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ENVIRONMENTAL PROTECTION AGENCY

VOLUME V

Manpower for Environmental Pollution Control

A Report to the
U.S. Environmental Protection Agency
from the
Committee for Study of Environmental Manpower

Commission on Human Resources
National Research Council

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1977

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Foreword

This report is one of a series prepared by the National Research Council for the U.S. Environmental Protection Agency.

In June 1973 the Subcommittee on Agriculture, Environmental, and Consumer Protection of the Appropriations Committee of the U.S. House of Representatives held extensive hearings on the activities of EPA, and the ensuing appropriations bill for fiscal year 1974 directed the Agency to contract with the National Academy of Sciences for a series of analytical advisory studies (87 Stat. 482, PL 93-135). EPA and the Academy agreed upon a program that would respond to the Congressional intent by exploring two major areas: the process of acquisition and use of scientific and technical information in environmental regulatory decision making; and the analysis of selected current environmental problems. The Academy directed the National Research Council to formulate an approach to the analytical studies, and the National Research Council in turn designated the Commission on Natural Resources as the unit responsible for supervising the program.

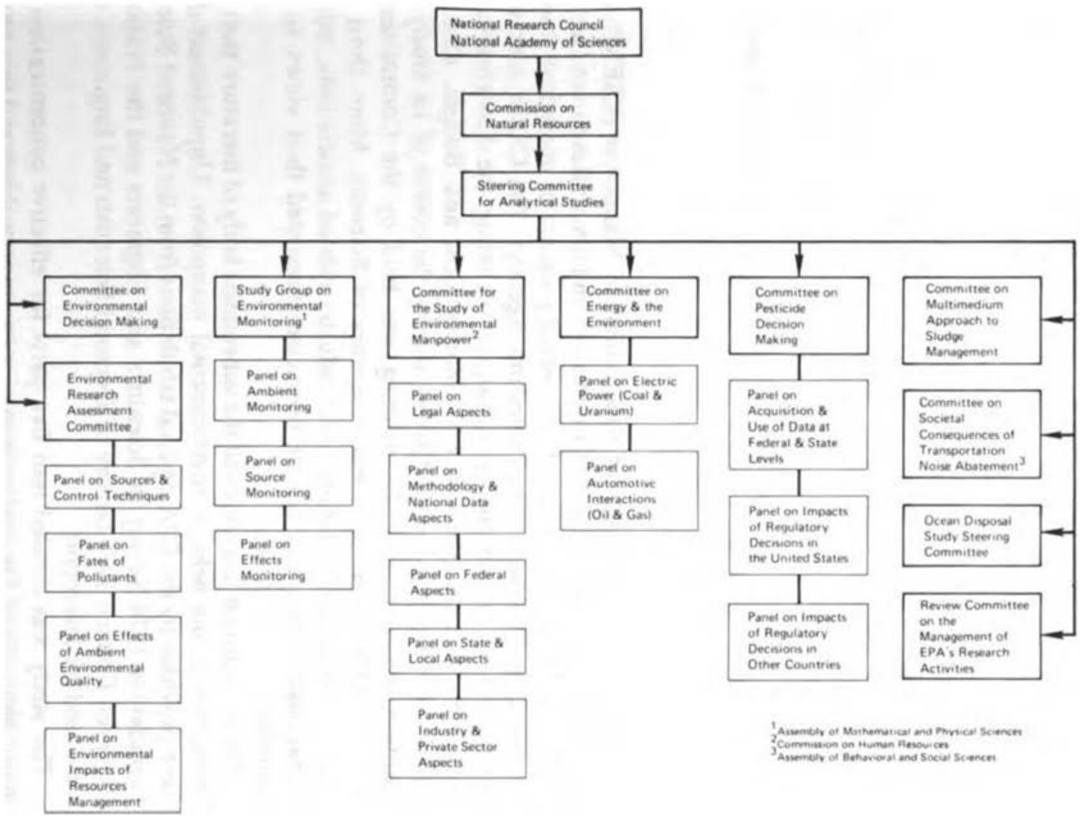
The other studies in the series, and a diagram of the structure of the program are presented on the following pages. Each of the component studies has issued a report on its findings. Volume I of the series, *Perspectives on Technical Information for Environmental Protection*, is the report of the Steering Committee for Analytical Studies and the Commission on Natural Resources. It describes in detail the origins of the program and summarizes and comments on the more detailed findings and judgments in the other reports.

Components of the NRC Program of Analytical Studies for the U.S. Environmental Protection Agency

Project	Project Chairman	Sponsoring Unit of the NRC
Steering Committee for Analytical Studies (SCAS)	R. M. Solow	Commission on Natural Resources
Environmental Decision Making (CEDM)	J. P. Ruina	Environmental Studies Board, Committee on Public Engineering Policy
Environmental Research Assessment (ERAC)	J. M. Neuhold	Environmental Studies Board
Environmental Monitoring (SGEM)	J. W. Pratt	Committee on National Statistics, Environmental Studies Board, Numerical Data Advisory Board
Environmental Manpower (CSEM)	E. F. Gloyna	Commission on Human Resources
Energy and the Environment (CEE)	S. I. Auerbach	Board on Energy Studies
Pesticide Decision Making	W. G. Eden	Board on Agriculture and Renewable Resources, Environmental Studies Board [a]
Multimedium Approach to Municipal Sludge Management	H. O. Banks	Environmental Studies Board
Societal Consequences of Transportation Noise Abatement	W. J. Baumol	Assembly of Behavioral and Social Sciences [b]
Disposal in the Marine Environment	D. S. Gorsline	Ocean Affairs Board
Review of Management of EPA's Research Activities	R. W. Berliner	Commission on Natural Resources

[a] In cooperation with the Building Research Advisory Board.
[b] In cooperation with the Building Research Advisory Board and the Transportation Research Board.

Structure of the NRC Program of Analytical Studies for the U.S. Environmental Protection Agency



Preface

The Committee for Study of Environmental Manpower (CSEM) was appointed and directed by the Commission on Human Resources (see the Foreword for a description of the overall program of analytical studies for the U.S. Environmental Protection Agency). The CSEM met with representatives of various organizations including the Environmental Protection Agency, the Office of Management and Budget, and the Council for Environmental Quality during the course of its study. In addition, an all-day public meeting was held by the Committee in January 1976 at the National Academy of Sciences. More than 100 representatives of professional and industry-related associations, educational institutions, and private businesses presented their views to the Committee at that time.

The Committee has reviewed the substantial body of literature that has developed in the field of environmental manpower. Unpublished data were provided by the EPA. Special tabulations from the National Science Foundation 1974 Survey of Scientists and Engineers and the National Research Council 1975 Survey of Doctoral Scientists and Engineers also were used for this report.

The study was divided into five parts for effective concentration on major elements of the environmental manpower problem and five panels were formed to provide detailed information on each of these elements.

The Committee and its panels used their expertise and their experience in environmental pollution control to analyze the best available existing data and to interpret the relevant gaps in the body of environmental manpower knowledge. While thoroughly tested data were not always available, the Commttee did obtain credible information in numerous conferences with experts from government, industry, environmental organizations, and the general public.

The report has been kept brief but addresses principal issues. Detailed discussion and tabular information are in supporting appendixes. Committee conclusions and recommendations are stated in the Executive Summary.

The Committee's staff provided exemplary service. As staff director, Stanton J. Ware brought to his task administrative skills of the highest order and a deep understanding of environmental issues. Philip P. Nowers, Staff Officer, and Helen A. MacNeil, Office Manager, contributed in many ways to the completion of the Committee's assignment.

EARNEST F. GLOYNA, *Chairman*

Executive Summary

The Executive Summary provides a brief description of the study, along with the Committee's conclusions and recommendations emphasizing the need for a well-coordinated environmental manpower program and for experienced professional competence in the development and administration of the regulations under which EPA must fulfill its responsibilities. The Committee suggests particular attention to conclusions and recommendations numbers 1, 2, 3, and 11.

INTRODUCTION

Manpower aspects of pollution control are a key factor in carrying out the nation's goals for improving environmental conditions. Shortages of well-trained and experienced manpower can slow the development of control technologies, affect program administration, cause inefficient control plant operation and process failures, and boost the costs of achieving environmental controls. Numerous complex and interrelated factors are involved in assuring that the supply of and demand for trained and experienced people are well balanced. The Environmental Protection Agency (EPA) has responsibilities in this regard that are explicitly called for by existing statutes, implicit in the intent of Congress, and inherent in Agency leadership in these matters, either in meeting defined responsibilities or in seeking clarification of EPA's role.

The national pollution control effort has relied in general on traditional market mechanisms to generate and allocate human resources, but concern exists in this case about the effectiveness of these mechanisms. The Committee concludes that a large-scale or general shortage of pollution control manpower is not now apparent or likely to develop in the near future. Since this conclusion does not call for action, it is not included with the recommendations that follow. It is possible, however, that shortages will occur in selected, specialized occupations. The Committee notes a possible lack of appreciation by EPA of the value of using engineers and scientists who are experienced in pollution abatement. Also, it is apparent that the quality of the current environmental work force could be upgraded through supplemental training and improvements in the educational process.

CONCLUSIONS AND RECOMMENDATIONS

PRIORITY OF MANPOWER POLICIES

Conclusion 1

Legislative authorizations, strategies, and levels of activity vary among the several environmental programs. All the programs are affected by legislatively established time schedules, specifically directed responsibility for manpower development, anticipated funding commitments, and environmental interest and performance in the public and private sectors. Yet the emphasis placed by EPA on manpower development has diminished since the Agency's inception. This practice shows the low priority given the manpower aspects of the pollution control effort. (See Chapter 3 and Appendixes A and C.)

Recommendation 1

- *The Committee recommends that Congress clarify its intent for environmental manpower development and training activities in existing legislation and provide EPA with a clear directive concerning its manpower and training authority.*

- *The importance of manpower needs should be recognized by Congress and the Executive and appropriately reflected in the Agency's budget. Manpower planning and training should be adequately funded, and there should be no diversion of manpower planning funds to other activities.*

- *To define and focus environmental manpower responsibilities in EPA, we recommend that a high-level group be established within its headquarters* *with representation from the regional offices to ensure adequate manpower planning and development. This group should coordinate and supplement the activities of manpower planning and training staffs in the program areas of air, water supply, wastewater, solid wastes, and other program elements.*

MANPOWER PLANNING

Conclusion 2

Leadership for planning and developing a national manpower program for environmental pollution control logically rests with EPA. Congress and the Executive Branch should support this effort. Although the Committee concludes that a large-scale or general shortage of pollution control manpower is not now apparent or likely to develop in the near future, shortages may occur in selected, specialized occupations. Changes affecting manpower development and training needs in the environmental field could come rapidly as a result of the following factors: (1) the diversity of skills required among the professional personnel who plan, design, and manage pollution control programs and also among the subprofessionals, some of whom must be highly trained to operate and maintain the pollution control systems; (2) the immensity of the anticipated program in which expenditures during the next 10 years will be several times those of the U.S. space program; (3) the extremely short time span mandated to accomplish this program; and (4) the shift from ambient quality standards to quantitative emission standards in air pollution control. All these will draw heavily upon the nation's finite resources of money, energy, and manpower.

Success will depend on the uninterrupted availability of specialized, highly-trained professional manpower to manage national pollution control programs and to conceive, design, construct, and monitor the complex systems needed to meet mandated standards. Many of these systems do not now exist or are in early stages of development. The efficient operation and maintenance of these sophisticated systems will depend upon the availability of highly-trained subprofessional manpower.

The many skills required to carry out the programs and to operate control facilities at their designed capacities require that manpower factors be considered in all phases of program development and operation. The Committee concludes that increases in the manpower supply in some specialized fields may not be sufficiently rapid to meet the need within the mandated time. Shortages of trained manpower could result in inefficient plant operations and could waste capital investment and operating funds far in excess of what is required for adequate manpower development and training. (See Chapters 2, 3, and 6, and Appendixes B and C.)

Recommendation 2

- *The Committee recommends that EPA present to the Executive Branch and Congress a comprehensive program of support for the development of professional and subprofessional manpower and operators. (The section in Chapter 3 entitled "Present and Proposed Manpower Activities" contains guidelines as to when training programs would be recommended.) This program should be appropriate to the legislated goals of controlling environmental pollution. Such a program should include a long-term strategy for environmental manpower development based on manpower planning and using the most appropriate educational techniques. The manpower program would be implemented at the federal, state, and local levels under the leadership of EPA.*

- *An environmental manpower impact analysis should be made to assure that the professional and highly-trained subprofessional manpower required to implement environmental legislation can become available within the prescribed time. This thorough assessment of manpower requirements should be done when legislation is drafted and hearings are held rather than after enactment of the legislation.*

- *EPA should use these impact analyses as a basis for making recommendations to Congress and the Executive Branch concerning programs required to avoid shortages in the manpower necessary to carry out the proposed legislation.*

TECHNICAL INPUT TO EPA DECISION MAKING

Conclusion 3

Since the statutes and regulations under which EPA must act are complex, they require a high level of experienced technical input in operation to avoid conflicting directives and regulations that lead to unnecessary litigation. In the Committee's view, although EPA has many well-qualified technical personnel, there are too few experienced technical personnel at decision-making levels. Unfortunately, there has been substantial confusion in the development of clear, workable guidelines for problem solution, management of construction grants, issuance of permits, and, particularly, in the conduct of enforcement actions. The situation is more complex because EPA is subject to Executive policy, Congressional mandates, and court decisions resulting in instances of conflicting operational directives. (See Chapter 3 and Appendix C.)

