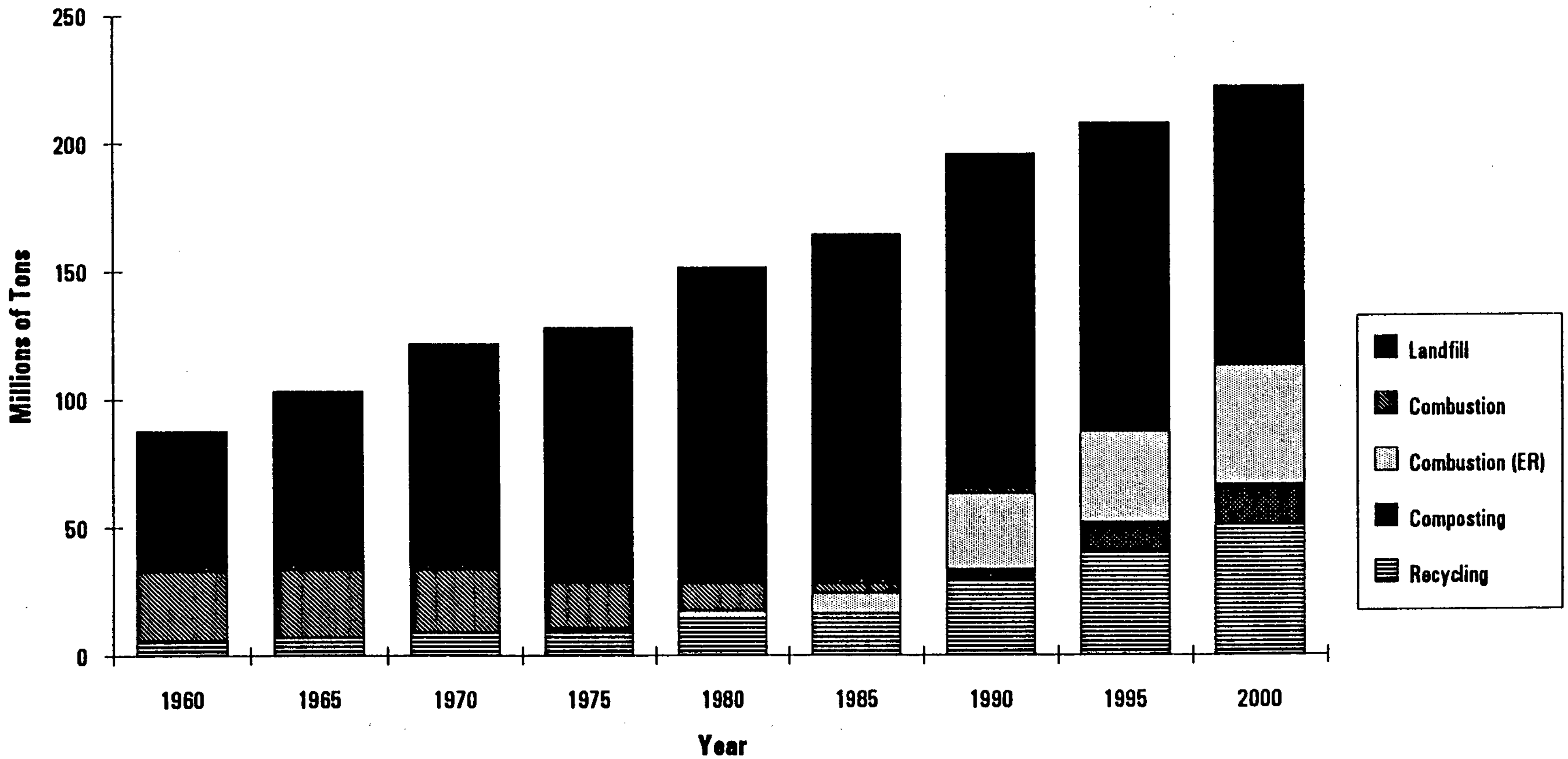
The federal government manages its own solid waste, spending approximately $304 million in 1990, but, otherwise, does not invest in solid waste management infrastructure.[191] In 1990, solid waste management net capital stocks are estimated at $11 billion (1987 dollars) in the United States, increasing from $6.8 billion in 1985.[192] This represents an average annual increase of 10.15 percent over this time period. Expenditures for both the public and private sector are expected to continue increasing at a similar rate as municipalities and companies comply with environmental regulations at existing facilities and replace older capacity with more expensive, modern disposal capacity.

Figure 9-1: Materials Generated in MSW by Weight, 1990, (Total Weight = 195.7 million tons)



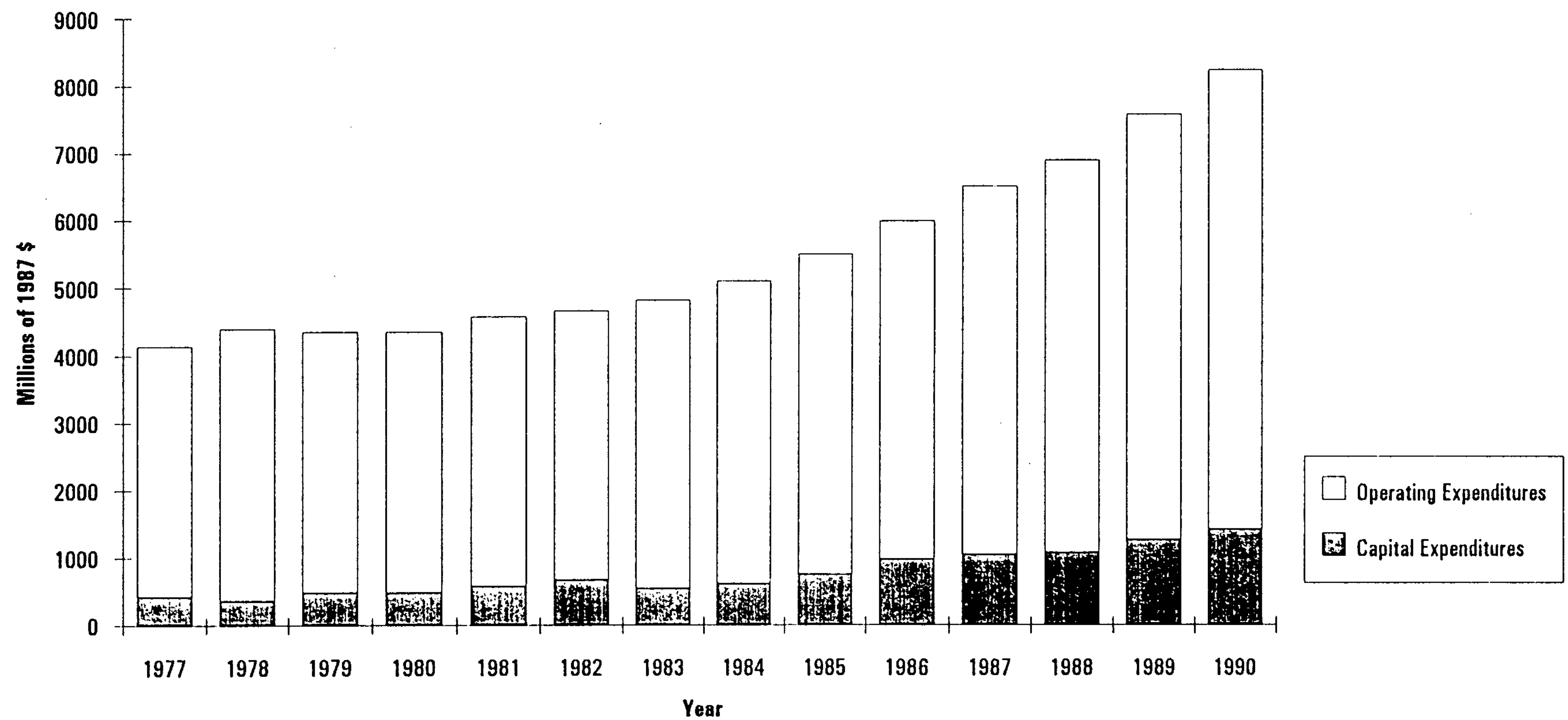
Source: EPA Characterization of Municipal Solid Waste in the United States: 1992 Update

Figure 9-2: Generation, Recovery, Combustion, and Disposal of MSW, 1960-2000



Source: EPA Characterization of Municipal Solid Waste in the United States: 1992 Update

Figure 9-3: Local Government Capital and Operating Expenditures for Solid Waste Management, 1977-1990



Source: Census Government Finance data

Collection. Solid waste collection of recyclables and discards is provided by a municipality, franchised or contracted out to the private sector by a municipality, or performed by the private sector. Approximately 8,000 municipalities and private trash haulers pick up the country's garbage using 140,000 refuse collection units.[193] There is little national data on the quality and cost of collection services in the United States; however, there are several regional studies that document collection costs. For example, a 1990 study of residential collection for disposal in New York City found that per ton collection costs ranged from $75 to $94.[194] A 1988 study found that the per ton garbage collection costs of five communities in Maryland, Washington, Nebraska, California, and Minnesota ranged from $30 to $71.50.[195] Previous work has indicated that private firms offer lower costs than public providers. On average, municipal refuse collection is 28 to 42 percent more costly than refuse collection by a private contractor.[196] A 1990 survey of 22 curbside recycling collection programs found that private contractors utilized smaller crews and generally had a significantly higher collection efficiency (528 stops per day) than municipal crews (415 stops per day).[197] Because of these efficiency gains, many jurisdictions contract out their solid waste collection services to private firms. In 1991, private companies served around 60 percent of all households and removed more than 90 percent of the nation's commercial refuse.

Recycling/Composting

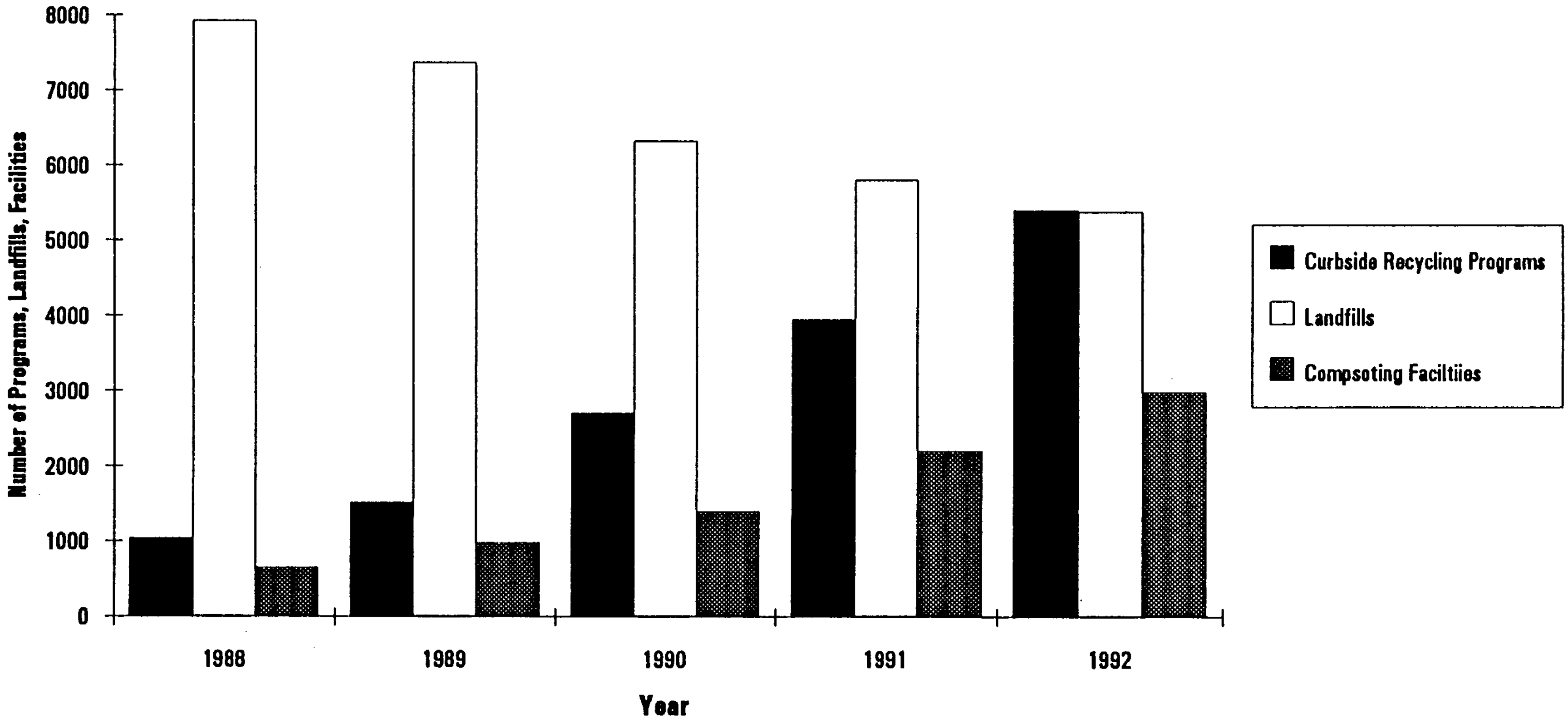
In 1990, approximately 33.4 million tons of MSW were recycled. The number of curbside recycling programs increased 38 percent from 1991 to 1992 from 3,912 to 5,404 programs (Figure 9-4). Since 1990, the population receiving curbside recycling service has nearly doubled -- from 40 million to 78 million. Every region in the country reported an increase in curbside recycling programs in 1992 with the Mid-West experiencing the largest escalation (290 percent) and the Mid-Atlantic region the smallest (13 percent).