Recommendation 3

- *EPA should better use its technical personnel to assure that its directives can be accomplished with existing or soon-to-be-available technology.*

MANPOWER COORDINATION AT THE FEDERAL LEVEL

Conclusion 4

Although EPA has a primary role in environmental manpower development, it has not coordinated its programs with the environmental manpower research and training programs carried on by the Department of Health, Education, and Welfare, the Department of Defense, and other federal agencies. (See Chapters 3 and 6, and Appendix C.)

Recommendation 4

- *The Committee recommends that EPA establish a well-coordinated federal manpower planning and training program for environmental control. Such a responsibility should be mandated by Congressional and Executive action.*

ASSISTANCE FOR STATE AND LOCAL AGENCIES

Conclusion 5

Cooperation is needed among various levels of government and the private sector to assess environmental manpower needs and to plan cost-effective programs to meet them.

Many of the training programs for operators and technicians are at state and local levels. These include local school districts, state vocational education programs, community colleges, and federal programs to reduce unemployment such as those under the Comprehensive Employment and Training Act. Local manpower planning and training are generally limited to those occupational categories where local resources can meet the demand. While local educational programs produce a substantial number of operators and technicians, the dispersed nature of the system makes national summary data difficult to obtain. (See Chapters 3, 4, and 6, and Appendix D.)

Recommendation 5

• *The Committee, recognizing that delivery systems for specialized training are largely in the hands of state and local officials, recommends that EPA pursue a three-part strategy to assist in monitoring and mobilizing these resources for pollution control:*

(1) EPA should provide technical assistance and grants to give state and local agencies the tools needed to plan for manpower demands in environmental protection;

(2) EPA, state, and local environmental officials should work with education administrators concerning special training programs. Careful manpower planning is essential in order to make the most effective use of all available resources; and

(3) EPA should identify the gaps in state and local programs and prepare a national assessment of demand and supply. Working with the U.S. Department of Labor, the Office of Education, industry, and professional associations, EPA should provide leadership in the development of programs to support state and local manpower activities.

PROJECTION MODELS

Conclusion 6

Demands for environmental manpower are strongly affected by legislative action, the resulting EPA regulations, and the national economy. Thus, demand projections, particularly over long periods of time, are highly conditional by nature. The critical importance of policy and economic assumptions to accurate projections must be kept in mind in assessing the validity of such projections. Still, projection models can identify possible imbalances based on the best available information, particularly for incremental analyses involving program changes.

Projections of environmental manpower supply and demand have been subject to a number of deficiencies which are of particular concern to the Committee. Most of these projections have been aggregated at a national level. This makes their use risky, because the comparison of projected supply and demand ignores distances between geographic sources of supply and points of demand. But distances between jobs and potential workers are important, and they are more important in occupational categories whose job-seeking radius tends to be local than in others with a national job market. This aspect of planning is but one of several important behavioral characteristics that are ignored in current projection models, all of which have potentially important impacts on imbalances between the supply of and demand for environmental manpower in different occupational categories. (See Chapter 5 and Appendix B.)

Recommendation 6

• *The Committee recommends that EPA increase its use of manpower analysis tools that are available both within and outside the Agency for a better understanding of future manpower requirements. Data sources and projection models from the National Science Foundation, Bureau of the Census, and Bureau of Labor Statistics should be used more extensively.*

• *EPA should also strengthen its support for state and local manpower planning. Support should be encouraged from other governmental agencies interested in local labor market planning in order to develop an adequate data base. Emphasis should be placed on a detailed examination of portions of an overall manpower projection model, concentrating on more local or regional problems, or both. Efforts should be made to identify those occupational specialities that are critical to effective pollution control.*

• *The Committee further recommends that EPA itself improve its environmental manpower projection methodologies by relying both on staff expertise and advisory committee evaluations. These projections should be disaggregated to specific job groups in each categorical program and to sufficiently small geographic areas to be of use to state and local environmental manpower planners. Much greater emphasis should be placed on accounting for those behavioral characteristics of the environmental labor force that are likely to have a bearing on imbalances between supply and demand, particularly at state and local levels.*

ADVISORY PANEL

Conclusion 7

EPA terminated its limited use of advisory panels in the fields of manpower planning and training. The Committee concludes that the complete absence of regular input from experts to the development of manpower policy is a deficiency that should be corrected. (See Chapter 3 and Appendix C.)

Recommendation 7

- *The Committee recommends that a technical panel be established to advise EPA in manpower planning and education. This panel should include experts from state and local agencies, industry, and the academic community. Specifically, the panel should include engineers, scientists, manpower planning specialists, and managers of environmental control systems.*

CHARGES FOR TRAINING

Conclusion 8

EPA's role in conducting training programs in pollution control for personnel not employed by EPA and charges to participants in these programs have been controversial. These charges have adversely affected participation in the training programs, particularly by state and local employees. Various actions have discouraged EPA from providing direct, specialized instruction. Nonetheless, a need exists for the training of instructors and a capability for the development of training materials. (See Chapter 3.)

Recommendation 8

- *The Committee recommends that EPA make a major effort to develop local institutional arrangements to meet specialized training requirements. EPA should continue to develop training materials where appropriate, and to train instructors. Involvement in direct training should continue on a limited basis. Since participation is constrained when fees are imposed, the Committee recommends that EPA eliminate fees for these training programs.*

RESEARCH, TRAINING, AND TECHNICAL CENTERS

Conclusion 9

Research is an integral component of professional education, particularly in the complex field of environmental control. Therefore, research policy should explicitly embody training objectives as a major element. Furthermore, investment in research helps to build centers of expertise that provide training for the areas in which they are located. These contributions to overall pollution abatement efforts offer lasting and significant results beyond individual project work. This should be recognized by EPA's Office of Research and Development, and research funding should be planned in coordination with the proposed EPA manpower planning group. (See Chapters 4 and 6.)

Recommendation 9

• *The Committee recommends that, as a means for expediting technology transfer, personnel associated with technically-based environmental systems be provided with opportunities to obtain up-to-date career training by association with research activities. Funds should be allocated to educational institutions for development of environmental research and training centers that can serve as such sources of technical assistance to small businesses and to government. This recommendation should be accorded a priority high enough to assure student involvement in ongoing studies of pollution abatement and control methodology. Funding for such centers should be awarded on a competitive basis.*

ENVIRONMENTAL MANPOWER REQUIREMENTS IN THE PRIVATE SECTOR

Conclusion 10

The private sector is a major employer of environmental manpower. Estimates of these manpower requirements can be related to planned environmental expenditures to estimate the magnitude of future needs. Traditionally, larger industries have used in-house and on-the-job training to develop manpower to solve environmental problems and have relied on educational institutions to provide basic education. Although this trend will continue, the emphasis on highly specialized manpower will stimulate additional needs for formal training and continuing education in environmentally-related disciplines. Various small businesses, on the other hand, may find themselves confronted by highly technical problems but with no reliable access to needed technical advice on problem-solving capabilities. Therefore, additional assistance must be provided to these firms as well as to individuals. (See Chapters 4 and 6, and Appendix E.)

Recommendation 10

(1) EPA should analyze manpower needs for industry and the private sector as these needs are influenced by existing and proposed environmental legislation.

(2) EPA should obtain the participation of private industry in its training mission for environmental manpower. More specifically, student cooperative

programs should be extended to potential employees, and continuing education efforts should be enhanced. Private industry should be encouraged to take a more active role in advising the appropriate educational institutions, environmental agencies, and EPA in their assessments of training requirements.

(3) EPA should cooperate closely with the private sector to design and conduct a long-term personnel study to produce the data necessary to assess current personnel use and to project future manpower requirements and training needs.

(4) Congress should appropriate funds to enable local agencies and organizations to provide technical assistance and accurate information to farmers and small businesses unable to afford technical manpower to carry out the objectives of environmental legislation.

CONTINUITY IN OPERATION OF POLLUTION CONTROL SYSTEMS

Conclusion 11

Most environmental control systems are based upon biological processes that degrade wastes. These systems must be operated on a continuous basis to be effective. If they are not and if the operating environment is not properly controlled, microorganisms die and render the processes inoperative for extended periods of time. One of the most serious obstacles to the continued operation of pollution control systems is work stoppages of environmental control facilities. Interruption of biologically-based environmental protection systems can be disastrous, causing damage to the systems, degradation of the environment, and potential impairment of the health of the people. (See Chapter 2 and Appendix D.)

Recommendation 11

- *EPA should recognize and study the critical necessity for continuous operation of biologically-based environmental protection systems and make appropriate recommendations to Congress concerning solutions to this problem.*

SUMMARY OF CHAPTERS 1 THROUGH 7

INTRODUCTION

(See Chapter 1)

The Committee for Study of Environmental Manpower examined environmental pollution control manpower needs, both existing and anticipated. A broad spectrum of related problems was studied.

The statutes, through which Congress has set the desired course of action, were examined to determine applicability to manpower planning and development. It is apparent that EPA was expected to take the lead in assuring availability of adequate manpower for carrying out the national pollution control program.

Manpower is a key element in controlling the pollution of our environment. The long-range success of abatement and control programs depends not only upon the passage of legislation and compliance with the laws, but upon the cooperation of state, local, and federal governments and industry to make the best use of manpower for achieving established national goals.

RATIONALE FOR ENVIRONMENTAL MANPOWER PLANNING AND POLICY

(See Chapter 2)

The question of adequate environmental manpower should concern Congress, EPA, and the nation. The rationale for environmental planning and policy involves four factors: the time schedule imposed by law for specific environmental goals; specific directions in legislation for federal authorities to study appropriate labor markets and stimulate the development of certain occupations; the levels and patterns of capital and other expenditures that may be needed to achieve environmental goals; and the fact that the pollution control program is highly reliant on the public sector.

MANPOWER DEVELOPMENT ROLE OF EPA

(See Chapter 3)

EPA staff is characterized by good technical qualifications, higher-than-average grade levels, and by generally higher educational levels and a greater proportion of scientists and engineers than similar federal technical agencies. Yet there is a need for greater practical, technical experience in design and systems operation, especially in senior management.

The Agency lacks a clear and comprehensive directive to engage in overall manpower planning and development activities. A long-term manpower strategy or centralized leadership is needed to carry out existing manpower functions. The various offices charged with these responsibilities interpret their tasks in widely different ways. Funds and personnel allocations for manpower planning and training programs have decreased drastically, and academic training grants and fellowships are being discontinued at the direction of the Office of Management and Budget.

EMPLOYMENT OF POLLUTION CONTROL MANPOWER

(See Chapter 4)

The EPA and others have voiced concern that, as the environmental pollution control program develops on a nationwide scale, manpower in the future might not be in balance with increased demands. Ensuing chapters of this report provide information that can assist in assessing potential imbalances by examining current employment (Chapter 4), estimated future demand through 1985 (Chapter 5), and the supply of manpower (Chapter 6).

Time did not allow for conduct of new surveys, but a substantial body of data was already available, although it was sometimes inconsistent. The data showed that the impact of pollution control manpower is greatest for local governments and the private sector. Direct employment attributable to all pollution control activities amounts to some 700,000 persons.

Environmental scientists and engineers play an important role in all aspects of the anti-pollution program. The most recent data available, for 1974, indicated that almost 135,000 scientists and engineers worked in pollution control as a primary activity. A principal area of employment is in research and development.

DEMAND FOR POLLUTION CONTROL MANPOWER, 1974–1985

(See Chapter 5)

A major difficulty in balancing future supply and demand lies in the virtually impossible task of predicting economic and related conditions even a decade in advance. Combined with economic uncertainty are the imponderables of changing Congressional priorities and associated federal policies. Changing public interest has a far-reaching and potent effect on the degree of support provided by any Administration as well as by Congress. Added to these factors are the requirements dictated by the international situation, both economic and political. Consequently, the Committee considered it unwise to adopt a unified set of projection results based on available manpower modeling techniques.

Separate sectors of environmental pollution control activity were considered in order to analyze significant changes in future manpower demand. The Committee anticipates that federal needs will remain stable or decrease slightly, while state and local agencies will assume increasing responsibility for pollution control programs. The greatest manpower demand should arise from local activities involving operators and subprofessional personnel.

Manpower demand changes from 1974 to 1985 are estimated as follows: (1) federal, private sector (including industry), and local solid waste management—little change; (2) local water supply—small increase of about 10 percent; (3) local water quality operations and state-local regulatory activities—substantial increase of about 50 percent; and (4) air pollution—little growth, but change in nature of activities and skill mix.

SUPPLY OF POLLUTION CONTROL MANPOWER

(See Chapter 6)

The bulk of future environmental manpower needs is likely to be met by employment of persons transferring from other activities and possessing varied basic training. Current and future supplies of highly-trained personnel are related to those generally available in the economy as a whole, as affected by competition from other national programs. Less than 1 percent of all workers, but 12 percent of all scientists and engineers, now are engaged directly in pollution control activities; the ratio is 6 percent for scientists and engineers at the doctoral level. Examination of degree projections over the next decade reveals that the educational system normally will produce enough scientists and engineers overall to meet the nation's requirements. At the same time, more good quality supplemental pollution control education will be needed. Major sources of training for operators and technicians are expected to produce an adequate number of workers in these categories, although the quality of training is expected to vary considerably.

QUALITY OF MANPOWER

(See Chapter 7)

Size of the labor pool is only one aspect of manpower needs in pollution control. Also involved are the characteristics, efficiency, and cost effectiveness of environmental manpower.

Pollution control personnel must be versatile and have a wide variety of knowledge and skills in fulfilling their major responsibilities. Examples drawn from the nation's wastewater treatment program indicate the kinds of problems that may occur if specialized technical training is neglected. Some surveys suggest that poorly trained operators make it difficult for numerous treatment plants to function at a high level of efficiency. Furthermore, the economic benefits of training are significant as compared to costs.

1 Introduction

This study is one of several done under a contract with the Environmental Protection Agency (EPA) which provides for analytical studies of the Agency's decision-making processes. The agreement resulted from a Congressional directive in the EPA appropriations bill for FY 1974. The basis for that action was explained in a report by the Subcommittee on Agriculture, Environmental, and Consumer Protection of the House Committee on Appropriations (House Report 93-275).

OBJECTIVES

Manpower is a key element in successful prosecution of an effective national pollution control program. This Committee was responsible for analyzing current and future scientific and technical manpower needs for such a program. In its study, the Committee considered the profile of personnel requirements in this field, estimates of personnel supply and demand, sources of personnel, and the ways in which individuals with scientific and technical competence are brought into the pollution control work force. In addition, the Committee examined EPA responsibilities and programs for education and training of pollution abatement and control manpower.

SCOPE OF STUDY

The study covers a wide range of manpower problems that EPA can be expected to face, especially in the period 1976 to 1985. It assesses personnel needs stemming from emerging technologies and changing patterns of federal, regional, state, and local cooperation and it explores the availability and use of training and education facilities and how workers can be recruited in manpower-short fields. The Committee gave particular attention to the interaction between EPA and educational institutions, including exchange of scientific and technical personnel and funding of training programs to supply the expertise needed by state and local employers. The Committee also looked at EPA's use of scientific and technical personnel, especially at policy-making levels.

STRUCTURE OF THE STUDY

Since EPA must operate according to mandates established by Congress, the Committee took into consideration the requirements of existing statutes. These requirements were the foundation for assessments of manpower development needs, supply and demand characteristics, quality factors, and federal responsibilities for the development of education and training resources.

COMMITTEE ORGANIZATION

The 12 Committee members and its chairman came from all parts of the nation and from business and industry, federal and local government, and the academic community.

Five supporting panels, which were coordinated by the Committee, were responsible for manpower analyses in specific areas of major concern. All Committee members served on a panel and each panel was chaired by a Committee member. To draw upon an even wider range of knowledge and experience for the study, additional panel members from state government, industry, and the academic community were invited to participate. Their names are listed in the panel reports, which accompany this document as appendixes.

WORK OF THE PANELS

The five panels were set up because a more detailed study of manpower for environmental pollution control was required than could be done by the Committee alone. Their reports serve as specific data sources to provide subject coverage in detail that was not practicable in the Committee report. Appendix reports were prepared by panels on: Legal Aspects; Methodology and National Data Aspects; Federal Aspects; State and Local Aspects; and Industry and Private Sector Aspects.

SYNTHESIS OF THE STUDY

Projecting manpower supply and demand for environmental pollution control is difficult at best. Changing technologies, unevaluated operating data, and the lack of experience on which to base forecasts and to judge the effect of regulations combine to hinder the construction of dependable projections from general economic information.

The nation's pollution control effort relies for the most part upon traditional market mechanisms to generate and allocate the resources, both material and human, needed to achieve national goals and it ignores most forms of planning for resource distribution. However, the effort does represent a departure from the past in establishing specific goals as part of U.S. law. This presumes that demands for goods and services generated by the pollution control program will be met by increased flows of trained persons through existing channels of supply. Although this may be a valid assumption, there is substantial concern in the environmental community that the effective operation of the market may be more complex than is sometimes assumed and that the flow of high quality people into pollution control may be constrained by such factors as an inadequate flow of information among students and workers.

Consequently, there appears to be good cause to study carefully the demands for and sources of qualified manpower as a basis for the development of a plan to assure that the workers who are needed to achieve environmental goals will be available. This report tries to assess the manpower impact of the national environmental pollution control program and it analyzes both supply and demand aspects of the problem. Precise quantitative answers were unobtainable, especially for as far in the future as 1985. However, estimates were made and opinions were formed that are based on professional experience in environmental control.

Manpower numbers alone are by no means the entire story. Quality is a highly significant factor involving training and experience. The Committee was particularly concerned with examining the quality factor within EPA because this plays an integral role in the Agency's decision-making process. Furthermore, EPA has both internal and external training and education responsibilities that affect the quality of environmental manpower. Relevant statutes stipulate that state and local governments should receive assistance and support from EPA in meeting their requirements for scientific, technical, and operating personnel. This report and its appendixes examine areas where meaningful collaboration can be established with educational and other institutions to achieve realistic training goals.

Time did not allow for collection of original data or for extensive case analyses for this report. Such studies might have improved the Committee's analyses and reflected more accurately the environmental manpower requirements in 1985. Data used in the report were the best and most credible to be had. Valuable basic studies have been conducted or supported by a number of organizations such as the National Science Foundation, Bureau of Labor Statistics, Council of Environmental Quality, National Commission on Water Quality, National Planning Association, and the Water Pollution Control Federation. All generously shared their findings with the Committee, as did EPA. Other important information was available to the Committee in the combined experience and knowledge of its members.

There are no hard-and-fast solutions to the problems involved in maintaining a balance between manpower supply and demand for environmental pollution abatement and control. The Committee applied its collective experience to interpretation of the best available data and other information. The results of these analyses are presented in the hope that they will serve as a guide to improved manpower planning, training, and use.

2 Rationale for Environmental Manpower Planning and Policy

Why should the question of adequate environmental manpower concern Congress, EPA, or any other national body? And even if there might be serious imbalances between supply and demand, are any tools available to deal with these imbalances?

In the past, many highly technical innovations were accomplished without help from national agencies. There was, for example, the recent and rapid shift to the use of automatic data processing technology by virtually all sectors of the economy. Although the federal government was much involved for at least 30 years in the development of computer technology before the emergence of a commercially viable new industry, the prodigious manpower requirements for the shift to automatic data processing were met without the promulgation of a national policy to coordinate the training of all the analysts, programmers, repair workers, engineers, managers, and operators needed to install and run the new systems. For the most part, traditional market mechanisms operated effectively to allocate human resources with appropriate skills and in adequate numbers to successfully manage this highly innovative and technical endeavor.

If the normal functioning of the labor market does not produce all of the human resources needed for attainment of the nation's pollution control goals, the government should consider participation in the development of such resources if the goals are to be met. Government participation could also be useful in the event that there happened to be an excess of trained manpower in some specialties. The reasons lie in several fundamental differences between the pollution control program and other national pursuits. These important differences are based on national environmental policy, as reflected in years of legislative action, which has established and reaffirmed the commitment to a cleaner environment. The specific approach that has come to characterize this legislation necessitates support by the federal government and other national institutions in the balanced development of pollution control manpower.

There are four interrelated reasons for this special concern with environmental manpower that are discussed in this chapter. These reasons are:

- the time schedules for specific goals that are imposed by environmental legislation;
- specific directions in some of the environmental legislation which call for federal study of the appropriate labor markets and stimulation of manpower development in certain occupations;
- the high levels and patterns of capital and other expenditures that are anticipated in achieving environmental goals; and
- the fact that the pollution control program is highly reliant on the public sector.

LEGAL FRAMEWORK OF THE NATIONAL POLLUTION CONTROL PROGRAM

The Committee's analysis was made on the basis of legislation existing by early 1976. Therefore, it was not feasible to make adjustments which may have resulted from legislation approved after that time. It is believed that more recent legislation does not substantially affect the manpower analysis.

The National Environmental Policy Act (NEPA) of 1969 created a broad framework for restoring and maintaining environmental quality. Subsequent legislation sets goals and time schedules for rehabilitation and high quality maintenance of the nation's water, air, and general environment, with major responsibility vested in EPA. (The Legal Panel explains this subject more fully in Appendix A.)

In the case of *water*, the goal is to have navigable waters clean enough for "the protection and propagation of fish, shellfish, and wildlife and . . . for recreation in and on the water," by July 1, 1983. Elimination of pollutant discharges into navigable waters is an objective which presumably will be achieved in 1985. Interim goals for wastewater treatment for 1977 and 1983 are established for government and industry under the Federal Water Pollution Control Act Amendments of 1972. With respect to drinking water, the Safe Drinking Water Act of 1974 required EPA to publish proposed interim primary drinking water regulations by June 1975, to take effect 18 months after promulgation. Secondary drinking water regulations were to be promulgated by December 1975.

Goals for *air* include the establishment of national primary and secondary ambient air quality standards by mid-1972 to protect public health and welfare. Plans were to be developed and implemented for attainment of primary standards within specific time periods and within a "reasonable time" for secondary standards. Hazardous pollutants were to be identified and schedules established for control of sources. When a new source standard is established, new sources in all areas of the United States are required to apply "best available control technology" as defined and promulgated by EPA. Statutory standards of automobile emissions are to be achieved by 1978. In addition, EPA is required to prevent "significant deterioration" of ambient air quality in areas presently having better air quality than called for by the standards.

The Federal Environmental Pesticide Control Act of 1972, as amended, requires EPA to register all *pesticides* sold in the United States. To be registered, a pesticide must perform its intended function "without unreasonable adverse effects on the environment." States were given until October 1976 to submit plans for the certification of pesticide applicators and EPA was allowed until October 1977 to approve state plans for certification programs. Applicators were to be certified by October 1977.

Under the Solid Waste Disposal Act of 1965, EPA is required to recommend guidelines for *solid waste* recovery, collection, separation, and disposal. However, no target dates or mandatory authority are included in the law.

The Noise Control Act of 1972 gave EPA the responsibility to control certain sources of *noise*. To carry out this responsibility, EPA was to publicize criteria based on the identifiable effects of noise on public health and welfare, and by October 1974 was to promulgate revised regulations for construction equipment; transportation equipment except aircraft, motors, and engines; and electrical and electronic equipment.

With respect to *radiation* control, responsibility is divided between EPA and the Nuclear Regulatory Commission. The Nuclear Regulatory Commission is to issue uranium fuel cycle standards and to develop, implement, and enforce standards for individual nuclear facilities. In May 1975, EPA proposed standards for limiting the total quantity of radioactive materials entering the general environment from the whole uranium fuel cycle.

The policy of Congress in setting fairly specific goals and timetables for environmental action apparently is based on the social and political realities within which this legislation is formulated. One implication of this policy is the necessity for a crash program of government and private capital spending which will bring improved technology into action much sooner than would be the case if normal capital depreciation and replacement procedures were followed. From a manpower point of view, it would be advisable for Congress to avoid establishing abbreviated time schedules that allow too little opportunity for labor market mechanisms to operate effectively.

Therefore, unlike voluntary and evolutionary shifts in production methods, the program for capital expenditures and construction is being carried out according to a single national timetable that will inevitably place stresses on the institutions charged with supplying the necessary human resources. Not only must the goals be met by relatively early dates, but all those involved must meet these goals at the same time. Educational institutions with suitable training programs may then become immediately loaded to or above their capacities. However, in some cases new programs might not be developed to provide adequately prepared professionals and technicians because of the short lead-time or the absence of historical market demand. Such demand in the past has influenced both the educational institution and the potential worker who is thinking of investing in a career in this field. Also, it may be difficult for educational institutions to establish programs for small numbers of persons.

When such situations arise as a result of deliberate government policy, and become counterproductive to the original aims of that policy, it is reasonable to expect responsible government agencies to assume leadership. This task would include making accurate assessments of the situation at all times and intervening as necessary to assure that the attainment of Congressionally-mandated national goals is not prevented by shortages in the supply of qualified workers.

LEGISLATIVE AUTHORIZATION FOR EPA EDUCATION AND MANPOWER PLANNING ACTIVITIES

Throughout the legislative history of pollution control, Congress has been sufficiently mindful of these special considerations to expressly and implicitly authorize EPA to take positive action to prevent the occurrence of potential manpower problems. The expressly authorized manpower development requirements assigned to EPA by Congress are of particular relevance in the context of the Committee's report because they add legal, as well as rational and economic, reasons for government study and involvement in the supply of qualified pollution control manpower. This subject is presented in detail in Appendix A.