Physical Assets. Material recovery facilities (MRFs) separate commingled recyclables (such as glass, aluminum, and newspapers) and prepare these materials for shipment to end-users. There are approximately 172 MRFs in the United States, processing 18,644 tons of recyclables per day.[198] Another 50 MRFs are expected to come on-line in 1993 that should add 10,608 tons per day of capacity. These facilities will each process an average of 212 tons per day. The private sector owns approximately 73 percent of all MRFs and operates 82 percent. This trend in private sector ownership and operation is expected to continue.[199]

Facilities composting leaves, grass, brush, and other yard trimmings increased from 2,201 in 1991 to 2,981 in 1992 (Figure 9-4).[200] There were 21 mixed waste composting facilities in operation as of November 1992. Many communities are banning the disposal of yard waste, which should fuel additional growth in composting facilities.

Service Delivery. In 1990, approximately 33.4 million tons of MSW were recycled. By the year 2000, EPA estimates that 30 percent of the waste stream will be recycled. Paper accounts for almost 63 percent (by weight) of all materials recovered in the United States for recycling. According to the American Paper Institute, 28.9 million tons of the 86.5 million tons of paper and paperboard used in 1990 were recovered.[201] The recovered material included 44 percent of all old newspaper and just over half the nation's corrugated boxes. In 1990, nearly 44 billion aluminum beverage cans (63.6 percent of the nation's total) were collected and recycled. By the end of the decade, manufacturers plan to recycle 75 percent of aluminum cans. Other materials that are being recycled include glass bottles and jars, steel cans, and yard

Figure 9-4: Number of Curbside Recycling Programs, Compost Facilities, and Landfills in the U.S., 1988-1992



Source: 1993 Nationwide Survey, The State of Garbage, BioCycle waste. EPA estimates that the amount of yard waste composted will increase from 500,000 tons in 1988 to 9.5 million tons in 1995. In addition, some communities are beginning to experiment with food waste and mixed waste composting.

Quality of Service/Cost Effectiveness. While collection programs continue to grow, market demand for recycled material remains weak. Prices for recycled commodities remained flat for 1992, with only prices for paper products increasing slightly during the year.[202] The marketability of recycled materials depends on several complex economic factors, including the price of competing raw materials, fluctuating supply of recyclables, existing manufacturing capacity, raw material versus recyclable manufacturing costs, and contaminants in the recycling supply. Aluminum recycling, for example, has thrived over the years because recycling an aluminum can saves an estimated 95 percent of the energy to mine and smelt aluminum.[203] For newspapers, mandatory curbside collection markets flooded the market with recyclables, forcing many communities to pay to have newspapers taken away. While the surplus has lasted three years, a number of deinking plants are now under construction, and experts believe that deinking capacity will absorb the supply of newspapers.

There are several recent studies comparing costs of recycling to traditional waste disposal options. For example, virtually every Western Washington county reported in a 1993 survey that they expect recycling programs to continue to cost more (per ton) than disposal options.[204] On the other hand, a study in New Jersey found that while some materials, primarily plastics, were more expensive to recycle than dispose, other material recycling efforts, such as glass and aluminum, were saving the state money.[205] It appears that recycling is cost-effective for certain materials in certain markets. The costs and benefits of recycling will depend on a variety of market and material characteristics such as avoided disposal costs, collection costs, and the demand for recyclable material. To stimulate demand for recycled materials, many states have adopted tax credits for recycling, voluntary or mandatory minimum-content requirements, and recycled-content procurement policies.

Likewise, the cost effectiveness of composting yard waste is determined by several factors including the costs of collecting yard waste, local markets for compost, and avoided disposal costs. For example, a 1989 EPA study found composting cost-effective for several communities with high tipping fees in the Northeast.[206]

Landfills

Landfills managed approximately 130.4 million tons of MSW in 1990 (66 percent of the total). In a 1992 study, it was estimated that landfills managed approximately 72 percent of the nation's garbage. While landfilling is still the predominant solid waste management alternative, its dominance is eroding in sheer numerical terms and market share.

Physical Assets. The number of municipal solid waste landfills decreased from approximately 8,000 at the end of 1988 to 5,386 at the end of 1992 (Table 9-2 and Figure 9-4). Most landfills that closed were small, unlined facilities, minimizing the impacts on actual landfill capacity. In the late 1980s, there were concerns at the federal, state, and local level that America was facing a "disposal crisis." In fact, it appears that adequate landfill capacity is available in the U.S., and capacity shortfalls are restricted to specific areas of the country such as New York and New Jersey. In 1991, NSWMA found that 10 states had less than five years of landfill capacity remaining while 22 states had at least 10 years of capacity.[207]

Table 9-2: State-by-State Breakdown of MSW Landfills and MCWs, 1992

State	Landfills	Combusters	State	Landfills	Combusters
Alabama	92	2	Montana	87	1
Alaska	740	3	Nebraska	36	0
Arizona	92	0	Nevada	90	0
Arkansas	120	5	New Hampshire	48	15
California	322	3	New Jersey	12	4
Colorado	125	1	New Mexico	113	0
Connecticut	40	7	New York	101	17
Delaware	3	1	North Carolina	145	2
D.C.	0	0	North Dakota	43	0
Florida	140	14	Ohio	96	11
Georgia	181	1	Oklahoma	110	3
Hawaii	13	1	Oregon	86	2
Idaho	79	0	Pennsylvania	46	6
Illinois	105	1	Rhode Island	5	0
Indiana	65	2	South Carolina	59	2
Iowa	82	1	South Dakota	100	0
Kansas	115	0	Tennessee	105	5
Kentucky	30	0	Texas	390	4
Louisiana	29	0	Utah	162	1
Maine	185	4	Vermont	25	2
Maryland	30	4	Virginia	254	10
Massachusetts	122	9	Washington	45	4
Michigan	67	7	West Virginia	40	0
Minnesota	45	8	Wisconsin	138	5
Mississippi	75	1	Wyoming	77	0
Missouri	77	0	Total	5388	169

Source: 1993 Nationwide Survey, The State of Garbage, BioCycle

More than half of the landfills in the United States (57 percent) are owned by local governments, 14 percent are owned by the private sector, and the remainder are owned by the state/federal government or solid waste authorities.[208] These landfills vary greatly in size and capacity. About 40 percent of them are smaller than 10 acres and nearly 95 percent are smaller than 100 acres. Approximately one-third of all landfills receive less than 30 tons of waste a day and only 5 percent receive more than 100 tons. Privately owned facilities actually represent roughly half of the country's remaining disposal capacity.[209]

Additional landfill closures are expected this year as the new Subtitle D requirements go into effect in October 1993. Subtitle D requirements set forth minimum criteria for location, operation, design, ground water monitoring and corrective action, closure and post-closure, and financial assurance. These regulations require major capital investments and, consequently, will favor larger facilities that can spread these costs across high volumes of waste. Because of the resulting economies of scale, small, inexpensive landfills (mostly municipally owned) are gradually shutting down in anticipation of the October 1993 RCRA Subtitle D deadline. In 1992 alone, over 400 landfills closed. In a recent survey, 29 states reported that 1,177 landfills, or 22 percent of their operating landfills, may close this year due to Subtitle D requirements.[210]

Industry analysts and state officials conclude that the impact of Subtitle D requirements on landfill capacity will be quite small for two reasons.[211] First, landfill capacity is concentrated at a relatively few, large facilities which will probably not close due to Subtitle D requirements. For example, a 1986 EPA Landfill Survey found that 157 landfills (out of 6,034 landfills) accepted 40.2 percent of landfilled waste in the U.S. Second, many states have already imposed Subtitle D requirements while other states may postpone their imposition to allow for proper environmental closure. In either case, the impacts of Subtitle D will not be felt all at once but will rather be phased in over a number of years.

In a 1991 study, 32 states reported complete data on landfill closures, new landfill permits per state, and landfill expansion permits.[212] On average, there were 63 landfill closures per state, six new landfill permits per state, and 10 landfill expansion permits per state. Most states were unable to provide capacity data or comparable data for both lost and added capacity. Again, because of the trend toward larger, safer facilities, it is not possible to draw conclusions regarding capacity effects from these figures.

Service Delivery. Landfills remain the major solid waste management option in this country, disposing of approximately 130.4 million tons of waste in 1990. Over time, the amount of waste managed in landfills has fluctuated with the availability of other waste management alternatives. For example, in 1960 landfills only managed approximately 62.5 percent of the nation's waste because of the availability of incinerators. As the use of these incinerators phased out in the late 1970s, the management of MSW in landfills peaked at approximately 81.4 percent of the waste stream in 1980. With the advent of waste-to-energy combustion and recycling in the 1980s, landfills' share of the waste stream decreased sharply to roughly 66 percent. EPA estimates that this trend will continue through the year 2000, reducing the market share of landfills to 49 percent of the MSW stream.

Quality of Service/Cost Effectiveness. Environmental concerns associated with landfills include contamination of groundwater supplies by leachate from the landfill, contamination of surface water supplies by runoff from the landfill, migration of landfill gases, wind blown litter and debris and the existence of vermin. The Subtitle D requirements are expected to quantify these costs associated with land disposal of MSW in the United States. These regulations will ensure that landfills are designed, constructed, operated, and closed in an environmentally sound manner. As landfills invest to meet these requirements, disposal costs will continue to increase.

Tipping fees at landfills continue to show an upward trend, increasing the last few years due to more stringent environmental controls and regional capacity shortfalls. The National Solid Waste Management Association (NSWMA) surveyed 219 municipal solid waste landfills in 1990 for their disposal fees, design characteristics, size, incoming volumes of waste, and other characteristics. Tipping fees in each region were inversely related to the region's capacity and were higher where more stringent environmental protection requirements were in place.[213] For example, New Jersey and New York, two states with capacity shortfalls, have average landfill tipping fees of $74 and $62 respectively.[214] Another study found that average tipping fees in the nation increased from $26.50 in 1991 to $29 in 1992. Even after the imposition of Subtitle D requirements, landfills will more than likely remain, on average, the nation's least expensive management alternative.

As local landfills close due to the Subtitle D requirements, waste disposal costs may increase in communities that need to haul their waste to regional facilities or site new capacity. On the other hand, several major cities, including Cleveland, Philadelphia, and Boston, have recently negotiated long-term disposal contracts with private sector companies that will reduce each cities' disposal costs by over 20 percent. As municipalities and local governments learn more about the costs of waste management for such functions as collection, recycling, transportation, and disposal, they will be able to make more cost-effective waste management decisions. Large, environmentally sound landfills operate more cost-effectively at higher volumes of waste; therefore, regional coordination between municipalities and states will be necessary to capture these economies of scale.