Personnel training and development are expressly provided for by the Federal Water Pollution Control Act Amendments of 1972 as part of a national program to reduce and prevent water pollution. The most significant personnel development projects authorized by Section 104 of the Act are programs for training personnel to operate and maintain waste treatment works. The EPA Administrator is authorized to support these training programs by grant or contract with public or private agencies, institutions, and individuals and through research fellowships for the education or training of personnel. Sections 109 and 111 of the Act give the Administrator further authority to support the development of personnel to operate wastewater treatment works. Under Section 109, grants may be made to institutions of higher education to assist in establishing projects to prepare undergraduate students for occupations in wastewater treatment. Section 111 empowers the Administrator to award scholarships to undergraduates who plan to enter such occupations.

The Safe Drinking Water Act expressly provides for training personnel. The EPA Administrator is authorized to make grants to any public agency, educational, or other institution to train personnel for public health occupations involved in providing safe drinking water, and to train inspectors and supervisory personnel for public health aspects of the program.

The Clean Air Amendments of 1970 provide for personnel development in Section 103, which establishes a national research and development program for the prevention and control of air pollution. As part of this program, the EPA Administrator is authorized to award grants to, and contract with, public or private agencies; to provide direct training grants; and to establish research fellowships. Two other sections of the Act provide for personnel development, although not specifically for training activities. Section 105 authorizes the Administrator to make grants to air pollution control agencies for amounts up to two-thirds of the cost of planning, developing, establishing, or improving, and up to one-half the cost of maintaining, programs for the prevention and control of air pollution or for the implementation of national ambient air quality standards. Grants to certain state and joint municipal agencies may total up to three-fourths of the cost of developing, and three-fifths of the cost of maintaining, such programs. Section 210 provides for funding state agency programs for the development of effective vehicle emission control devices and the establishment of inspection and testing of vehicle emission systems.

The Resource Recovery Act of 1970, which amended the Solid Waste Disposal Act of 1965, expressly provides for federally-supported personnel training programs. The EPA Administrator is authorized to support, by grant or contract, projects designed to train persons for occupations involving the management, operation, or maintenance of solid waste disposal and resource recovery equipment and facilities. Such projects may combine training, education, and employment. In addition, EPA is authorized to support programs for training instructors and supervisory personnel to train workers in the occupations involved. Grants or contracts may be made to state or interstate agencies, municipalities, educational institutions, or any other organization capable of effectively carrying out such a training project.

The Federal Environmental Pesticide Control Act of 1972 (FEPCA) expressly provides for the training of personnel to enforce and administer the Act. The EPA Administrator is authorized to enter into cooperative agreements with states, to which EPA has delegated the power to enforce the Act, for the support of training programs on the state level. The cooperative agreements may be designed for training both enforcement personnel and "certified applicators," who are required under the Act to supervise the use of "restricted use" pesticides. Training of certified applicators also may be undertaken by federal and state agencies under contracts with EPA.

Federal *radiation* and *noise control* statutes do not expressly provide for EPA programs in manpower training or development.

As a whole, the environmental legislation leaves little doubt that it was the intent of Congress to place leadership for assuring adequate supplies of qualified human resources for pollution control with EPA. Congress has not only specifically authorized and directed EPA to involve itself with manpower issues, but in the entire thrust of the environmental legislation has given the Agency a much greater, although less well-defined, role in environmental manpower affairs.

LEVELS AND PATTERNS OF ENVIRONMENTAL EXPENDITURES

Another reason for national concern with environmental manpower is the sheer size of the program in economic terms. While no authoritative estimates of total cost exist, EPA and others, such as the National Commission on Water Quality (NCWQ 1975) and the Council on Environmental Quality (CEQ 1976), have tried to make reasonable projections of the cost of mandated control programs. Tables 2.1, 2.2, and Figure 2.1 show one version of these projections for water and air pollution control through 1985. The figures are based on data gathered by EPA and its contractors (U.S. EPA 1976).

The most striking aspect of the projections is their overall magnitude—a total national expenditure of about $371 billion for air and water pollution control between 1975 and 1985. Regardless of how accurate such calculations may turn out to be, it seems certain that a great deal of money will be spent on pollution control technology and that those dollars inevitably will generate thousands of jobs. Some of the jobs undoubtedly would have been created by normal economic activity or by government spending for other purposes. However, the selection of pollution control as a national goal will greatly affect the occupational composition and geographic distribution of national employment, if not its total level.

It has been assumed in most economic projections that capital spending for environmental controls will be a one-shot operation and that it will be heavily weighted toward the late seventies and early eighties. However, it is likely that this assumption will prove erroneous because new waste management concepts, designs, and operations must be updated on a continuing basis. In addition, expenditures for operating and maintaining pollution control facilities will continue to rise substantially.

Charting the future course of spending on capital equipment for pollution control is difficult because this spending depends on the availability of financing and on undiminished public interest. Today's pressures that are brought on by population growth and public concern with as yet unknown environmental hazards undoubtedly will be balanced against new priorities in the 1980s and 1990s. However, even with shifting national priorities, there still will be the need to bring new treatment concepts into operation and to improve the efficiency of existing capital equipment.

The economic size of the pollution control program warrants careful attention to its impacts on society. Data from the Bureau of Labor Statistics suggest that as many as 70,000 jobs are generated directly and indirectly for each billion dollars spent on pollution control (U.S. DOL 1975). With 1974 national spending for pollution control totaling about $15 billion, and with annual projections for 1976 to 1985 easily doubling that amount, there is ample reason for national interest.

In terms of manpower policy, the economic projections suggest that care should be taken by national planners to avoid strategic shortages in critical occupations. Should other new programs be planned that might

TABLE 2.1 Estimated Annual Cost of Water Pollution Control to Industry and Government, 1975 to 1985

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Total
					(in billions of 1975 dollars)							
Industry:												
Investment	6.70	5.00	6.00	4.90	6.90	7.90	7.50	6.80	4.91	2.00	2.26	60.87
Operation and maintenance	3.00	4.00	4.99	6.00	7.10	8.20	9.20	10.20	11.20	10.38	10.38	84.65
Total	9.70	9.00	10.99	10.90	14.00	16.10	16.70	17.00	16.11	12.38	12.64	145.52
Municipal:												
Investment[1]	3.89	6.55	8.11	8.13	5.59	2.94	1.77	0.80	0.70	0.70	0.53	39.71
Operation and maintenance	0.60	0.68	0.93	1.36	1.61	1.76	1.84	1.89	1.93	1.97	2.00	16.57
Total	4.49	7.23	9.04	9.49	7.20	4.70	3.61	2.69	2.63	2.67	2.53	56.28
Other Government:												
Federal investment	0.25	0.33	0.29	0.25	0.21	0.18	0.16	0.13	0.12	0.12	0.12	2.16
Federal and state control programs	0.47	0.44	0.37	0.33	0.33	0.33	0.30	0.30	0.30	0.30	0.30	3.77
Total	0.72	0.77	0.66	0.58	0.54	0.51	0.46	0.43	0.42	0.42	0.42	5.93

[1] Includes EPA grants.

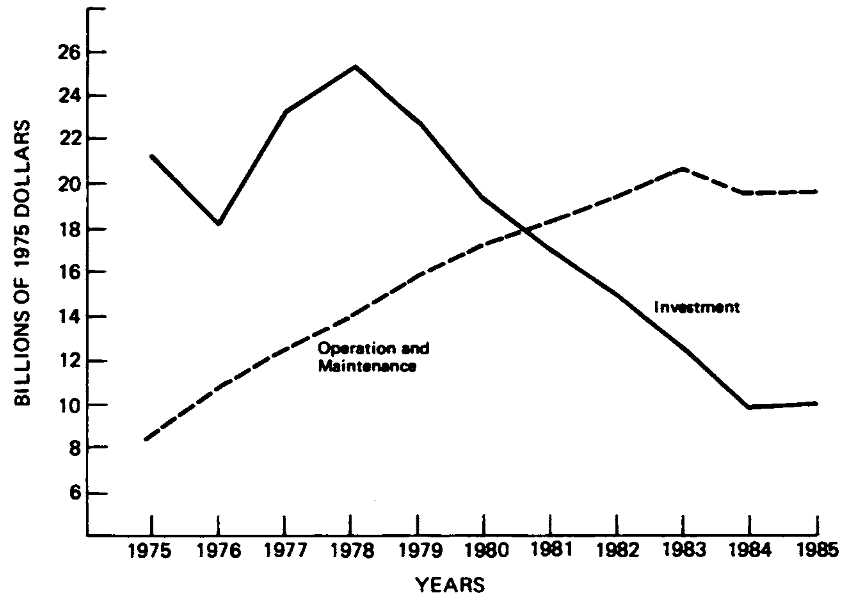
SOURCE: U.S. EPA (1976).

TABLE 2.2 Estimated Annual Cost of Air Pollution Control to Industry, Government, and for Mobile Sources, 1975 to 1985

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Total
					(in billions of 1975 dollars)							
Industry:												
Investment	7.90	3.30	5.50	6.00	4.20	1.73	1.42	0.95	0.50	0.60	0.62	32.72
Operation and maintenance	3.01	4.15	4.67	5.07	5.42	5.67	5.70	5.72	5.74	5.76	5.78	56.69
Total	10.91	7.45	10.17	11.07	9.62	7.40	7.12	6.67	6.24	6.36	6.40	89.41
Government:												
Investment	0.45	0.38	0.31	0.30	0.29	0.28	0.26	0.25	0.23	0.22	0.20	3.17
Operation and maintenance	0.35	0.38	0.35	0.38	0.42	0.45	0.49	0.53	0.57	0.61	0.66	5.19
Total	0.80	0.76	0.66	0.68	0.71	0.73	0.75	0.78	0.80	0.83	0.86	8.36
Mobile Sources:												
Investment[1]	2.04	2.58	3.03	5.65	5.65	6.29	5.88	6.00	6.14	6.22	6.34	55.82
Operation and maintenance[2]	1.22	1.09	0.92	0.91	0.87	0.80	0.80	0.77	0.74	0.71	0.67	9.50
Total	3.26	3.67	3.95	6.56	6.52	7.09	6.68	6.77	6.88	6.93	7.01	65.32

[1] Private sector.
[2] Excludes fuel penalties associated with emission control devices.

SOURCE: U.S. EPA (1976).



SOURCE: Based on Tables 2.1 and 2.2.

FIGURE 2.1 Estimated annual investment and operation and maintenance costs of air and water pollution control, 1975–1985.

draw on the same types of skills as are used in the pollution program, some form of government action to establish priorities may be better than having a collection of understaffed programs. Or the government could stimulate the entry of more people into an occupation if it seemed likely that environmental spending patterns would create an excessive demand for that occupation. Either of these strategies clearly requires carefully assessed methods to determine the nature of possible difficulties and alternative solutions.

Equally important is the fact that, while much environmental control activity will be permanent and will even grow, significant aspects are likely to terminate within a few years. Plans can and should be made now to minimize the high economic and social costs of these rapid shifts in the demand for environmental manpower.

PUBLIC SECTOR ROLE IN POLLUTION CONTROL

Traditionally, much of the responsibility for pollution control in the United States has been in public hands. Virtually all wastewater treatment plants serving residential needs are publicly-owned and predominant segments of the drinking water supply and solid waste management industries are owned or operated by local governments. In addition, public agencies at local, state, and federal levels have been charged with monitoring and enforcing a complex and pervasive set of environmental laws. While these agencies draw heavily on private contractors and consultants for advice and information, much of the work and most of the decision making is done by public officials.

In general, government cannot cope with rapidly changing situations as quickly or as directly as can the private sector. It is an historic fact, for example, that public agencies generally are bound by rigid personnel systems. Immediate cash wages of public employees, particularly in smaller communities, often have been below wages for people employed in the private sector. Moreover, the public agency has a highly constrained flexibility in meeting changing needs as a result of various kinds of civil service restrictions. If the rapid mobilization of government resources is to be part of national policy, as it clearly seems to be in the case of pollution control, it is essential that responsible leadership at the national level explicitly recognize the unique situation of local government employers and develops measures to assess and remedy special manpower problems before they become obstinate barriers to achieving environmental goals.

The Construction Grants Program administered by EPA has the objective of encouraging the construction of wastewater treatment systems that achieve the water quality goals of the Federal Water Pollution Control Act Amendments in a cost–effective and environmentally acceptable manner. The level of water quality established by the law is to be reached by meeting technology-based effluent standards and supplementary site-specific water quality standards. Neither the law nor the grants program specifies a method of treatment, although the latter specifies basic objectives for assuring technical, environmental, and fiscal integrity of systems for which funds are provided.

Present cost estimates for the national construction effort for wastewater disposal amount to more than $40 billion and, if storm wastewater is included, some estimates exceed $300 billion. The point is that the nation will have a large capital investment, as will local government, in pollution control treatment plants. Similarly, the annual operating and maintenance burden will be huge.

The demand for improved quality of effluent is accompanied by increasingly sophisticated treatment plant design and operation. The "best practicable waste treatment technology" called for by existing statutes will require increasingly complex treatment processes and techniques. Some of these are biological processes that must operate continuously under carefully controlled conditions, to avoid destruction of the microorganisms necessary to the process. The trend, therefore, is toward continuous and skillful operation of treatment plants with avoidance of shutdowns and by-passing of polluted water.

The EPA is aware of the need for emergency response plans and performance reliability analyses. Each wastewater treatment system is designed to operate under controlled particular conditions, and any situation that changes these conditions must be provided for in an adequate emergency program for that system. Yet there are a number of circumstances of process interruption common to most, if not all, systems across the country that cannot have special attention. Potential factors leading to process interruption or complete breakdown include power outage, storm damage, equipment failure, and absence of operating personnel. These are basic emergency conditions that must be planned for and effectively managed if treatment plant failure is to be avoided. While EPA has taken the lead in encouraging state and local governments to develop and put into effect emergency plans, much remains to be done.

The Committee realizes that catastrophic events such as earthquakes can create damage beyond human control, but even in such situations an emergency plan can speed progress toward restoration of operations. A number of factors, especially the necessity for uninterrupted availability of operational personnel, can be solved by good planning. Neither EPA nor the state and local governments have demonstrated adequate progress in this area. The Agency should take the lead by assessing potential manpower problems, including analysis of the cost in dollars for damages to treatment plants as well as to the environment. Ultimately, Congress will need to address the problem of continuous operational requirements whenever additional pollution abatement legislation is considered.

PRIVATE SECTOR ROLE IN POLLUTION CONTROL

Private employers generally have a greater ability to work through the labor market to obtain needed manpower than do state and local government employers. This ability is limited, however, by the pool of available talent in the labor force and by its geographic distribution. Because the deadline for reaching certain effluent standards is a national one, and requires all industries to clean up by essentially the same time, the environmental program creates much simultaneous demand for professionals with expertise in environmental pollution abatement. While a single employer might raise wages sufficiently to attract highly specialized talent, all employers acting in this manner at the same time might be unable to cope with a short-term shortage in specialized personnel. Many positions filled under these circumstances might result from substantial inter-occupational mobility and the employment of less qualified personnel. This might mask serious training deficiencies and have negative net impacts on the whole environmental effort.

All of this is of major importance to industry because the selection of appropriate pollution control technology and its efficient implementation require the expenditure of enormous sums of money and the commitment to modes of production that will be difficult to alter.

Without question, the primary responsibility for managing the private sector aspects of the pollution control program lies with industry. Government assistance might be limited to preparing and publishing assessment data so that industry can gauge the dimensions of its specialized manpower supply and demand. It is industry's responsibility to promote the development of its own personnel and to encourage students to participate in new or existing environmental training programs. Industry also might improve its environmental manpower situation by working closely with local training institutes and by hiring cooperative education students.

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3 Manpower Development Role of EPA

The purpose of this chapter is to review briefly how EPA has handled manpower management problems in the past and to suggest an appropriate course of action which will enable the Agency to provide leadership in the field of environmental manpower.

The Committee has a twofold interest in the EPA personnel structure. First, the Agency is charged with interpreting and enforcing virtually all national pollution control legislation. As such, the technical ability of its staff, particularly in the decision-making role, is an important concern. Second, EPA should serve as an example for state and local environmental units on how to maintain professional and technical staff competence.

The limits on the data presented in this section should be made clear. The data are basically distributions of occupational, grade level, and educational statistics which indicate the nature of talent and skills available within EPA. These compilations do not show how such capabilities are organized or used for effective environmental decision making and action. They do provide valuable indicators of strengths and weaknesses within the Agency's own supply of human resources. The question of EPA manpower use is examined in greater detail in a companion report by the Committee on Environmental Decision Making, which made one of the component studies under the EPA–National Academy of Sciences contract.

PROFILE OF AGENCY PERSONNEL

By federal government standards, EPA is not a large agency. It currently employs about 10,000 full-time permanent workers, almost all of them "white-collar." This figure represents about one-half of 1 percent of the total federal civilian white-collar labor force of some 1.9 million.[1]

Although the Agency is not large, its responsibilities are broad and complex. EPA is charged with leading a highly technical endeavor within a complicated economic, social, and political environment. Whatever else such a program needs for success, skilled and sensitive leadership is vital. This Committee could address only the matter of skills available within the Agency as determined by Civil Service grades and occupational groupings. While the Committee was unable to draw firm conclusions from the data, the multifaceted nature of the environmental control program points to the complexities in doing an analysis of staffing patterns. Because EPA responsibilities usually relate to the technical aspects of pollution control, the Agency should be certain that its staff has adequate technical expertise. Otherwise, criticism of EPA from the scientific community, local agencies, and the private sector for formulating policies and regulations not sufficiently attuned to the technical realities of pollution abatement processes may be justified. An overall view of the occupational mix within EPA is shown in Table 3.1.

Except for general administrative and clerical positions, which account for nearly 38 percent of EPA employment, the three largest occupational groups in the Agency are engineers, physical scientists, and biological scientists. Among the engineers, sanitary engineering is the dominant professional identification and accounts for more than 600 individuals. This is shown in more detail in Table 3.2.

Perhaps the most outstanding feature of EPA's personnel makeup is the large proportion of scientists and engineers at top and middle levels of the Agency hierarchy. Scientists represent 65 percent of the Civil Service "supergrade" (GS 16–18) employees of EPA, while engineers account for 5 percent. At the middle management level of the career service, scientists also dominate with 32 percent of the positions in the GS 12–15 range. Engineers are also well represented at this level and have 27 percent of the jobs. Thus, nearly 60 percent of the entire Agency work force at the middle level is made up of scientists and engineers.

The relationship between position in a federal agency and influence on decision making is by no means clear. In EPA there are a small number

[1]Based on Central Personnel Data File (CPDF) figures provided to the Committee by the U.S. Civil Service Commission.

TABLE 3.1 Distribution of All Full-Time, White-Collar EPA Employees, by Occupation and Grade Level, March 1976

	Number of Employees by Grade Level (GS)[2]				Total	
Occupational Category[1]	1-5	6-11	12-15	16-18	Number	Percent
General administrative, clerical, and office services	1,911	1,303	644	19	3,877	37.7
Engineering	188	674	1,008	6	1,876	18.3
Physical sciences	208	540	814	81	1,643	16.0
Biological sciences	170	329	397	5	901	8.8
Accounting and budget	62	150	176	3	391	3.8
Legal	9	78	177	5	269	2.6
Information and arts	33	116	87	1	237	2.3
Personnel management	36	81	79	1	197	1.9
Business and industry	35	75	69	1	180	1.8
Social sciences	8	52	96	0	156	1.5
Mathematics and statistics	14	42	82	7	145	1.4
Medical	3	59	43	2	107	1.0
Other	70	137	89	2	298	2.9
Total number	2,747	3,636	3,761	133	10,277	–
Total percent	26.7	35.4	36.6	1.3	–	100.0

[1] See Table 3.2 for the professional occupational distribution of engineering and scientific categories, not including technicians and trainees given here.
[2] Effective October 1, 1976, the basic annual salary structure for federal civilian employees is as follows:

Grades (GS)	1-5	$ 5,810-12,093
	6-11	10,370-22,177
	12-15	20,442-43,923*
	16-18	39,629-54,410*

*The rate of basic pay for grades 15-18 is presently limited to $47,500. Until March 1, 1977 the basic pay for these grades was limited to $39,600.

SOURCE: Derived from unpublished data provided by the Personnel Management Division of the U.S. Environmental Protection Agency (1976).

of executive positions above the career Civil Service, including the Administrator, Deputy Administrator, General Counsel, and some Assistant Administrators and Regional Administrators. Therefore, while scientists and engineers occupy most of the top Civil Service positions in the Agency, they do not as a rule hold the highest-level decision-making posts. Another factor limiting the effectiveness of scientists and engineers in determining policy is the general lack of practical experience in design and operation of systems required for pollution abatement, particularly as related to problems that are peculiar to industry and local government.

TABLE 3.2 Scientists and Engineers in EPA on 13 March 1976

	Number of Personnel	
Occupational Category[1]	Subgroup	Major Group
Engineering		
Engineers		
Sanitary	607	
General	501	
Chemical	190	
Mechanical	135	
Civil	78	
Other	61	
Total		*1,572*
Physical Sciences		
Scientists		
General	640	
Chemistry	604	
Physics	28	
Health physics	25	
Oceanography	20	
Hydrology	19	
Geology	13	
Meteorology	6	
Total		*1,355*
Biological Sciences		
Scientists		
General	476	
Microbiology	94	
Entomology	30	
Pharmacology	21	
Other	85	
Total		*706*

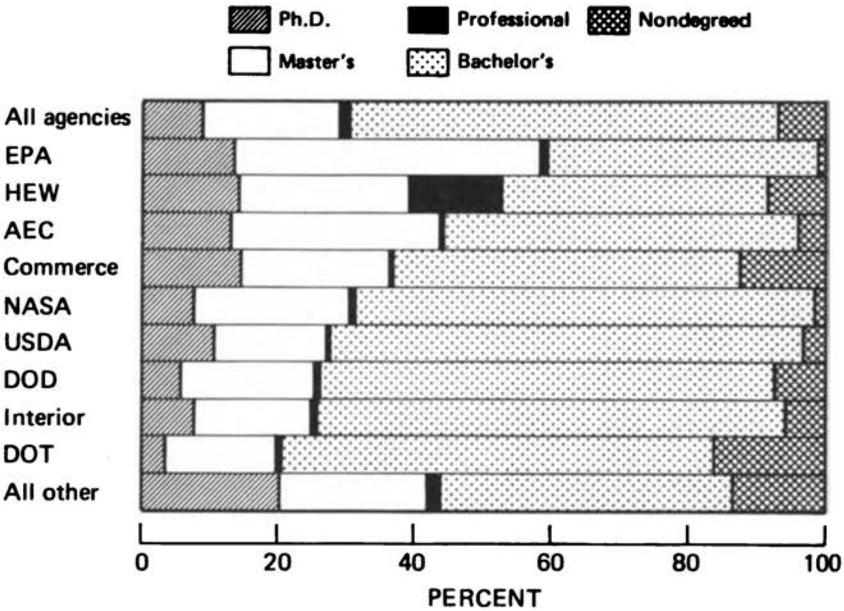
[1] Technicians and trainees included in the totals in Table 3.1 are omitted from this tabulation.

SOURCE: Derived from unpublished data provided by the Personnel Management Division of the U.S. Environmental Protection Agency (1976).

Furthermore, many are involved with laboratory and research work which is not directly related to the regulatory functions of the Agency.[2]

In educational attainment, EPA ranks high. Recently reported

[2] The report of the Committee on Pesticide Regulation (NRC 1977) includes a number of recommendations on involvement of scientific and technical personnel in the decision- and policy-making process.



SOURCE: NSF (1976).

FIGURE 3.1 Degree levels of federal scientists and engineers in major federal agencies, January 1974.

National Science Foundation data suggest that EPA scientists have the highest educational levels of any federal agency. These comparisons are shown in Figure 3.1. Nearly 60 percent of all EPA employees have college degrees, with the largest number of these degrees in engineering, biological, and physical sciences. Details are shown in Table 3.3.

It is relevant to note that the occupational distributions shown in Tables 3.1 and 3.2 differ somewhat from what might be expected on the basis of the academic background of EPA employees, as shown in Tables 3.3, 3.4, and 3.5. Some 1800 EPA employees hold degrees in engineering, for example, although there are only 1600 persons who are employed as engineers in EPA. There is a similar situation in the biological sciences. This suggests that a substantial number of persons with engineering or scientific backgrounds are in administrative or nonscientific positions.

Table 3.5 focuses on EPA's Office of Research and Development (ORD). It does not seem surprising that more advanced degrees are present in ORD than in the EPA enforcement or other administrative offices, and it is noteworthy that more than 30 percent of all of the

TABLE 3.3 Distribution of Full-time EPA Employees, by Academic Discipline and Highest Degree, February 1976

Academic Discipline of Highest Degree	Number of Employees by Highest Degree			Total	
	BA/BS[1]	MA/MS	PhD/D[2]	Number	Percent
Engineering	961	746	93	1,800	30.5
Biological sciences	470	259	210	939	15.9
Physical sciences	529	196	186	911	15.4
Business administration	303	149	7	459	7.8
Social sciences	281	121	24	426	7.2
Law	252	42	10	304	5.2
Agriculture and natural resources	70	48	26	144	2.4
Mathematics	82	45	16	143	2.4
Other	452	284	42	778	13.2
Total number	3,400	1,890	614	5,904	–
Total percent	57.6	32.0	10.4	–	100.0

[1] BA/BS includes Bachelor of Laws degrees.
[2] PhD/D includes professional doctorates, such as medicine or education.

SOURCE: Derived from unpublished data provided by the Personnel Management Division of the U.S. Environmental Protection Agency (1976).

professional employees in ORD hold doctorates and another 27 percent hold master's degrees.

In an examination of the data on EPA personnel, several patterns show up. First, the Agency employs 43 percent of its 10,000 full-time, white-collar personnel in scientific and engineering occupational categories, a higher proportion than in most government agencies. Second, the educational level of EPA professional personnel is high, with 6 percent holding Ph.D. degrees and 19 percent master's degrees. Third, EPA full-time scientists and engineers earn mean salaries of $24,128 per year. Within ORD mean salaries for scientists and engineers are higher—$26,140 per year.[3] These figures are expected to increase before this report is published. At the early 1976 level, they compared favorably with national median salaries for scientists and engineers of $19,000 in business and industry and $16,400 in state government employment (NSF 1975).