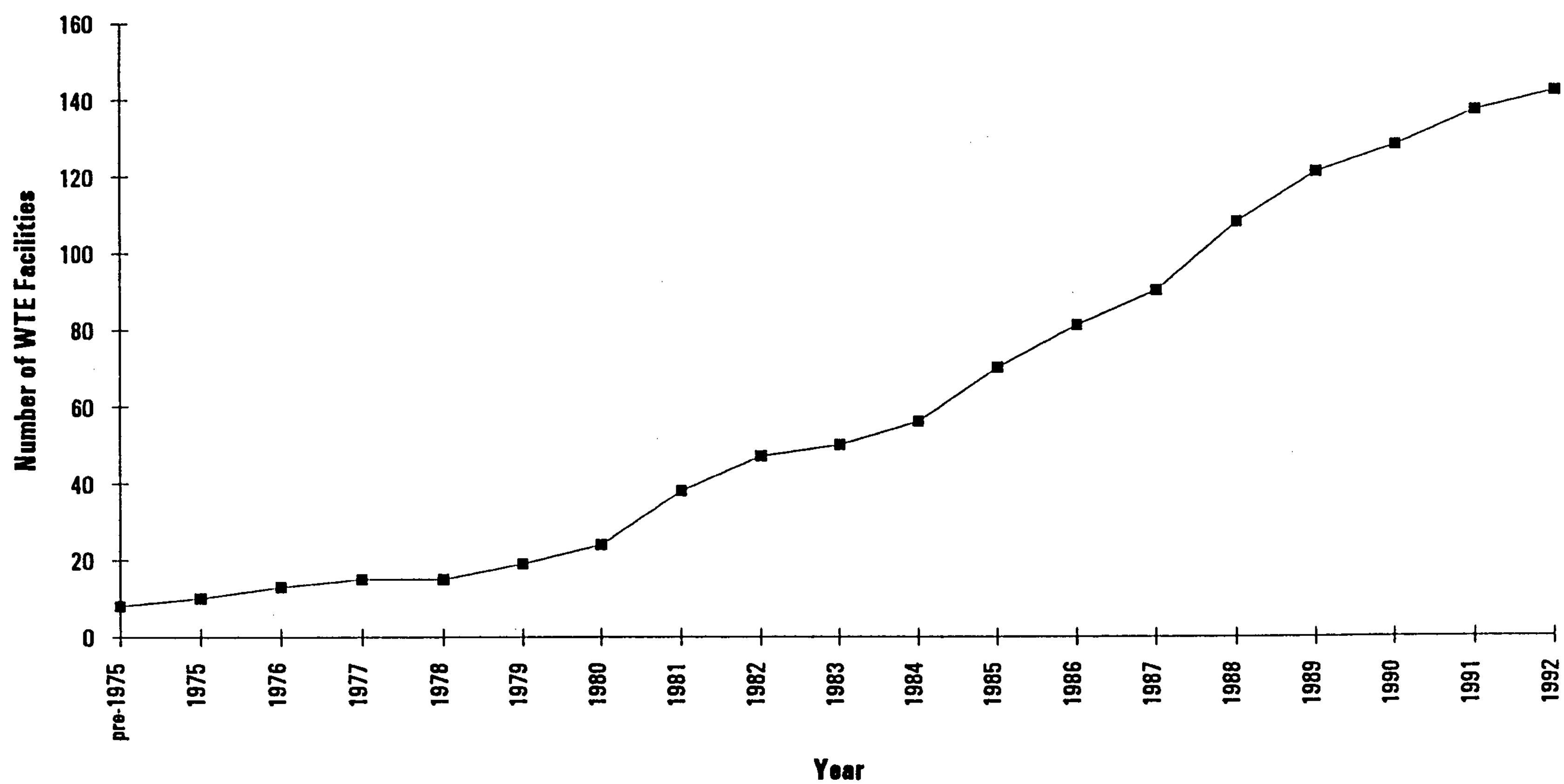
Municipal Waste Combustion

In 1990, over 31.9 million tons of MSW (16.3 percent of the total) were combusted at waste-to-energy (WTE) plants and non-energy recovering incinerators, collectively known as municipal waste combustors (MWCs). Waste-to-energy facilities burn garbage to reduce its volume, a process that generates steam for heating and producing electricity. A typical plant pays for approximately one-third to one-half of its operating costs by selling steam or electricity. More importantly, combustion reduces the volume of garbage by up to 90 percent and reduces weight by 70 to 75 percent.

Physical Assets. In 1992, there were 176 MWCs in the United States, managing nearly 34 million tons of waste per year.[215] The total number of WTE facilities now operating in the United States is 142 (Figure 9-5). These facilities have a rated MSW processing capacity of approximately 101,000 tons per day and process 16 percent of the U.S. MSW stream (see Figure 9-6 for trends in MWC capacity).[216] At this time, WTE facilities manage roughly 93 percent of all MSW combusted in the U.S; incinerators manage the remaining 7 percent. Since 1990, the number of incinerators has declined from 40 facilities to 34, and no new incinerator capacity has come on-line since 1986. The downward trend in operating incinerator capacity is expected to continue, especially with the new control requirements of the 1990 Clean Air Act amendments. A 1990 study found that 64 percent of WTE facilities were publicly owned and 36 percent were privately owned. However, 60 percent of the facilities are privately operated and 40 percent of the facilities are publicly operated.[217]

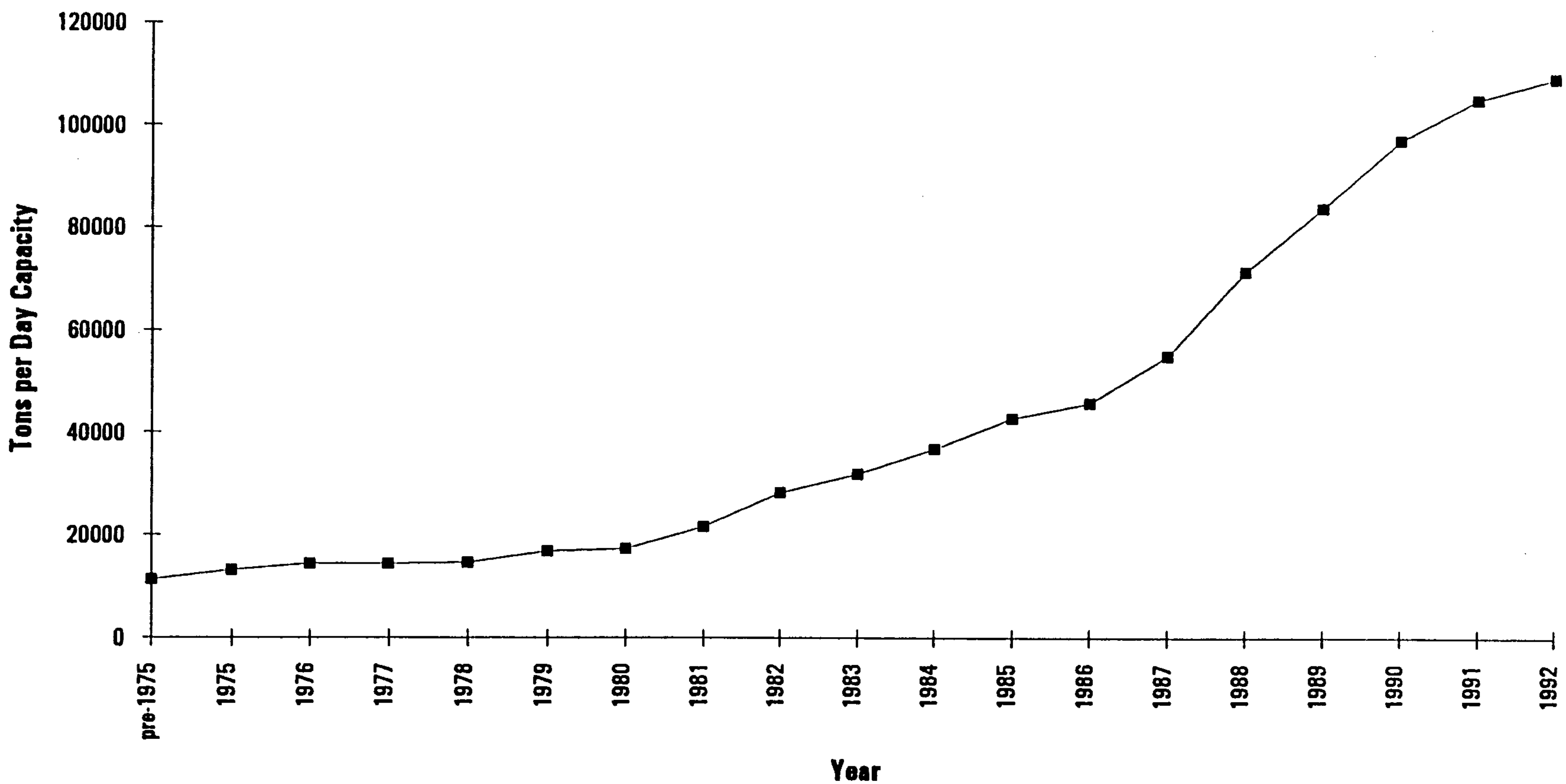
There are currently three WTE facilities with a rated design capacity of nearly 3,200 tons per day under construction in the U.S. In addition, there are currently an estimated 37 WTE facilities in the planning stage and nine inactive MWC projects with a combined rated design capacity exceeding 43,700 tons per day (tpd) in the U.S. Thirty-four states have operating WTE plants, with the majority located in the Northeast and South. Most of the states without WTE facilities are located in the West due to the availability of inexpensive land for landfill construction. From 1986 to 1992, the number of WTE

Figure 9-5: Number of Waste-to-Energy (WTE) Facilities in the U.S., (pre 1975-1992)



Source: Integrated Waste Services Association and Kidder Peabody, Inc.

Figure 9-6: Municipal Waste Combustion Capacity in the U.S. (Pre-1975-1992)



Source: Integrated Waste Services Association facilities has increased from 81 facilities to 142, an increase of roughly 78 percent. Florida leads the nation with 17,000 tpd of capacity, followed by New York with 14,000 tpd capacity.

Immediate future industry growth is expected to drop off significantly.[218] There are many reasons for this downturn, including a number of projects that remain on hold or that have been canceled as a result of limited financing or lack of project support. Other contributing factors include the lack of clear legislative and regulatory guidelines on emissions control, ash management, and the sale of power in new markets.

Service Delivery. The MWCs processed approximately 33.6 million tons of waste in 1992. EPA estimates that MWCs will manage 35.4 million tons of waste in 1995 and 46.2 million tons of waste (20.4 percent of the projected total) in 2000. States with disposal capacity shortfalls such as New Jersey view WTE as an attractive long-term component of their waste management plan. In fact, New Jersey is recommending that its counties coordinate to develop joint-WTE capacity for managing their solid waste. Through this cooperation, the counties may ensure that they take advantage of economies of scale associated with a WTE facility.

Energy from MSW is captured through the generation of steam in a boiler which, in turn, can be put to beneficial use in numerous applications. For example, power in the form of steam or hot water can be used for space heating in buildings, as process heat for industrial operations, or to run a turbine to generate electricity. Operating WTE facilities in the U.S. have an electricity generating capacity equivalent to approximately 2,300 megawatts, which could supply power to over 1.3 million homes.[219]

Quality of Service/Cost Effectiveness. Environmental concerns regarding MWCs revolve around questions related to air emissions, such as dioxins, mercury, and acid gases, and the existence of toxic elements in the residue ash. Combustion in waste-to-energy plants occurs at extremely high temperatures (1,800 to 2,000 degrees Fahrenheit) to reduce waste volumes and minimize the release of pollutants. These facilities must also meet stringent federal and state standards. For example, EPA's New Source Performance Standards (NSPS), promulgated in January 1991, require that by 1994, new units with daily capacity exceeding 250 tons must have scrubbers that will reduce metals emissions by 99 percent, organic compounds by 99 percent, and acid gases by 90 to 95 percent. Existing facilities must also be retrofitted with scrubbers to reduce these pollutants. Debate continues on whether to classify ash as nonhazardous or hazardous. At this time, EPA maintains that ash is not a hazardous waste and it can be managed effectively in Subtitle D approved landfills. If ash is classified as hazardous, MWC operating costs would rise dramatically.

Average per ton MWC tipping fees for the 18 states that reported them in 1992 ranged from $12 in Montana (1 facility) to $93 in New Jersey (4 facilities). New York, the state reporting the second highest daily capacity in the nation -- 14,000 tons per day, has average tipping fees of $75.[220]

CHAPTER X: HAZARDOUS WASTE MANAGEMENT

GOALS OF HAZARDOUS WASTE MANAGEMENT

U.S. policy in hazardous 'waste management programs is intended to protect human health and the environment at the lowest cost to the nation. Two national programs help achieve this goal: regulation of currently generated hazardous wastes under the 1976 Resource Conservation and Recovery Act (RCRA) and its amendments; and cleanup of accidental spills and past mismanagement of wastes on land under the 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and its amendments. These regulations apply to both private and public sectors. Therefore, while federal, state, and local governments regulate private sector hazardous waste generation, treatment, and disposal, they must also comply with these same regulations. In fact, the federal government authorized over $9.9 billion for federal agency hazardous waste compliance and cleanup related activities in 1993. In addition, the federal government provides funding for the remediation of contaminated sites through the Superfund and Leaking Underground Storage Tank programs (LUST).

OVERALL PERFORMANCE OF HAZARDOUS WASTE MANAGEMENT

Private Sector

The U.S. Environmental Protection Agency (EPA) collects and maintains information about the generation, management, and disposition of hazardous waste regulated under RCRA, as amended.[221] In 1989, a total of 197.5 million tons of RCRA hazardous waste was generated nationwide by 20,233 large quantity generators. It is estimated that private industry spent approximately $2.379 billion in 1989 to manage hazardous wastes.[222] The private sector is solely responsible for the provision of hazardous waste management infrastructure for managing private sector hazardous waste.

Historically, federal and state regulations were designed to require the safe handling of all hazardous wastes from "cradle to grave" -- from generation to disposal. However, in recent years, there has been a shift in hazardous waste management from "end-of-pipe" pollution control strategies to waste minimization strategies.[223] This shift can be observed in the federal and state mandates that either require or encourage reductions in hazardous waste generation through source reduction, recycling, and energy recovery. For example, the 1986 Emergency Planning and Community Right-to-Act (EPRCA) set up the Toxic Chemical Release Inventory system, known as TRI. TRI requires facilities to publicly report their releases of toxic chemicals to all environmental media (air, water, land) for each substance used, manufactured, or processed above certain weight thresholds. Companies near the top of state TRI lists are responding to public pressure and investing in pollution prevention and control projects to remove themselves from the top of the lists. In addition, many companies are pursing aggressive hazardous waste reduction programs to avoid the high cost of managing RCRA wastes, reduce their potential liability under CERCLA, and/or build a proactive corporate image. In fact, there were 937 participating companies as of October 1992 in EPA's voluntary 33/50 pollution prevention project, where companies sign on to reduce their generation of 17 toxic chemicals 33 percent by 1992 and 50 percent by 1995.[224]

Approximately 31 of the 50 states now have significant laws relating to hazardous waste reduction and pollution prevention.[225] The motivating force behind these laws was the State Capacity Assurance Planning process set up in 1986 by Section 104(k) of CERCLA, which had the principal goal of preventing future Superfund sites. Each state is now required to assure the EPA Administrator that it will have adequate capacity to manage its own hazardous waste for the next twenty years (through one or a combination of waste minimization, in-state waste management capacity, and regional capacity assurance agreements). The goal of the state laws is generally to protect public health and the environment by encouraging industry to generate less hazardous waste, use smaller amounts of toxic substances, or cut toxic releases to the environment.

Federal Hazardous Waste Programs: Superfund, Leaking Underground Storage Tanks (LUST), Federal Facility Management

The federal government administers two national programs aimed at cleaning up previously contaminated sites (Superfund and LUST); in addition, federal facilities must comply with RCRA, CERCLA, and their respective amendments. In fiscal year 1992, EPA spent approximately $1.781 billion on the Superfund program and $58.45 million on the LUST program. Federal expenditure and performance data for these programs are available; however, there are no uniform data for either state government or private sector Superfund and LUST expenditures. Authorized federal expenditures for hazardous waste cleanup and compliance activities at federal facilities have increased from approximately $3.019 billion in 1989 to $9.9 billion in 1993.[226] Eight agencies requested appropriations for hazardous waste cleanup and compliance in 1993, but two agencies, the Department of Energy (DOE) and Department of Defense (DOD), were responsible for over 97 percent of authorized spending. While DOE and DOD have made waste minimization a priority at operating sites, they both face major facility cleanup challenges.

IMPROVING PERFORMANCE REPORTING IN THE FUTURE

Private sector performance reporting of hazardous waste generation and management has substantially improved in the United States during the last ten years. In response to reporting requirements authorized in RCRA and the Hazardous and Solid Waste Amendments of 1984, EPA developed regulations that specify a reporting format and schedule for hazardous waste generators and TSDs. The 1987 and 1989 National Biennial Reports are a census of this regulated community and provide detailed information on the amount and types of waste generated by particular facilities, waste minimization activities, as well as how and where these wastes are managed. While there are limitations to this data, the Biennial Report provides a relatively comprehensive overview of hazardous waste management in the U.S.[227]

The nation spends billions of dollars every year on the management of hazardous wastes; therefore, improved performance data on the relative risks of hazardous wastes as well as the cost effectiveness of certain regulatory control strategies is necessary. For example, approximately 95 percent of RCRA hazardous waste reported for 1989 was wastewater, a substantial portion of which was classified as hazardous due to the "mixture"[228] and "derived from"[229] rules.[230] At the moment, these wastes are managed as hazardous regardless of their actual environmental and health risks. Because of the high costs associated with managing hazardous waste, it is important that only *hazardous* wastes are managed in Subtitle C facilities. Therefore, better information on the relative risks of these materials is needed to make cost-effective regulatory decisions.

Information on the cost and benefits of remediating contaminated sites is another area where more useful performance data is needed. Estimates of total remediation costs for orphaned, privately held, and federally owned facilities in the United States range from $300 billion to $1 trillion over a time period of 30 to 50 years.[231] Today, the federal government is spending over $5 billion a year on cleanup activities. In its current state, CERCLA strongly favors permanent cleanup remedies at contaminated sites, which may lead to excessively high remediation costs with minimal overall actual risk reduction. A 1989 EPA report, "Comparing Risks and Setting Environmental Priorities," ranked the risks from hazardous waste sites among the lowest the agency has to address.[232] Therefore, information on the cost and benefits of different cleanup approaches such as containment, stabilization, cleanup for intended use, and cleanup for unrestricted use would be helpful. Government and private expenditures on hazardous waste cleanup divert capital from alternative investments; therefore, information on the relative rates of return and cost effectiveness of regulatory approaches and cleanup strategies would assist government officials in designing regulations and developing site-specific remedial plans. Because of the regulatory and economic uncertainty associated with CERCLA cleanup, federal agencies were reluctant to provide estimates of future CERCLA-related expenditures.

HAZARDOUS WASTE PERFORMANCE INDICATORS

Private Sector

Physical Assets

The EPA's National Biennial Report collects data on the number, location, and type of hazardous waste treatment, storage, and disposal (TSD) facilities in the United States; however, only limited information is available on the current capacity of hazardous waste management facilities or the private sector's ability to add new capacity, given future demand. In 1989, there were 3,078 TSD facilities that reported management of 196.5 million tons of RCRA hazardous waste in units subject to RCRA permitting requirements -- 1,170 of these sites were storage only facilities (Table 10-1). A few sites accounted for most of the hazardous waste managed. In fact, the three largest hazardous waste TSD facilities accounted for 57 percent of the total RCRA hazardous waste management quantity, while the largest 50 TSD facilities accounted for more than 90 percent of the total. Ninety-six percent of the hazardous waste generated was managed on site, and four percent of the RCRA hazardous waste was shipped off site for management.

Among the states, the largest managers of RCRA hazardous waste were New Jersey (46.9 million tons), Michigan (35.1 million tons), Tennessee (34.5 million tons), Texas (27.8 million tons), and West Virginia (14.3 million tons) (Table 10-2). California reported the largest number of TSD facilities with 357, followed by Texas with 304 facilities. The 60 largest management facilities managed roughly 93.3 percent of the nation's hazardous waste, of which 14.6 percent of the waste managed was characteristic, 36 percent listed waste, and 49.4 percent a combination of both listed and characteristic waste.[233]

Table 10-1: Quantity of RCRA Hazardous Waste Managed by Management Method

Management Method	Quantity of Tons Managed	Percent of Total	Number of Facilities
Metals Recovery for Reuse	1,362,362	0.70	56
Solvents Recovered	485,790	0.20	193
Other Recovery	290,616	0.10	98
Incineration	1,280,216	0.70	221
Energy Recovery (Reuse as Fuel)	864,618	0.40	82
Fuel Blending	691,138	0.40	76
Aqueous Inorganic Treatment	10,416,235	5.30	220
Aqueous Organic Treatment	58,601,949	29.80	42
Aqueous Org. and Inorg. Treatment	80,911,585	41.20	25
Sludge Treatment	120,135	0.10	41
Stabilization	1,068,268	0.50	45
Other Treatment	9,390,962	4.80	446
Land Treatment	598,302	0.30	51
Landfill	2,275,783	1.20	86
Surface Impoundment	34,256	0.05	11
Underground Injection	27,956,284	14.20	59
Other Disposal	8,136	0.05	29
Invalid System Type	144,218	0.10	118
Total	196,500,853	100	1,899

Source: U.S. EPA, National Biennial RCRA Hazardous Waste Report (Based on 1989 Data)

Forty of the 60 largest TSD facilities were in the chemical and allied products industry, accounting for 87.6 percent of total waste managed nationwide. Other industries included among the 60 largest facilities were the petrochemicals and coal products industry, electronic and other electronic equipment industry, fabricated metal products industry, primary metals industry, and electric, gas, and sanitary services industry.

Hazardous Waste Management Methods

Primary methods of hazardous waste management are: treatment; underground injection; thermal destruction; landfilling; and waste minimization. In terms of quantity of hazardous waste managed, the predominant waste management method is biological, physical, or chemical treatment of wastewater, which accounts for 76 percent of the total. The management method that ranked second in quantity of waste managed was underground injection wells (14 percent), which also dispose of wastewater. Approximately 2.3 million tons of waste were disposed of in 86 landfills, and 1.3 million tons were incinerated at 221 facilities.

Treatment. Hazardous waste treatment technologies include a wide variety of chemical, biological, and physical processes. These on-site industrial or off-site commercial technologies either remove hazardous constituents from wastewater or convert hazardous waste into less hazardous or nonhazardous forms. In 1989, approximately 148.6 million tons of hazardous wastewater (76 percent of the total hazardous waste stream) was treated in aqueous inorganic, aqueous organic, and aqueous organic and inorganic treatment facilities. Over 99 percent of these wastes were managed on site.

Underground Injection. The practice of deepwell injection involves pumping hazardous waste several thousand feet below the surface into saline, permeable injection zones. Deepwell injection is regulated by the EPA through the Underground Injection Control Program (UIC) of the 1974 Safe Drinking Water Act. In 1989, 59 underground injection facilities disposed of almost 28 million tons of hazardous wastewater. In 1992, there were only eight facilities that offered commercial underground injection disposal.[234] In large part, this is due to the implementation of EPA's land ban restrictions, which require treatment of hazardous waste prior to injection into the ground. In addition, several major waste generators are phasing out deep well injection or have eliminated its use entirely in favor of other disposal technologies to reduce future liabilities.[235]

Thermal Destruction. Thermal destruction technologies include all types of incineration: liquid injection; rotary kilns; fluidized-bed plus cement kilns; and industrial boilers. The method used depends on the waste phase -- liquid, sludge, or solid -- and the heating value of the particular waste stream. In 1989, 1.1 percent of hazardous waste generated was managed in either incineration or energy recovery facilities. Commercial incinerators and energy recovery facilities managed approximately 804,000 tons of hazardous waste in 1989. In early 1992, there were approximately 52 commercial incinerators, cement kilns, and industrial boilers and furnaces burning hazardous waste in the U.S.[236]

Landfills. Almost 2.3 million tons of hazardous waste were buried in 86 hazardous waste landfills in 1989. A majority of these wastes, 2.1 million, was sent to the nation's 51 operating commercial landfills. In fact, 26.4 percent of commercially managed hazardous wastes in the U.S. was disposed in landfills. Since 1989, the number of commercial landfills has decreased to 21 due primarily to the land ban restrictions, tighter regulatory requirements, and difficulties in siting new facilities.[237]

Waste Minimization. While the quantity of hazardous waste generated fell from 238.3 million tons in 1987 to 197.5 million tons in 1989, this decrease was largely due to shifts in management of wastewater from surface impoundments subject to RCRA permitting requirements to tanks exempt from those requirements. However, of 20,713 sites that reported in 1989, 6,067 sites (29 percent) engaged in one or more new waste minimization activities in 1989. These sites accounted for 50 percent of the total quantity of RCRA hazardous waste generated in the nation. Approximately 38 percent of the sites in manufacturing industries engaged in new waste minimization activities. Ninety percent of all waste minimization activities involved source reduction, compared to only 16 percent that involved recycling (6 percent involved both source reduction and recycling).