A more complete analysis and additional data are presented in Appendix C. The Committee concludes that while the personnel data

[3] Mean salaries computed by EPA's Personnel Management Division as of January 29, 1977. The salary scale is that given in footnote 2 of Table 3.1.

TABLE 3.4 Detailed Educational Distribution of Full-time EPA Employees with Engineering, Biological, and Physical Science Degrees, February 1976

Academic Discipline	Number of Employees by Highest Degree			Total	
	BA/BS[1]	MA/MS	PhD/D[2]	Number	Percent
Engineering					
Environmental and sanitary	156	443	30	629	34.9
Chemical	235	82	29	346	19.2
Civil	231	64	3	298	16.6
Mechanical	133	43	9	185	10.3
Other engineering disciplines	206	114	22	342	19.0
Total number	961	746	93	1,800	–
Total percent	53.4	41.4	5.2	–	100.0
Biological Sciences					
General biology	231	42	11	284	30.2
Microbiology	43	29	36	108	11.5
General zoology	47	29	10	86	9.2
Entomology	25	23	27	75	8.0
Biochemistry	18	12	31	61	6.5
Ecology	16	19	19	54	5.8
Marine biology	15	16	12	43	4.6
Other biological sciences	75	89	64	228	24.3
Total number	470	259	210	939	–
Total percent	50.0	27.6	22.4	–	100.0
Physical Sciences					
General chemistry	309	35	20	364	40.0
Analytical chemistry	60	20	17	97	10.6
Organic chemistry	18	29	41	88	9.6
Geology	43	25	2	70	7.7
Physical chemistry	4	14	49	67	7.4
General physics	29	17	11	57	6.3
Oceanography	6	13	4	23	2.5
Meteorology	8	10	3	21	2.3
Other physical sciences	52	33	39	124	13.6
Total number	529	196	186	911	–
Total percent	58.1	21.5	20.4	–	100.0

[1] BA/BS includes Bachelor of Laws degrees.

[2] PhD/D includes professional doctorates, such as in medicine or education.

SOURCE: Derived from unpublished data provided by the Personnel Management Division of the U.S. Environmental Protection Agency (1976).

TABLE 3.5 Distribution of Full-time EPA Employees in the Office of Research and Development, by Academic Discipline and Highest Degree, February 1976

Academic Discipline		Number of Employees by Highest Degree BA/BS	MA/MS	PhD/D	Total Number	Total Percent
Engineering		103	99	44	246	23.7
Biological sciences		108	80	115	303	29.2
Physical sciences		186	65	106	357	34.4
Health professions		19	11	7	37	3.6
Mathematics		8	13	8	29	2.8
Agriculture and natural resources		5	6	13	24	2.3
Other		13	10	20	43	4.1
Total	number	442	284	313	1,039	–
	percent	42.5	27.3	30.1	–	100.0

SOURCE: Derived from unpublished data provided by the Personnel Management Division of the U.S. Environmental Protection Agency (1976).

present a positive image of EPA, much important information could not be gleaned from these data. For example, it is not possible from available data to state how scientists, engineers, and technicians are assigned to their duties, whether they are up-to-date in their disciplines, or whether they are consulted to the fullest extent possible in the actual decision-making process. There is evidence that more practical experience in pollution abatement and technical input is needed at the top level of management in the Agency. Detailed exploration of such issues comes within the purview of another committee working under the EPA–National Academy of Sciences contract, but this aspect of the EPA manpower situation should not go unheeded by this Committee.

PAST MANPOWER ACTIVITIES

EPA has an established legislative as well as a practical program responsibility for manpower planning and development. This requirement extends beyond the Agency's own immediate needs and encompasses other federal departments, state and local governments, and the private sector.

Ongoing program activities need trained manpower to achieve their goals. This requires making plans to encourage a good balance between the supply of and demand for the necessary numbers of people with the proper qualifications.

TRAINING AND EDUCATION PROGRAMS

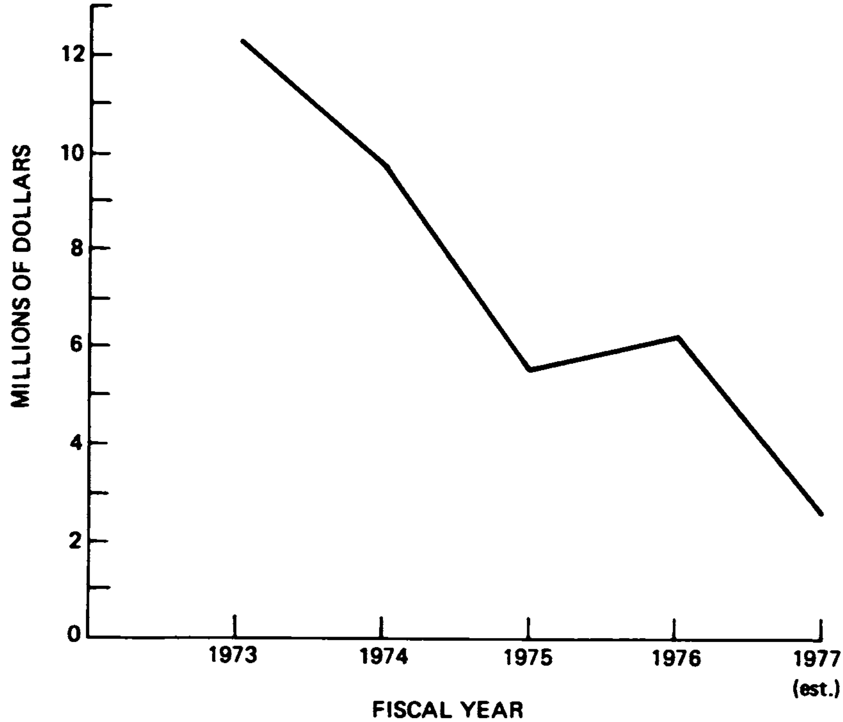
EPA has recognized the necessity for limiting its efforts to developing only those manpower programs required to fill or to assist in filling areas of need. The Office of Management and Budget (OMB) has emphasized this point for a number of years. The important question is whether training and education cutbacks are advisable at this time.

The EPA manpower development and training program is divided among the Office of Federal Activities and various assistant administrators and regional offices. The different statutes under which these activities are conducted are covered in detail as a part of Appendix A, the report of the Legal Panel. Since establishment of EPA in December 1970, until recently, there has been little change in program approach. Figure 3.2 and Table 3.6 show the levels of support for manpower and training activities and numbers of personnel trained, with indications that funds and personnel allocations available in EPA for manpower purposes have decreased drastically and that a number of manpower planning and training activities are being curtailed or phased out.

The various offices responsible for manpower functions in EPA interpret their responsibilities and objectives in widely differing ways. It is true, of course, that the Agency's legislative mandates are not entirely consistent and that no centralized leadership has been established for an EPA manpower planning, training, and education program. Within the past two years, for example, the Office of Education and Manpower Planning has been transferred from a position directly under the Assistant Administrator for Planning and Management to a markedly subsidiary position in the Office of Federal Activities. Its personnel has been reduced substantially to the point where it is virtually impossible for this unit to perform effectively.

The problem apparently is one of organization rather than inability to recruit and retain trained and experienced personnel because of salary considerations. At one time federal salaries were inadequate in this respect, but the government recognized the need for trained pollution control manpower at the federal level, and that condition has improved in recent years.

A major responsibility for meeting the requirements of federal environmental legislation lies with state and local governments and EPA has recognized this. The principal problem is that many state and local agencies are unable to compete effectively with the federal government or with private industry in hiring and retaining skilled manpower. As a



SOURCE: Based on Table C.3 in Appendix C.

FIGURE 3.2 EPA funding for manpower-related programs, 1973–1977 (excludes Office of Pesticide Programs Funding).

result, EPA adopted the practice of providing direct federal assistance to states and local governments for developing sufficient manpower to meet their responsibilities.

Generally, large industries have been able to train their own personnel or, where necessary, recruit trained personnel from other sources. While EPA has cooperated with industry, there has been no apparent need for direct federal aid for manpower training and education. When federal courses have been offered, especially in new laboratory techniques and procedures, large businesses have been able to obtain training for their technical personnel without much difficulty. However, small firms often find it difficult to compete for trained environmental workers.

TABLE 3.6 Training Activities Supported by EPA, by Office and Type of Funding, FY 1973 through FY 1977

	Number of Awards and Courses Offered				
Training Activity, by Program	FY 1973	FY 1974	FY 1975	FY 1976	FY 1977 (Estimated)
Office of Water Program Operations					
Training grants	156	130	126	133	85
Fellowships	31	38	74	82	40
Undergraduate training			104	104	5
Direct training of students			407	500	360
Number of courses			36	37	30
Office of Air Quality Planning and Standards					
Training grants	46	23	15	9	9
Fellowships	56	70	70	70	70
Direct training of students	3,021	2,793	2,105	1,442	2,200
Number of courses	128	116	77	66	80
Office of Solid Waste Management Programs					
Training grants	35	30	0	0	0
Direct training of students	721	0	0	0	0
Number of courses	19	0	0	0	0
Office of Radiation Programs					
Training grants	170	46	10	0	0

SOURCE: Table developed by the U.S. EPA for internal review (1976).

EDUCATIONAL INSTITUTIONS

Universities and colleges have assumed an increasingly active role in the education of managerial and technical personnel for environmental pollution control. Except for highly specialized courses, educational institutions have been able to attract and retain the professional staff they need for teaching and research. The most important area of EPA assistance to institutions of higher learning has been to provide training grants that cover faculty support and to make funds available for equipment purchases and for the development of new courses of instruction. In recent years, this EPA funding has been drastically reduced, with resultant concern in the universities that severe damage was being done to their ability to train necessary environmental manpower.

The situation has been well described in the field of air pollution control.[4] A typical training grant to a college or university at the graduate level five years ago would have amounted to about $100,000 a year. Of that total, about one-half was available for faculty support and for updating laboratory equipment to maintain a high level of instructional quality. The other half could be used to support qualified students. More recently there has been a severe cutback in this funding, with essentially the total withdrawal of support for the university itself and with all of the available funding specified for student support. Training grants have been reduced and new restrictions have been placed on the grants. For example, a master of science student may be supported for not more than one year under the traineeship program and support for new doctoral students has been eliminated.

There also have been crippling reductions in short-course training and the assessment of user fees against all students in the EPA training program has sharply reduced state and local participation. At the same time, the use of EPA personnel for teaching short courses has been virtually eliminated in favor of contracting for such services. This means a loss of valuable interaction between EPA employees and the state-local officials and others who attend such courses.

The National Air Pollution Manpower Development Advisory Committee was established in 1962 by the Public Health Service to provide an independent evaluation and assessment of manpower needs for air pollution control. It was transferred to EPA in December 1970 under Reorganization Plan Number 3 and continued in an active role until terminated on January 5, 1976.

PRESENT AND PROPOSED MANPOWER ACTIVITIES

EPA manpower planning, education, and training activities are in a state of flux. Further, the EPA education and manpower planning staff has been reorganized and the number of its personnel has been reduced drastically in the past few years. Each assistant administrator's office appears to have a different idea about how training and education should be accomplished and there is no agencywide organized and coordinated program.

Surveys have been made to evaluate current manpower development and training activities and systems that are designed to promote the effectiveness of state and local implementation of EPA regulations,

[4]Testimony of Dade W. Moeller, School of Public Health, Harvard University, and former chairman of the National Air Pollution Manpower Development Advisory Committee to the Committee for Study of Environmental Manpower at its public meeting, January 1976.

standards, and guidelines. Some states and local agencies have been consulted on their ideas as to what the approach should be. In addition, recent assessments have included manpower demand, which implies a need for manpower planning, identification of training needs, analysis of training programs, implementation of training and education programs, and the reporting and evaluation of program results.

EPA has recognized that trained manpower is a resource that is required to implement every facet of its basic program activities. If there are not enough adequately trained and properly qualified workers or there are not adequate institutional training capabilities to train such workers, manpower programs must be developed in response to needs. If existing training organizations and institutions find that it is not cost-effective nor otherwise feasible to expand their training programs, it is evident that greater government participation in training will become an essential component of environmental pollution control programs.

The Committee's recommendations do not support the policy of training Ph.D.s or others in science, engineering, and other disciplines or operational techniques unless the trainees are needed and qualified for the environmental pollution control program. It is important, however, to evaluate the continuing need for technically competent operators of up-to-date, sophisticated pollution control systems as well as the need for skilled scientists and engineers at baccalaureate and advanced levels. Full recognition is given to the importance of avoiding an excess of trained manpower. Therefore, the Committee encourages EPA to establish a comprehensive manpower analysis and planning program which would serve to determine which selective training areas should be emphasized.

EPA would have the responsibility for the manpower planning and for developing recommendations to the Executive Branch and Congress that would provide for education and training only where detailed studies reveal a firm need for program support. Particular attention would be given to those technical specialities, at whatever educational level is needed, that require long lead-time for preparation and participation in the nation's environmental protection effort.

OFFICE OF WATER PROGRAM OPERATIONS

The Office of Water Program Operations under the EPA Assistant Administrator for Water and Hazardous Materials has the most cohesive and certainly the most ambitious Agency program for manpower planning and training. Its Manpower Planning and Training Branch of the Municipal Permits and Operations Division (MPOD) has an important program responsibility related to the Federal Water Pollution

Control Act, since billions of dollars will be channeled into the construction of municipal wastewater treatment facilities for some years to come. There is no time to lose in assuring the availability of well-trained manpower in adequate numbers for this program in accordance with the performance standards that have been developed under the statutes.

It is not possible here to cover in detail the current and proposed MPOD program for manpower planning and training activities. Major program items include: development of program guidance to help state agencies achieve self-sufficiency; organization and management assistance for training programs by giving financial and technical aid to state and local governments, making available instructor training facilities, and coordinating training support activities with other EPA offices; conduct of operator certification activities; and development and activation of manpower information and planning systems.

ACADEMIC TRAINING GRANTS

Although academic training grants have been an important part of the EPA manpower program, discontinuance was directed by FY 1977 of all EPA academic training grants and fellowships. Meanwhile, the FY 1977 Congressional appropriation included $4 million for academic training for air and water quality control programs. The intent of Congress was clearly expressed by the Senate Committee on Appropriations, which recognized that the additional funds for such grants were being made available despite the Administration's decision to phase out this part of the program.

One way to augment EPA's manpower activities might be through interagency agreements and a transfer of funds to the U.S. Office of Education and the Department of Labor to obtain training and education support. This approach seems to be most feasible for vocational training. There has been some degree of success in training applicators of pesticides and inspectors of automotive emissions through agreements with state agricultural extension services and vocational agriculture and technical education programs. Similar arrangements might be made with the Office of Education for handling academic training grants and fellowships administered by EPA. The enabling legislation appears to be adequate for this purpose and the Office of Education seems to favor the idea. EPA will have to decide soon on whether to follow this course.

Recent internal EPA analysis of manpower and training activities has resulted in recommendations for organizational realignment. Program efforts are being redirected primarily toward developing a comprehensive strategy that will most effectively foster the expansion of state and local resources for manpower training and development. The Committee has concluded that efforts to strengthen the manpower aspects of pollution control would be desirable. In categorizing manpower training and education as a support activity, Executive Branch policy has been to minimize federal participation in direct financial and technical assistance for advanced academic and professional manpower development and training.

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4 Employment of Pollution Control Manpower

The Committee examined a large quantity of data on current employment of pollution control manpower. These data were not always consistent. Some of the material was generated by statutory reporting requirements and much of it by serious concern on the part of EPA and others that adequate manpower supplies would not be available to meet sharply increased demands occasioned by environmental legislation.

The following sections cover those data that the Committee considered most relevant and accurate. More complete supporting presentation for these data is included in the individual panel reports, Appendixes B, C, D, and E.

SUMMARY OF CURRENT EMPLOYMENT ESTIMATES

While few of the individual sets of data evaluated by the Committee were directly comparable, there were numerous points at which relatively reliable data tended to confirm or reject more speculative attempts at employment estimation. As a result, it was possible for the Committee to reach general agreement on the overall dimensions of demand based on different studies of specific elements of the environmental manpower universe. A summary tabulation aggregating these separate estimates for 1974 is presented below in Table 4.1.

The development of an aggregate estimate is not an entirely satisfactory exercise. First, there is always the element of mixing data gathered under widely differing assumptions. Second, there is a temptation to

TABLE 4.1 Estimated Direct Employment in Pollution Control Activities,[1] Summary Data 1974

	Type of Employer						
Occupation	Federal	State	Local Government	Industry	Educational Institutions	Other	Total
Scientists	11,400	3,800	2,200	14,900	5,500	3,100	40,900
Engineers	8,300	5,200	5,700	64,700	1,300	8,800	94,000
Technicians	1,000	2,000	20,000	25,000	Na	Na	48,000
Skilled operators	4,000	Na	155,000	112,000	Na	Na	271,000
Unskilled, clerical, other	4,000	3,000	147,000	67,000	Na	3,000	224,000
Total	28,700	14,000	329,900	283,600	6,800	14,900	677,900

Na Indicates those areas for which data were unavailable.

[1] Excludes manpower in the fields of noise and radiation control and pesticide application.

SOURCE: See text.

oversimplify the real complexities of a large-scale manpower demand situation by failing to go beyond the numbers such an aggregation provides.

The data of the first two occupational categories in Table 4.1 are based on the 1974 National Survey of Scientists and Engineers as reported by the Panel on Methodology and National Data Aspects (Appendix B). The remaining data are based on a synthesis of the material in the panel reports on Federal Aspects (Appendix C), State and Local Aspects (Appendix D), and Industry and Private Sector Aspects (Appendix E). A brief presentation of the demand data in each of these sectors is made in this chapter.

The summary data reveal that by far the largest impact of the pollution control program will be on local governments and on the private sector of the economy. Federal involvement is substantial, however, and includes EPA, research and administrative work in other agencies such as the Departments of Defense and Agriculture, and the operation of a limited number of treatment facilities. State governments are involved primarily at the regulatory level, with little research or actual operational responsibility. The category of "Educational Institutions" is included in the table to indicate the size of the teaching and academic research base currently available. The "Other" category includes employees of non-profit organizations and the self-employed.

Local government employment is largely accounted for by its heavy direct involvement in the operation of wastewater collection and treatment facilities, water supply activities, and solid waste management. However, most of these workers are below the professional and technical level. The basic concern of the Committee is focused on the substantial number of skilled workers and professional personnel upon whose performance the effectiveness of the environmental program depends. It is also notable that professional employment is heavily concentrated in the private sector. This is due in part to the relative complexity of many industrial pollution problems and the heavy use by government and industry of private consultants and researchers.

The total direct employment in pollution control is substantial—nearly 700,000 people. Of these, 20 percent are scientists and engineers and nearly 50 percent are skilled operators or technicians.

FEDERAL GOVERNMENT EMPLOYMENT

Direct federal employment for pollution abatement and control falls into three main categories. First, in terms of dollars to be expended, is the Construction Grants Program authorized by the Water Pollution Control Act and presently funded at $18 billion. This program is intended to

TABLE 4.2 EPA End-of-Year Employment by Pollution Abatement Programs and Budget Categories, FY 1975 and FY 1977

Pollution Abatement Program	Number of Employees by Budget Category: Research and Development 1975	Research and Development 1977	Abatement and Control 1975	Abatement and Control 1977	Enforcement 1975	Enforcement 1977	Agency and Regional Management 1975	Agency and Regional Management 1977	Other 1975	Other 1977	1975 Total Number	1975 Total Percent	1977 Total Number	1977 Total Percent
Air	452	473	696	815	410	482	–	–	–	–	1,558	16.9	1,770	18.5
Water quality	586	548	1,677	1,816	892	764	–	–	–	–	3,155	34.3	3,128	32.8
Water supply	74	85	99	210	–	4	–	–	–	–	173	1.9	299	3.1
Solid wastes	21	22	162	161	–	–	–	–	–	–	183	2.0	183	1.9
Pesticides	151	157	611	639	157	156	–	–	–	–	919	10.0	952	10.0
Radiation	73	30	201	174	–	–	–	–	–	–	274	3.0	204	2.1
Noise	3	–	45	74	1	21	–	–	–	–	49	.5	95	1.0
Interdisciplinary	261	214	–	129	–	–	–	–	–	–	261	2.8	343	3.5
Toxic substances	–	7	44	45	–	–	–	–	–	–	44	.5	52	.5
Program management and support	218	142	197	167	143	177	–	–	–	–	558	6.1	486	5.1
Agency and regional management	–	–	–	–	–	–	1,827	1,798	–	–	1,827	19.9	1,798	18.8
Other	–	123	–	–	–	–	–	–	202	117	202	2.2	240	2.5
Total	1,839	1,801	3,732	4,230	1,603	1,604	1,827	1,798	202	117	9,203[a]	100.00	9,550	100.00[b]

[a] The total number of EPA employees is constantly changing. This accounts for the slight differences in total EPA employment shown in several tables of this report.

[b] Totals may not add to 100.00 due to rounding.

SOURCE: U.S. EPA (1974, 1976b).

provide 75 percent of the capital investment needed by local governments to construct or improve wastewater treatment facilities so as to conform to federal effluent standards.

Second, EPA is empowered to conduct and direct relevant research and development, provide technical assistance and support to other government agencies and industries, and enforce existing environmental regulations. EPA responsibilities include control programs in water pollution, water supply, air pollution, noise, solid wastes, radiation, and the regulation of pesticides. The Agency received FY 1977 appropriations of slightly over $718 million, not including supplemental funds or the Construction Grants Program.

Third, the federal establishment itself generates some pollution in operating its own facilities. Control of this pollution will require initial capital investments and continuing operation and maintenance expenditures to conform to federal standards. Also, other agencies besides EPA do research and have programs aimed at pollution control. These programs, together with control programs at federal installations, may equal or exceed the operational expenditures of EPA in any given year.

Spending in these categories determines federal demand for manpower for pollution abatement and control. In the case of grants to local governments for construction of wastewater facilities, the federal government has a minimal role in supervising and auditing the funds. To the greatest extent possible, direct authority over this spending is delegated to state regulatory agencies. The comparatively little federal employment generated by this program is located within EPA.

In addition to channeling funds to state and local governments, EPA has substantial research, regulatory, and enforcement programs. Full-time, white-collar employment at the Agency is about 10,000 and has been quite stable since 1972. The FY 1975 and 1977 distributions of full-time employees in EPA are presented in Table 4.2, but it should be noted that the current allocations of personnel within the Agency are subject to changes among programs as a result of new priorities and legislation. In addition to this base of about 10,000 permanent employees, EPA hires several thousand other workers in various temporary capacities and as consultants. Chapter 3 of this report presents in considerable detail the occupational and educational distribution of EPA personnel.

The federal government operates numerous pollution control facilities for its own residential, industrial, and recreational activities. For drinking water supply and wastewater treatment alone, EPA estimates 1974 federal employment at about 5000 (Kauffman 1975). Table 4.3 indicates the dimensions of this employment by broad functional category. No comparable statistics are available for air or solid waste management, but thousands of people are employed for these purposes.

TABLE 4.3 Federal Wastewater Treatment Plant and Water Supply Personnel, 1974

Agency	Management/ Supervision	Operation/ Maintenance	Laboratory	Distribution/ Collection Pumping	Total
Military services	455	2,970	104	168	3,697
Civilian agencies	271	889	49	65	1,274
Total	726	3,859	153	233	4,971

SOURCE: Adapted from Kauffman (1975).

In addition to its direct pollution control activities, the federal government is engaged in environmental research, monitoring, and administration in such agencies as the Departments of Defense, Transportation, and Agriculture, and the Tennessee Valley Authority. National Science Foundation (NSF) National Survey data indicate that nearly 20,000 federal scientists and engineers devoted a significant portion of their professional time to environmental concerns in 1974. As only about 4500 of this number are employed by EPA, it is clear that professional environmental activity is diffused throughout the federal establishment.

SUMMARY OF FEDERAL EMPLOYMENT

Based on the NSF survey data, the results of the Kauffman survey of federal treatment plant employment, and additional information developed by the Federal Panel in this study, the Committee concluded that direct federal employment for pollution control in 1974 totaled about 29,000.

STATE AND LOCAL REGULATORY EMPLOYMENT

A major thrust of recent national environmental legislation is to delegate most or all of the monitoring and enforcement responsibilities to the states. This has created a need for new or expanded state and local agencies with staffs competent in some technical and sophisticated areas of pollution control.

WATER QUALITY

Under the Water Pollution Control Act, the primary responsibility for monitoring and enforcing water quality standards lies with state agencies. These agencies also are responsible for planning and coordination for their jurisdictions. Because of these responsibilities, state agency manpower will consist chiefly of highly trained professionals and technicians.

Using information from state applications for program grants, EPA determined the occupational composition and number of state water pollution control agency personnel in 1971. This information is presented in Table 4.4 along with projections made in 1972 for 1976 staffing requirements. By extrapolating from these data, it can be inferred that EPA was projecting total state agency employment during 1974 at about 6400.

An EPA study in November 1975 estimated that the states will require about 7300 people to meet their statutory obligations under the Water Pollution Control Act (U.S. EPA 1975). Census data on 1974 employment by state agencies for water quality control showed about 6900 persons, or 400 less, than those requirements. However, the crucial thing about state agency personnel is not the number of people, but the high skill levels needed. Thus, the real issues regarding the state work force involve qualitative rather than quantitative factors and relate to the effectiveness rather than simply to the size of the agencies.

WATER SUPPLY

As is the case for wastewater management, the Safe Drinking Water Act gives the primary responsibility for monitoring and enforcement to appropriate state agencies. There can be little doubt that state water supply staffs will increase sharply as a result of this and other new legislation.

The EPA Water Supply Division estimated 1974 employment in state agencies concerned with drinking water at 400 to 500 professional and technical personnel (McDermott 1975). This was corroborated by independent estimates by the EPA Municipal Permits and Operations Division, whose manpower planning staff estimates 1975 state water

TABLE 4.4 EPA Data on State Water Pollution Control Agency Personnel, 1971 and Projected 1976

Occupational Category	Personnel 1971	Personnel Required 1976
Professionals	2,100	5,500
Technicians	300	700
Others	1,200	2,100
Total	3,600	8,300

SOURCE: U.S. Congress, House (1972).

supply agency employment, including nontechnical personnel, at about 1000.