A more recent survey of waste generators found that 62 percent of responding medium and large manufacturing firms had reduced their hazardous waste generation from 1987-1991, despite the fact that a number of new wastes have come under the RCRA umbrella.[238] Many firms had reduced their wastes by 50 percent or more, and 66 percent of the firms had formal waste minimization programs. The idea of waste reduction seems to have taken hold within U.S. companies.

Service Delivery

In 1989, a total of 197.5 million tons of RCRA hazardous waste was generated nationwide by 20,233 large quantity generators (Table 10-2). Small quantity generators produce less than 1 percent of the hazardous waste generated in the nation.[239] The majority of the 100,000 small quantity generators are automotive repair shops, construction firms, dry cleaners, photographic processors, equipment repair shops, laboratories, electroplaters and schools. Approximately 95 percent of the RCRA hazardous waste reported in the National Biennial Report was wastewater. The largest 1 percent of sites generated nearly 97 percent of the hazardous waste. Over three quarters of the sites generated less than 1000 tons of hazardous waste each, together accounting for only 0.2 percent of the nationwide generation.

New Jersey reported the largest amount of hazardous waste, 47.1 million tons or 23.8 percent of the total, generated during 1989. Michigan, Tennessee, Texas, and West Virginia generated 35.1, 34.4, 28.2, and 14.4 million tons respectively. Twenty-two of the 50 states, District of Columbia, and four U.S. territories, reported generating less than 100,000 tons of RCRA hazardous waste, together representing only 0.2 percent of the nationwide total. California had the highest number of large quantity generators with 2,387, followed by Texas with 1,575, New Jersey with 1,434, and Illinois with 1,425. Even though California had the largest number of generators, 11.8 percent of the total, it generated 2.3 percent of the national quantity of RCRA hazardous waste, illustrating that there is little relationship between the number of generators and the quantity of RCRA hazardous waste generated.

Hazardous Waste Generation By Industry

In 1989, the top five hazardous waste generators accounted for over 55 percent of the national total. The 50 largest hazardous waste generators accounted for 92 percent of the national total quantity. Of the 50 sites, most are manufacturers, mainly in the chemical manufacturing and oil refining industries. The chemical allied products industry generated, by far, the largest quantity of hazardous waste, accounting for 88 percent of total generation.[240]

Table 10-2: RCRA Hazardous Waste Generation and Management by State, 1989

State	Total Tons Generated	Number of Generators	Total Tons Managed	Number of TSD Facilities
Alabama	403,701	224	564,189	71
Alaska	3,644	43	29	20
Arizona	124,595	175	95,737	17
Arkansas	805,150	51	824,156	24
California	4,670,579	2,387	4,978,478	357
Colorado	117,347	131	81,292	59
Connecticut	1,390,314	506	366,215	131
Delaware	19,766	59	3,472	7
District of Columbia	2,357	11	0	0
Florida	411,832	368	359,733	22
Georgia	2,615,210	378	2,551,209	57
GUAM	573	10	0	1
Hawaii	2,149	28	803	22
Idaho	15,062	20	45,951	9
Illinois	1,381,799	1,425	1,441,365	139
Indiana	1,843,015	697	2,021,016	44
Iowa	76,240	131	74,653	30
Kansas	1,713,963	192	1,700,795	34
Kentucky	149,612	337	145,481	51
Louisiana	9,094,768	445	9,205,887	46
Maine	52,528	46	0	4
Maryland	265,227	385	211,256	37
Massachusetts	34,142	494	0	0
Michigan	35,143,264	824	35,067,217	232
Minnesota	239,098	241	348,586	237
Mississippi	717,291	153	697,961	31
Missouri	384,289	298	289,531	74
Montana	4,978	28	2,857	9
Nebraska	72,209	72	83,959	12
Nevada	4,685	32	20,246	11
New Hampshire	18,211	111	5,952	6
New Jersey	47,096,658	1,434	46,931,754	98
New Mexico	10,961	46	6,355	19
New York	406,910	848	419,838	73
North Carolina	586,338	684	565,799	28
North Dakota	28,840	17	25,451	6
Ohio	2,727,383	1,176	2,710,118	161
Oklahoma	205,382	140	228,363	48
Oregon	27,954	77	65,285	13
Pennsylvania	1,246,706	1,004	1,139,446	157
PUERTO RICO	246,161	76	243,417	38
Rhode Island	5,565	191	12,897	4
South Carolina	106,224	394	175,807	34
South Dakota	1,088	12	0	2
Tennessee	34,363,940	446	34,533,270	67
Texas	28,171,860	1,575	27,788,963	304
TRUST TERRITORY	23	2	2	2
Utah	211,563	85	258,227	34
Vermont	13,481	42	106	6
VIRGIN ISLANDS	5,757	1	5,757	1
Virginia	5,227,092	287	5,324,021	52
Washington	228,323	714	170,943	56
West Virginia	14,390,206	102	14,335,403	19
Wisconsin	411,897	559	371,333	55
Wyoming	3,180	19	287	7
Total	197,501,090	20,233	196,500,868	3,078

Source: U.S. EPA, National Biennial RCRA Hazardous Waste Report (Based on 1989 Data)

Hazardous Waste Generated By Types

There were three types of RCRA hazardous waste generated in the U.S. in 1989: characteristic, listed, and characteristic and listed hazardous wastes. Characteristic waste is classified as hazardous because it is ignitable, corrosive, reactive, or toxic as determined by EPA. Listed wastes are hazardous because of the specific risks associated with each chemical or waste. Characteristic wastes were 16.5 percent of the national total, and listed waste were 36.2 percent. Combined characteristic and listed wastes were 47.3 percent of the total waste generated.

Quality of Service

There is no national data on the effectiveness of RCRA and CERCLA in protecting human health and the environment or the compliance rates of affected firms. In 1992, EPA launched its first coordinated enforcement initiative involving specific industrial sectors. On September 10, 1992, EPA and the Department of Justice filed a series of enforcement cases against industrial facilities in the pulp and paper manufacturing, metal manufacturing and smelting, and industrial organic chemical manufacturing sectors -- sectors that EPA had identified as having significant incidents of noncompliance and as releasing large amounts of toxic substances to the environment. By concentrating enforcement efforts in these sectors, EPA expects to increase compliance rates with all environmental statutes throughout these industrial sectors and to foster greater use of pollution prevention and control. In 1992, there were 291 federal administrative RCRA enforcement actions and 245 CERCLA related enforcement actions.[241] Civil and criminal penalties for federal environmental violations increased to an all-time high in 1992.

Cost Effectiveness

In 1991, industry spent $322.9 million on capital investments and $2.55 billion on operating and maintenance costs for hazardous waste abatement.[242] Industrial spending for hazardous waste control plant, equipment, and operations increased from approximately $634.4 million in 1983 to $2.9 billion in 1991, a total increase in nominal terms of 450 percent. As a proportion of total pollution abatement expenditures (air, water, nonhazardous and hazardous solid waste), expenditures for hazardous waste abatement have risen from just over 5 percent of the total in 1983 to almost 12 percent in 1991.[243] RCRA reauthorization, which may occur in the near future, will have a major impact on whether these costs continue to increase. Important items to be addressed by Congress with regard to hazardous waste include the "mixture" and "derived from" rule, interstate hazardous waste bans, and pollution prevention. Hazardous waste management costs will also depend on the type and amount of state regulations imposed on waste generators and TSDs.

There are no studies that have attempted to directly measure societal costs of hazardous waste management. However, numerous studies have estimated aggregate economic costs and employment effects of environmental regulations. In every case, these studies found that environmental regulations decreased productivity or reduced employment levels; however, none of these studies attempted to capture the positive benefits of regulation and resulting productivity and employment impacts.[244]

Federal Hazardous Waste Programs: Superfund, Leaking Underground Storage Tanks, and Federal Facility Management

Superfund

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) addressed a problem relatively ignored by RCRA -- how to handle hazardous waste contamination from past disposal activities. CERCLA established a federal program, commonly known as Superfund, to finance the cleanup of the nation's most contaminated waste sites. Superfund set detailed guidelines for cleaning up these sites and established a legal liability system to force those responsible for the contamination to pay for the cleanup. Where enforcement is not successful, the federal government can clean up a site using the CERCLA Trust Fund, which is supported by excise taxes on feedstock chemicals and petroleum and a broad based corporate environmental tax.

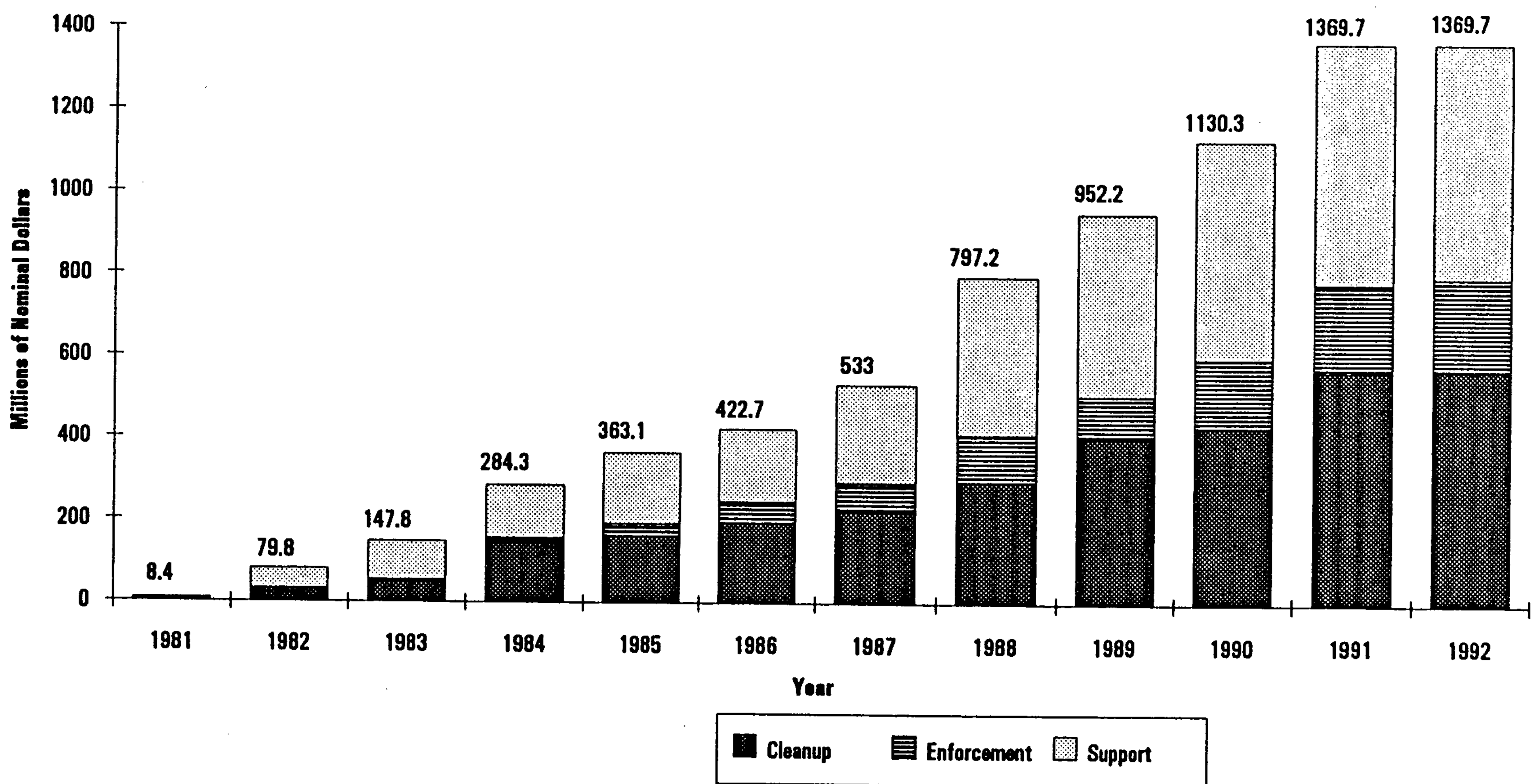
Financial Trends. From 1981 through 1992, the Superfund program disbursed $3.1 billion for cleanup related activities, including removal and remedial activities (Figure 10-1). From 1986 through 1992, 40.7 percent of the total $6.574 billion disbursements were allocated to cleanup activities; 44.8 percent for administrative support and other activities; and 14.15 percent for enforcement activities. In 1992, $571.6 million out of $1.370 billion, 42 percent, was disbursed for site cleanup activities; this is less than a one percent increase over 1991's $567.1 million. However, from 1985 to 1992, disbursements for cleanup activities (removal and remedial) have risen from $160 million to $571.6 million, an average annual increase of nearly 20 percent. Disbursements for support and other activities declined from $585.9 million in 1991 to $572.5 million in 1992. The EPA has recovered over $524 million from potentially responsible parties (PRPs) to assist in the cleanup of contaminated sites.[245]

State governments and private companies will also spend a great deal of money on Superfund cleanup. However, there is no data on historical expenditures, and cost estimates are based on a variety of uncertain assumptions such as the average cost to clean a site, the number of Superfund sites, and technical and regulatory developments. A 1990 EPA study estimated annualized state costs at $140 million in 1990, $379 million in 1995, and $727 million in the year 2000. Private sector annualized costs were projected at $950 million in 1995 and $1.8 billion in 2000.[246]

Service Delivery. As of November 1992, EPA identified 37,592 potentially hazardous waste sites across the nation. Of these sites, 93 percent have undergone a preliminary assessment to determine the need for further action. EPA maintains the Superfund National Priorities List (NPL), which identifies the nation's most seriously contaminated hazardous waste sites eligible for permanent Superfund cleanup. There are currently 1,280 sites on the NPL, with 757 sites under construction and 523 still under investigation. Emergency actions are underway at 521 sites, and long term construction is underway at 472 sites.[247] As of October 1992, 40 sites had been deleted from the NPL, and 84 sites were awaiting deletion.

Quality of Service/Cost Effectiveness. At 3,000 sites, Superfund has treated, isolated, neutralized, or removed from the environment 13 million cubic yards of contaminated soil and solid wastes, 1 billion gallons of liquid waste, 6 billion gallons of contaminated groundwater, and 316 million gallons of polluted surface waste. These actions have reduced potential risks to the 23 million people who live within four miles of a Superfund site, including more than 950,000 people who had been at risk to threats posed by direct contact with hazardous waste.[248]

Figure 10-1: Annual Superfund Disbursements



Source: U.S. EPA, Financial Management Division, August 6, 1993, Internal Document.

The Superfund program has been criticized the last few years on several fronts: the joint and several liability clause; high cleanup costs in relation to cleanup benefits; long period from listing to cleanup; and excessively high transaction and cleanup costs. These criticisms and overall budgetary pressures help explain the $195.9 million decrease in Superfund's budget from 1992 to 1993. In response to efficiency concerns, EPA has developed the Superfund Accelerated Cleanup Model (SACM), which is designed to make hazardous waste cleanups more timely and efficient. EPA's Regional offices will administer the program through Regional decision teams (RDTs) that include managers from assessment, removal, remediation, enforcement, and community relations. These teams will work with state officials to make cleanup decisions in a coordinated and integrated fashion, reducing duplication and downtime between site study and cleanup phases. SACM is currently being pilot-tested at 27 projects nationwide.

Leaking Underground Storage Tank Program

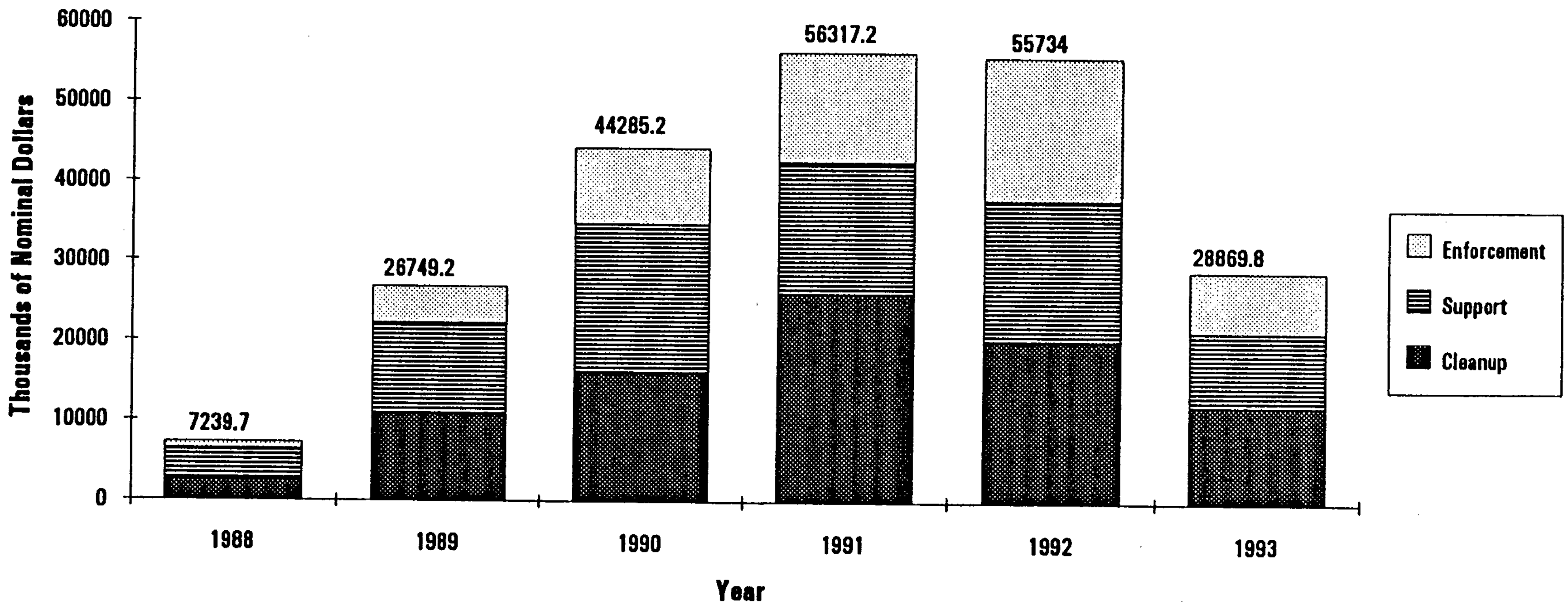
The Hazardous and Solid Waste Amendments of 1984 include a provision regulating the operation of underground storage tanks and requiring cleanup of contamination from leaking tanks. The technical and financial responsibility requirements for petroleum-containing underground storage tanks are expected to impose significant costs on the private sector. Annualized UST compliance costs for the private sector are estimated to be $3.2 billion in 1990, increasing to an estimated $4.6 billion by the year 1993. These private sector costs are driven primarily by corrective action activities over the years 1989-1993. Annualized costs are expected to drop off to approximately $3 billion over the next few years, and then jump to $3.8 billion in 1998, the compliance deadline year for tank upgrade/replacement.[249] Again, private sector compliance costs are estimated using a variety of uncertain assumptions, and there is no mechanism for collecting information on actual private sector UST expenditures. At the federal level, EPA disbursed approximately $248 million (nominal dollars) to the states for the UST program from 1987-1992 (Figure 10-2). In 1992, 36 percent of the $58.5 disbursed by EPA was earmarked for site cleanup, and the remainder was divided equally among administrative and enforcement activities.

There are 1,355,894 active petroleum tanks in the U.S and 673,985 closed underground storage tanks. There are 217,386 tanks with confirmed releases. Cleanups have been initiated at 165,701 sites and completed at 74,655 sites.[250] Only 636 of these cleanups were initiated by the Trust Fund. To date, there have been 6,818 emergency responses. More than forty states now have in place a fund that reimburses tank owners for all or part of their UST assessment and cleanup costs. While states have collected nearly $1 billion a year in fees to fund UST reimbursements, only about $730 million has been paid to-date to tank owners.

Federal Facility Management

Federal facilities must comply with the same environmental standards as private facilities. From 1989 to 1993, authorized spending for hazardous waste compliance and cleanup activities at federal facilities rose over 300 percent in nominal terms from $3.023 billion to $9.901 billion (Figure 10-3). The Department of Energy (DOE) and Department of Defense (DOD) were responsible for over 97 percent of authorized expenditures in 1993. Other agencies with significant hazardous waste expenditures include: the Departments of Agriculture, Interior, Transportation, Justice, Commerce; and NASA. There is no uniform reporting format for federal hazardous waste management agency expenditures (e.g., definitions of hazardous waste management expenditures and capital versus operating expenditures, and detailed accounting of expenditures); therefore, it is difficult to aggregate or compare data from the different agencies. This section of the report will present performance data for DOE and DOD and a brief overview of other federal agency hazardous waste management activities.

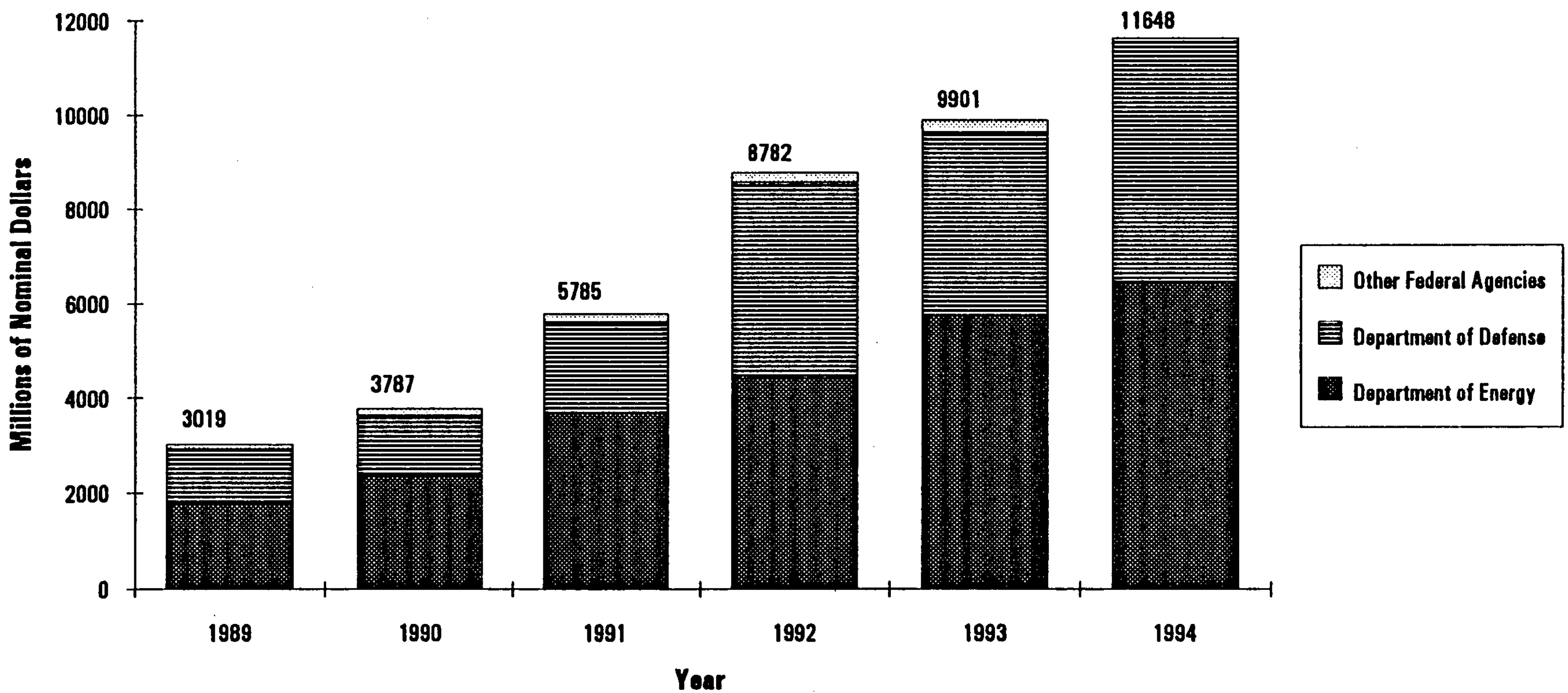
Figure 10-2: Annual Leaking Underground Storage Tank Trust Fund Disbursements



Source: LUST Trust Fund End-of-the-Year Report, FY 1988-1993, U.S. EPA

Note: 1993 expenditures are through 2nd quarter and miscoded disbursements are not included.

Figure 10-3 : U.S. Budget for Hazardous Waste Cleanup and Compliance at Federal Facilities



Sources: Executive Office of the President, Office of Management and Budget, Budget of the U.S. Government, FY 1991-1993. Only DOE and DOD provided budget request information for FY 1994.

Department of Energy

For forty years, the U.S. Department of Energy (DOE) was the agency primarily responsible for the production of nuclear materials and weapons in the U.S. However, there has been a shift in priorities the last few years from the production of nuclear materials and weapons to the cleanup and management of hazardous wastes at DOE facilities. The Office of Environmental Restoration and Waste Management (EM) is spearheading the agency's hazardous waste cleanup and compliance activities.

Financial Trends. The budget for DOE environmental restoration and waste management activities has tripled during the last three years, and this trend is expected to continue for the next several years (Figure 10-4). DOE's projected budget request for environmental restoration and waste management activities for fiscal year 1994 is $6.175 billion. In the FY 1994 request, 62 percent of the budget request is legally driven, 24 percent is for other environment, safety and health activities (required by internal DOE Order), and 14 percent is allocated for other desirable program activities.[251]

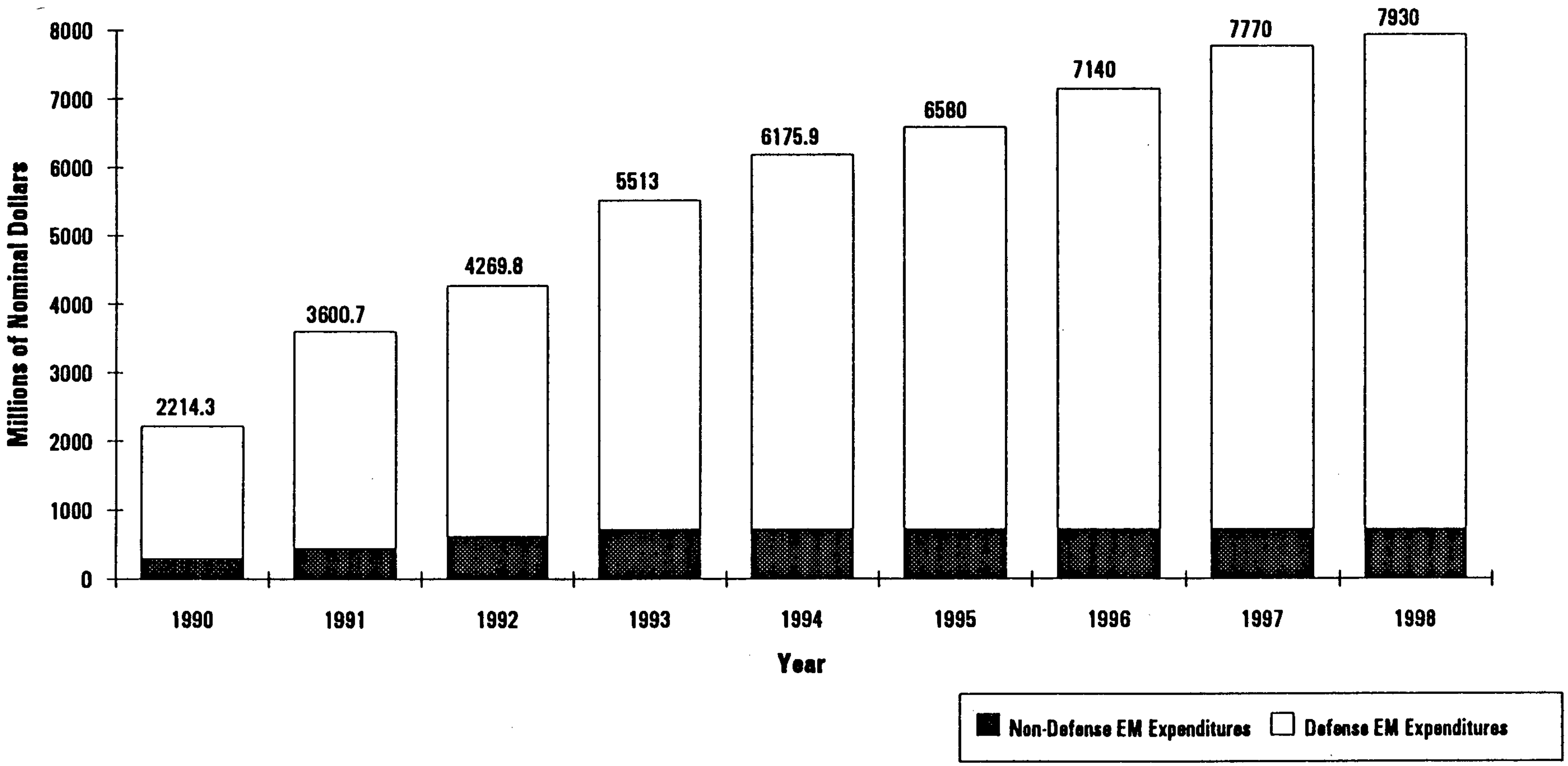
The DOE cleanup and compliance program encompasses four major categories of program activity: environmental restoration; waste management; corrective activities; and technology development. Environmental restoration activities include assessment, cleanup, and decontamination and decommissioning of contaminated facilities and sites that are no longer a part of active operations in order to meet regulatory requirements and standards. The FY 1994 budget request for environmental restoration activities is approximately $1.91 billion. Waste management operations provide for the management of hazardous wastes generated as a result of ongoing activities at active facilities. Waste management is accomplished through minimization, treatment, storage and disposal of various waste types including radioactive, hazardous, mixed and sanitary wastes, in compliance with applicable local, state, federal, and internal DOE requirements. Funding for waste management activities is the largest portion of the proposed 1994 budget, totaling $3.095 billion of the $6.175 billion budget.

Corrective activities include those actions needed to bring currently operating and standby facilities into compliance with applicable air, water, and solid waste regulatory requirements. DOE requested $26.46 million for corrective activities in FY 1994. Technology development provides for research and development activities, which will develop and apply more effective technologies to meet DOE's environmental restoration and waste management goals. The agency is requesting almost $650 million for technology development in FY 1994. Other major program expenditures planned for FY 1994 include $650 million for facility transition, $286 million for the uranium decontamination and decommissioning fund, $92 million for program direction, and $20 million for transportation management.

Service Delivery. DOE is responsible for hazardous waste management and cleanup of more than 100 contaminated installations in 36 states and territories. In DOE's latest Environmental Restoration and Waste Management Five-Year Plan (Fiscal Years 1994-1998), they evaluate their progress in three areas: environmental restoration, waste management, and technology development, education, and training. Programmatic objectives through FY 1997 include:

- Completion of all Corrective Activities by FY 1997;
- Complete assessment of contamination at more than 300 CERCLA and RCRA units;
- Completion of more than 250 cleanup and interim removal actions;

Figure 10-4: Historical and Projected Non-Defense and Defense EM Expenditures



Sources: U.S. Department of Energy: Office of Chief Financial Officer, Office of Budget (FY90-FY94) and Environmental Restoration and Waste Management Five-Year Plan (FY95-FY98).

- Opening or expanding more than 120 waste storage facilities by FY 1997;

- Completion of test phase and determination of suitability of Waste Isolation Pilot Plant (WIPP) for transuranic waste disposal by FY 1998; and

- RCRA compliance for mixed waste by FY 1997.

Environmental Restoration

There are 16 DOE sites on the Superfund National Priority List, and DOE, EPA, and several states have negotiated cleanup agreements for 15 of these sites. They have also worked closely with EPA and the states to establish cleanup standards to facilitate the cleanup efforts. In FY 1992, EM scheduled approximately 50 interim actions and closures of mixed waste sites, seepage basins, and settling bins throughout the United States.

Waste Management

DOE is securing adequate, permitted storage capacity for existing waste and attempting to minimize the generation of new waste. At the same time, DOE is constructing and testing innovative hazardous waste treatment and disposal facilities. Waste minimization programs are reducing the volume and toxicity of DOE waste generation; in fact, all DOE sites must prepare waste minimization plans and report annually on waste minimization progress. For example, the Savannah River Site has reduced waste generation in four of five categories, including hazardous waste, which was reduced by 58 percent. In addition, the Waste Management Program is focusing on safe, permitted treatment, storage, and disposal facilities to handle existing and future waste generation. For example, the Oak Ridge site used a commercial incinerator and supercompactor to achieve an 800-to-1 volume reduction on 16,000 cubic feet of low-level waste.

Technology Development, Education, and Training

A primary mission of DOE is to deliver faster, safer, and cheaper technologies for environmental restoration and waste management. Current technological developments and applications include the following: robotic characterization of wastes, a field use Ion Trap Mass Spectrometer to provide rapid on site analytical data at Oak Ridge and Savannah River Sites, and the development of technology for removing volatile organics from groundwater and soils which will result in major cost savings for the federal government. DOE sponsored environmental restoration and waste management research, education and training programs have reached thousands of students, faculty members, and employees.

<u>Quality of Service/Cost Effectiveness</u>. There are no data on the environmental and health benefits associated with DOE cleanup and compliance activities. However, an interagency review panel, which included members from DOE, EPA, OMB, and the Departments of the Army, Justice, and Defense, made several recommendations on improving the EM program. The panel found that current DOE budget and management systems do not relate cost estimates to legal requirements, do not track expenditures to legally required milestones, and do not measure accomplishments against those milestones. The panel also found excessive overhead costs at many sites and that many contractor contingency costs were too high. Finally, the panel recommended that DOE provide more effective federal oversight of contractors in the field. To facilitate agency cleanup efforts, DOE initiated the Environmental Restoration Management Contractor (ERMC) strategy to place outside cleanup and

construction firms in charge of site remediation. In the past year, they have awarded two major ERMC contracts.

DOE, on the other hand, is concerned about sequential and overlapping regulatory requirements, such as those of CERCLA, that can delay the construction of treatment, storage, and disposal facilities as well as the initiation of actual waste management and remediation operations.[252] In addition, many DOE sites are geographically remote and, therefore, pose few potential health risks. Under existing laws, however, DOE is forced to cleanup these sites regardless of the costs and benefits of remediation.

Department of Defense

The U.S. Department of Defense (DOD) is steward of 25 million acres of public land at 600 major installations in the United States and of an additional 2 million acres abroad. During the last few years, DOD has also started integrating the goal of improved environmental performance into all DOD activities.

Financial Trends. DOD environmental expenditures have risen from $1.155 billion in 1989 to an estimated $5.186 billion in 1994, a nominal increase of almost 450 percent. DOD's environmental budget is divided into five categories: environmental restoration; environmental compliance; base realignment and closure; strategic environmental research and development; and the Legacy Resource Management Program[253]. Table 10-3 below presents estimated and actual DOD expenditures for fiscal years 1992 - 1994.

Table 10-3: Department of Defense Environmental Programs (Millions of Nominal $)

	FY 1992 Actual	FY 1993 Estimate	FY 1994 Estimate
Environmental Restoration	$1,129.4	$1,638.4	$2,309.4
Environmental Compliance	$1,929.5	$2,513.5	$2,484.3
Base Realignment & Closure	$521.5	$549.6	$282.1
Strategic Environmental R&D	$69.8	$180.0	$100.0
Legacy	$25.0	$50.0	$10.0
Total	$3,675.2	$4,931.5	$5,185.8

Source: Internal Department of Defense 1992 budget document.

The environmental restoration appropriation provides for the identification, investigation, and cleanup of past contamination from hazardous substances and wastes; correction of other environmental damage, detection of unexploded ordinances; and demolition and removal of unsafe buildings, structures, and debris. This component of DOD environmental spending is expected to double in size from 1992-1994, rising from $1.129 to $2.309 billion (Table 10-3). The environmental compliance budget is designed to enable DOD to comply with increasing requirements attributable to accelerated federal and state enforcement and the enactment of additional laws regulating environmental corrective actions by state and local governments. Compliance projects address the following areas:

- Hazardous and solid waste management;
- Underground storage tanks;
- Air pollution abatement;
- Water quality management and safe drinking water; and
- Requirements based on specific environmental statutes.

The base realignment and closure budget is used to expedite environmental restoration and compliance work at approved sites. These expenditures are expected to fall to $282.1 million in FY 1994 from $549.6 million in FY 1993. The Strategic Environmental Research and Development (SERDP) Program is designed to accelerate the development and deployment of technologies to address issues such as environmental restoration, waste minimization, and hazardous waste substitutes. Estimated appropriations for FY 1994 are $100 million. Finally, the Legacy Resource Management Program, established in FY 1991 to improve public awareness of the DOD Conservation program and promote the sound management of DOD lands, is projected to decrease from $50 million in FY 1993 to $10 million in FY 1994.

Service Delivery. There are 1,800 military installations in the Defense Environmental Restoration Program (DERP). As of March 1993, there were approximately 99 DOD facilities on the Superfund National Priority List. In 1991, DERP accomplished the following:

- Cleanup of third of the 1,800 DERP sites with no further restoration activities required;
- Environmental training for 2,000 military and civilian personnel; and
- A 63 percent increase in DERP sites with completed studies quantifying the amount and extent of contamination.[254]

In June 1987, DOD established the goal of reducing hazardous waste disposal by 50 percent by the end of 1992. By 1991, DOD had reduced hazardous waste disposal by 53.9 percent -- despite the increased activity due to the Persian Gulf War. More than 85 percent of the reduction was attributable to improvements in waste minimization efforts at DOD shipyards, maintenance depots, and air logistic centers. These facilities account for roughly 60 percent of hazardous waste generated by DOD, and the remaining 40 percent is generated by such areas as daily installation operations and training facilities. Hazardous waste generation in DOD industrial operations fell from 251,830,000 pounds in 1987 to 91,800,000 pounds in 1991.[255]

In 1992, DOD accelerated characterizations of remaining contaminated sites and developed cost-reduction initiatives in an effort to produce a comprehensive restoration strategic plan by 1995. DOD also conducted 180 remedial actions at military installations on the NPL, which included immediate response actions to protect public health, immediate removal of contaminants, development of alternative drinking supplies, and the installation of permanent remedies such as groundwater treatment facilities.

To date, 40 states and territories have entered into agreements with DOD to support environmental restoration at over 400 military installations.

Quality of Service/Cost Effectiveness. There are no data on the environmental and health risk benefits associated with DOD hazardous waste cleanup and compliance. To increase the effectiveness and efficiency of its environmental programs, DOD will institute the following changes:

- Restructure the program's organization to account for unmet regional, state, and local needs;
- Provide environmental management education and training across all military services and members of the DOD community;
- Improve management of the restoration program to provide environmental protection at lower cost;
- Develop an environmental research and strategic plan to focus efforts and accelerate payback from DOD technology assets; and
- Correct deficiencies in environmental information management systems.

Otherwise, DOD faces many of the same problems and criticisms that DOE faces. Congress and the Administration must ensure that program costs are in line with program benefits, and the agencies themselves administer the programs in a cost-effective manner.

Other Federal Agencies

The Department of Agriculture, Department of the Interior, Department of Transportation, NASA, Department of Justice, and the Department of Commerce requested $236 million in FY 1993 for hazardous waste cleanup and compliance. Department of Interior requested the largest amount, $80 million. Hazardous waste expenditures for these agencies is expected to increase in the next several years, but expenditures will not approach the levels of the Departments of Energy or Defense.

REFERENCES

1. Net capital stocks presented in this report are prepared by Apogee Research, Inc. They are based upon capital outlay expenditures from the Bureau of the Census, U.S. Department of Commerce, Government Finances data from fiscal year 1932 through 1990. Capital outlays are further distinguished between construction and non-construction outlays. Construction outlays are assumed to represent structures, and equipment is approximated by non-construction outlays.

Census does not report a separate functional category for water resources. Therefore, water resources is represented by Census data for state and local government expenditures for water transport and terminals; and from investment flows provided by the U.S. Army Corps of Engineers for navigation, flood control, multipurpose, and Mississippi River and Tributaries.

A complete description of the methodology and assumptions used in constructing public infrastructure capital stock can be found in a report prepared by Apogee Research for the IWR, U.S. Army Corps of Engineers, as part of their federal Infrastructure Strategy, Assessing the Economic Effects of Public Infrastructure Investment: Data Report, 1993. This report also compares capital stock estimates using two alternative decay patterns, straight-line and economic efficiency.

2. Chapter III provides a figure showing the difference between aviation capital stock estimated from all government capital outlays and state and local government outlays, based upon straight-line decay.

3. Navigation, flood control, and multipurpose capital stocks constructed from U.S. Army Corps of Engineers data are based upon state level expenditure data from 1936 to 1992. The national total is the sum of the state values for each category.

4. U.S. Department of Commerce, Bureau of Economic Analysis, Fixed Reproducible Tangible Wealth in the United States, 1925-1989, Washington DC: U.S. Government Printing Office, January 1993.

5. Paving is assumed 52 percent of capital outlays; grading 26.5 percent; and structures 21.5 percent. This is based upon work-in-progress by Michael Bell and Therese McGuire for the Transportation Research Board, NCHRP Project 2(17)-3, and the work of Randall Eberts, Chul Soo Park, and Douglas Dalenberg, Public Infrastructure Data Development, National Science Foundation, May, 1986.

6. There is on-going debate over the appropriate decay pattern to use when constructing capital stock. Another pattern is economic, or efficiency, decay, which deducts a smaller proportion of the initial investment in the early years of the asset's life, relative to straight-line decay. As a result, the level of capital stock is significantly higher under efficiency decay than straight-line. Apogee's data report prepared for the Corps of Engineers as part of the federal Infrastructure Strategy presents a comparison of the two methods.

7. Total capital stock is the unweighted sum of the individual infrastructure modes.

8. Flood control and navigation include capital stock attributable to Mississippi River and Tributaries (MR-T) capital outlays. Seventy-five percent of MR-T expenditures are allocated to flood control, with the remaining 25 percent to navigation.

9. Classification Manual, Government Finance and Employment, U.S. Bureau of the Census, June 1992.

10. Erik D. Olson, Esq., Think Before You Drink: The Failure of the Nation's Drinking Water System to Protect Public Health, Natural Resources Defense Council, September 1993.

11. Congress and the Nation, Volume III, 1969-1972, (Washington, DC: 1973, Congressional Quarterly Press), pp. 156-158.

12. Congress and the Nation, Volume 1, 1945-1964), (Washington, DC: Congressional Quarterly Press, 1965), p. 530.

13. Congress and the Nation, Volume 1, 1945-1964), (Washington, DC: Congressional Quarterly Press, 1965), p. 560.

14. Congress and the Nation, Volume III, 1969-1972, (Washington, DC: 1973, Congressional Quarterly Press), pp. 151.

15. Congress and the Nation, Volume 1, 1945-1964), (Washington, DC: Congressional Quarterly Press, 1965), p. 773.

16. Congress and the Nation, Volume II, 1965-1969), (Washington, DC: Congressional Quarterly Press, 1969), p. 495.

17. Congress and the Nation, Volume II, 1965-1969, (Washington, DC: Congressional Quarterly Press, 1969), p. 765.

18. Congress and the Nation, Volume III, 1969-72, (Washington, DC: Congressional Quarterly Press, 1973), p. 792-796.

19. Congress and the Nation, Volume IV, 1973-1977, (Washington, DC: Congressional Quarterly Press, 1978), p. 549-550.

20. An enplanement is the act of boarding a plane.

21. FAA Office of Public Affairs: includes 4,323 heliports, 74 stolports and 433 seaplane bases.

22. Many private airports are available for public-use. The number of public-use airports, therefore, is somewhat higher than the number of publicly owned airports.

23. Aviation System Capacity Plan, 1991, FAA.

24. The remaining 6.1 percent are helicopters and other aircraft. FAA Aviation Forecasts, various years.

25. FAA Aviation Forecasts, various years.

26. 1993 FAA budget estimates; figures in current dollars.

27. FAA Office of Public Affairs.

28. From fiscal year 1993 budget estimates.

29. Most of this construction will completed by 1997 and includes $2.5 billion for the construction of New Denver Airport.

30. Revenue passenger miles are the total number of miles flown with paying passengers.

31. The all government (federal, state, and local) net capital stock, shown in Figure 3-4, is the denominator of the ratio presented in Figure 3-5.

32. A revenue passenger enplanement (RPE) is a paying passenger who boards an aircraft, excluding enplanements by the flight crew and passengers traveling on frequent traveler award tickets.

33. FAA Aviation Forecasts, various years.

34. Ibid.

35. Boeing, World Air Cargo Forecast, 1992.

36. Ibid.

37. FAA Aviation Forecasts, various years.

38. This represents a change from 1982, when only delays longer than 30 minutes were counted. While this change means the number of apparent delays has increased, it also makes it difficult to compare changes over time.

39. Aviation System Capacity Plan, FAA.

40. Ibid.

41. The highway fatality rate per passenger mile was determined by assuming a 1.6 vehicle occupancy rate for passenger vehicles and an average occupancy rate of 1 for trucks. Data sources include Highway Statistics (various years) for Highways, FAA Aviation Forecasts

(various years) and National Transportation Statistics (various years) for air carriers and general aviation.

42. Annual commercial air carrier and general aviation safety data are published by The National Transportation Safety Board in their 1991 Annual Report to Congress.

43. National Plan of Integrated Airport Systems: 1986-1995, FAA.

44. FAA Aviation Forecasts, various years.

45. The Consumer Price Index for Airfares was used to deflate revenues to 1987 dollars.

46. Nominal profit/loss figures deflated by CPI Airfare index, base year 1987.

47. US Department of Transportation, Aviation System Capital Investment Plan.

48. The National Highway System will consist of 155,000 miles of highways. The actual total may vary by 15 percent points above or below this base estimate; 67,000 miles are already designated by ISTEA legislation. This includes the Interstate System, the Strategic Highway Corridor Network and 2,200 miles of ISTEA high priority corridors. The remaining mileage will be determined by state agencies and relevant MPOs.

49. Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance, 1993.

50. A lower percentage of mileage in poor condition for the non-Interstate System results from a more stringent measuring system for Interstate Highways; 59.6 percent of interstate mileage is rated good or very good. In contrast, only 47.8 percent of other systems are in good or very good condition.

51. Structurally deficient bridges are closed or should be restricted to light vehicles because of deteriorated structural components. Functionally obsolete bridges were designed according to standards that do not meet current safety standards for the volume or type of traffic using them.

52. Our Nations Highways: Selected Facts and Figures, 1992.

53. Highway Statistics.

54. Toll charges are a user fee and are included in the 71 percent stated previously.

55. These figures exclude expenditures for research and development.

56. All capital expenditures are deflated with the highway construction index, base year 1987=100. Maintenance expenditures are deflated with the highway operations and maintenance index. Both price indices from Highway Statistics.

57. Values are deflated by the highway construction index, base year 1987=100; Highway Statistics.

58. Figures are a percent of all expenditures for highways, not just capital outlays and operations and maintenance.

59. In The Status of the Nation's Highways, Bridges, and Transit, it is estimated that in 1989 $6.4 billion was invested through the privates sector for on-site highway improvements and $3.2 billion for off-site improvements.

60. Different occupancy rates were applied to urban and rural areas.

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128. One problem with this calculation is that it assumes that floodplains would have been equally developed in the absence of flood protection. While this is unequivocally not the case, there is no way to control for induced floodplain growth.

129. Such a conclusion is based on the following assumptions: (1) a useful life of flood control facilities longer than the period over which they are financed; (2) financing facilities over a 50-year period; (3) equal annual capital outlays for 50 years prior to the year in question; and (4) a 3 percent real discount rate. In a given year, for example, if capital outlays totaled $100 million, the sum of 50 years amortized payments to that capital at 3 percent would be about $190 million. So long as flood damages averted that year exceeded that amount, or roughly a 2:1 ratio, benefits would exceed accumulated costs. If structures were financed over a shorter period, say with 30-year Treasury bills, the accumulated payments to capital would total $149 million for the year in question, implying a minimum ratio of 1.5:1 to conclude positive net benefits.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
December 1994

3. REPORT TYPE AND DATES COVERED
Final

4. TITLE AND SUBTITLE
Consolidated Performance Report on the Nation's Public Works: An Update

5. FUNDING NUMBERS

6. AUTHOR(S)
Apogee Research Inc.
4350 East-West Highway, Suite 600
Bethesda, MD 20814

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
Water Resources Support Center
Institute for Water Resources
Casey Building
7701 Telegraph Road
Alexandria, VA 22315-3868

8. PERFORMING ORGANIZATION REPORT NUMBER
IWR Report
94-FIS-13

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers, Headquarters
Directorate of Civil Works
Office of Interagency & International Activities
20 Massachusetts Ave., NW
Washington, DC 20314-1000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (703-487-4650)

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for Public Release; Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This report further develops a framework for measuring and monitoring performance in key federal infrastructure programs. It represents an update to the work of the National Council on Public Works Improvement in preparation for the issuance of "Fragile Foundations" (1988).

Performance is defined, measurable aspects of performance are identified, and data on these aspects are then presented, qualitatively and quantitatively, for three infrastructure categories: transportation, water resources, and waste management.

The specific programs covered are: aviation; highways; mass transit; water resources; wastewater treatment; public water supply; solid waste management; and, hazardous waste management.

14. SUBJECT TERMS
Performance, public management, infrastructure, public works, National Council on Public Works Improvement, Fragile Foundations, public administration.

15. NUMBER OF PAGES
316

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102