SOLID WASTE MANAGEMENT

Local government regulatory activity for the collection and handling of solid waste is minimal at the present time. Recent Census data indicate that about 700 persons are employed by state governments for solid waste management (U.S. Bureau of the Census 1976). Of that number, probably only a small percent is employed in activities of a regulatory nature.

AIR POLLUTION CONTROL

There is more substantial employment by state and local governments for air pollution control monitoring, regulation, and enforcement. The need for personnel by state and local governments in this control sector is determined basically by two factors: the requirements imposed by the Clean Air Act, plus any new requirements that may be enacted by Congress; and the time schedules imposed by the Act, and as proposed by EPA in administering provisions of the Act, that have no specific deadlines.

Fairly comprehensive data are available on state and local employment for air pollution control. The results of a 1971 survey showing the occupational distribution of state and local agency personnel are given in Table 4.5. Most of these employees were in technical or professional positions.

TABLE 4.5 Employment in State and Local Air Pollution Control Agencies by Occupational Title, April 1971

Occupational Title	Number of Persons
Director	232
Supervisor	313
Engineer	804
Chemist	335
Meteorologist	353
Technician	483
Inspector	864
Aide	98
Administrative, clerical, other	1,180
Total filled positions	4,662

SOURCE: U.S. EPA (1971).

By 1974, employment in state and local air control agencies had grown to 5719 (U.S. Bureau of the Census 1976), or by about 1000. The occupational pattern probably is similar to that in 1971.

SUMMARY OF STATE AND LOCAL REGULATORY EMPLOYMENT

The Committee estimate of the number of persons actually employed by state and local regulatory agencies in 1974 is summarized below. This group, not much larger than EPA itself, has the detailed, day-to-day responsibility for managing a complex and large-scale pollution control program.

State and Local Environmental Regulatory Agency Employment in 1974

Water Quality	6,900
Drinking Water Supply	1,000
Solid Waste Management	700
Air Pollution Control	5,700
Total	14,300

LOCAL OPERATING EMPLOYMENT

The primary involvement of local governments with pollution control is to operate sizable and complex waste treatment and handling facilities. Rather than being the regulatory body, as the state frequently is, the city, county, or regional government is usually the subject of regulation. Because of this major operational responsibility, local governments account for a large percentage of all government environmental quality control employment. In 1974 this employment was concentrated in three areas: wastewater collection and treatment; drinking water supply and distribution; and solid waste management.

WASTEWATER COLLECTION AND TREATMENT

Residential wastewater treatment is almost exclusively a local government enterprise in the United States. In 1974, it was estimated that there were 21,011 public wastewater treatment plants serving a population of nearly 155 million, or 72 percent, of the U.S. population (NCWQ 1975).

Based on plant inventory data from EPA and data from the Water Pollution Control Federation (WPCF), estimates of wastewater treatment plant employment in 1974 (not including sewerage system workers), by training level, have been calculated (Burke 1976) as follows: college graduates (4,089); technical, non-college graduates (23,000); and workers with little or no training (13,703), for a total of 40,792.

In 1975, the Bureau of the Census released results of a sample survey of public employment. This survey indicated that 86,047 people were employed in October 1974 for all wastewater collection and treatment functions (U.S. Bureau of the Census 1975). As the treatment of domestic and pretreated industrial wastewater in the United States is almost exclusively within the domain of local governments, this figure should be inclusive.

In a 1969 survey, the Water Pollution Control Federation (WPCF) found that treatment plant employees accounted for 47.3 percent of total wastewater utility personnel. By this standard, about 40,700 of the jobs with such functions in local governments in 1974 would have been in the operation and maintenance of wastewater treatment facilities. The closeness of the WPCF (40,792) and Census (40,700) figures in this regard contributes to their credibility. Table 4.6 summarizes the Committee's estimates of 1974 wastewater employment based on the Census and WPCF data.

DRINKING WATER SUPPLY AND DISTRIBUTION

The treatment and distribution of water supplies to consumers involve somewhat similar technologies and management procedures as those needed to collect and treat used polluted water from consumers. While significant differences exist, the systems are parallel in many respects within a given community, and the treated wastewater of one locality often contributes to the water supply source of another locality.

Because of these similarities and interdependencies, the management

TABLE 4.6 Local Government Employment for Wastewater Collection and Treatment in 1974

Category	Estimated Employment
Total wastewater utility system employment	85,000
Total treatment plant employment	45,000
Professional	3,500
Operator/technician	28,000
Unskilled	13,500

SOURCE: Committee estimates based on U.S. Bureau of the Census (1975) and Burke (1976).

TABLE 4.7 Employees in Public and Private Water Supply Facilities in 1968

	All Employees	
Function	Number	Percent Distribution[1]
Production	34,437	17.2
Distribution	59,952	30.0
Consumer services	14,315	7.2
Financing	15,628	7.8
Administration	25,751	12.9
Other	30,627	15.3
Subtotal	180,710	90.5
Managers	19,007	9.5
Total employees	199,717	100.0

[1] Percentage may not add to 100 due to rounding.

SOURCE: Hudson and Rodriguez (1970) Water utility personnel statistics. Journal of the American Water Works Association 62(8):485–488.

and personnel of distribution and collection systems are sometimes shared or interrelated in a community. Even when this is not the case, the inherent similarities of the two systems might be expected to produce fairly common patterns of manpower use, at least in production stages. On the other hand, water distribution involves detailed metering and accounting tasks that are not directly associated with wastewater collection systems and one might expect to find larger support and clerical staffs in water supply activities.

Several surveys by the U.S. Public Health Service and the American Water Works Association produced some interesting data during the 1960s. As published in 1970 (Hudson and Rodriguez 1970), these data indicated that total water utility employment in 1968 was about 200,000 (see Table 4.7).

It should be emphasized that the data in this table represent a reasonable estimate based on a 1968 survey of the entire water supply industry, both public and private. A 1974 report estimated that about 25 percent of the nation's water supply systems might be in private hands.[1]

[1] Oklahoma Foundation for Research and Development Utilization, Inc. (1974) Development of Manpower Planning Criteria for Water Supply Systems. Prepared for the Office of Education, HEW. Oklahoma City, Okla.: Oklahoma Foundation for Research and Development Utilization, Inc. (Unpublished report.)

If employment also was in this proportion, there would have been about 150,000 people working for local governments in water supply facilities in 1968, including a sizable number of persons in managerial, financial, and administrative positions. Census data gathered for 1974 (U.S. Bureau of the Census 1975) show a lower level of overall employment than was reported by the earlier study. The 1974 Census data show that all employment (full-time and part-time) by local governments for water supply functions totaled 129,000. Full-time equivalent employment amounted to 118,000.

However, these sets of data are in close enough agreement that they can be examined to determine the rough occupation mix involved in the water supply effort. As shown in Table 4.7, there were almost 35,000 production workers, mostly operators, in 1968. In addition, some of the managers and distribution personnel who were reported required special skills associated with water treatment and supply. Altogether the group requiring special training in water treatment technology could be estimated at about 66,000, or one-third the total employment in the field. The remaining water utilities workers are in occupational categories that do not require such training. Application of the same ratio to the 1974 Census data produces a local government work force requiring special training of about 39,000.

Based on the data presented above, the Committee estimates that this distribution of the water supply labor force is a reasonable one:

Local Government Water Utility Employment Total	*135,000*
Treatment plant and specialized distribution personnel	*52,500*
Professional	4,500
Operator/technician	39,000
Unskilled	9,000

SOLID WASTE MANAGEMENT

Historically, solid waste management has been shared at the local level by private enterprise and municipal governments. Sometimes, private enterprise has acted under contract to local governments and often it has been a direct contractor to the producers of solid waste in industry, agriculture, and mining.

TABLE 4.8 Distribution of Solid Waste Management Personnel in Local Government, 1972

Job Categories	Number Employed	
Managerial		*2,723*
General	2,356	
Other	367	
Clerical		*2,296*
Supervisory		*6,286*
Collection/transportation	5,078	
Disposal/other	1,208	
Skilled Laborers		*36,243*
Maintenance	2,179	
Collection/transportation	27,193	
Disposal/other	6,871	
Unskilled Laborers		*54,344*
Collection/transportation	51,583	
Disposal/other	2,761	
Total		*101,892*

SOURCE: Applied Management Sciences, Inc. (1972) Solid Waste Management Manpower: Profile and Analysis. Prepared for the Office of Solid Waste Management Programs. Washington, D.C.: U.S. Environmental Protection Agency. (Unpublished report.)

The first thorough study of solid waste management personnel was done for EPA in 1972 by Applied Management Sciences.[2] The study included interviews of managerial and other employees of public and private solid waste organizations. Table 4.8 presents the basic personnel inventory of approximately 3000 municipal and county agencies doing collection and disposal of solid wastes in the United States at the time.

Substantial support for the survey results is provided by recently released Census data on solid waste management expenditures and employment in FY 1974 (U.S. Bureau of the Census 1976). The Census report reveals that total full-time equivalent employment by local governments in 1974 was 123,207. Expenditures for the fiscal year totaled $1.9 billion.

[2]Applied Management Sciences, Inc. (1972) Solid Waste Management Manpower: Profile and Analysis. Prepared for the Office of Solid Waste Management Programs. Washington, D.C.: U.S. Environmental Protection Agency. (Unpublished report.)

The 1974 Census data are somewhat larger than the findings in the 1972 study as a result of better sampling techniques and normal increases over time. Based on the assumption that the same occupational distribution found in the Applied Management Sciences study is valid, the 1974 local government base level employment in solid waste management is extrapolated as follows: managerial (3293); clerical (2776); supervisory (7601); skilled laborers (43,825); and unskilled laborers (65,712) for a total of 123,207.

INDUSTRY AND PRIVATE SECTOR EMPLOYMENT

Industry and private sector demand for manpower is based on a multifaceted involvement with pollution control. First, many private firms provide public services such as solid waste collection and the supply of drinking water. These firms have manpower requirements similar to their publicly-owned counterparts, as discussed briefly in the previous section. Also, private companies provide most of the research and development expertise needed by federal and state regulatory bodies in developing policies and hardware for pollution control. In addition, private research and development firms provide advisory services as consultants to industry to meet regulatory requirements.

Related to the research and development function, private industry also provides virtually all of the facilities and specialized hardware used for pollution control. With capital spending on such equipment stimulated by federal and state law, demand for workers in this area is likely to increase and then taper off as requirements are met.

Finally, many industries generate pollution as a by-product of the processes they use to transform raw materials into economically useful products. Most industries currently are engaged in moderate capital investment programs to clean up the air and water they use before returning it to the environment. While the methods used to control pollution from industrial sources usually are highly capital intensive, substantial employment will result for operation and maintenance of the new facilities.

Less is known about current employment in the private sector than in the governmental sector for several reasons. Unlike government, industry often assigns pollution control tasks on a rotating or part-time basis. This means that while specialized skills may be needed, they may be used for only a few hours a week. It is difficult to count employees involved with

TABLE 4.9 Scientists and Engineers Engaged in Pollution Control or Environmental Protection Activities in 1974, by Type of Employer

	Industry	Government	Other[1]	Total
Scientists	25,283	22,532	5,835	53,650
Engineers	54,643	19,198	7,059	80,900
Total	79,926	41,730	12,894	134,550

[1] Includes nonprofit and educational institutions and self-employed persons.

SOURCE: 1974 National Survey of Scientists and Engineers. (See Appendix B.)

pollution control on this basis. Moreover, few industries effectively account for the operation and maintenance of pollution control facilities in terms of manpower, while data on capital spending are relatively easy to obtain.

It is known from the 1974 NSF National Survey cited earlier that industry accounts for the largest segment of scientific and engineering employment for pollution control. Table 4.9 shows the industry employment in relation to government and other employers.

While these figures indicate higher employment in private industry than in government, it should be noted that a large proportion of the private scientific and engineering employment is in research, development, and consulting enterprises. These service industries usually do not employ large numbers of support personnel.

CONSULTANTS AND EQUIPMENT MANUFACTURERS FOR WATER POLLUTION CONTROL

The Water Pollution Control Act and earlier programs for treatment of wastewater have led to much specialized employment in industry; for example, large numbers of professionals are employed by consulting firms. Middlebrooks et al. (1972) estimated that 1972 employment by consulting firms was about 15,000 scientists and engineers and 12,000 technicians.

Another area of importance in the private sector is the specialized water pollution control equipment industry. Based on the results of a survey he conducted, Middlebrooks estimated 1974 employment in the water equipment industry at about 6000 scientists and engineers and 18,000 technicians (Middlebrooks 1974).

TABLE 4.10 Private Sector New Plant and Equipment Expenditures for Abatement of Air, Water, and Solid Waste Pollution, 1973-76

Category	1973	1974	1975	Planned 1976
		(in billions of dollars)		
Air	$3.176	$3.343	$3.790	$3.860
Water	1.762	1.876	2.362	3.042
Solid waste	–	.398	.396	.444
Total	$4.938	$5.617	$6.548	$7.346

SOURCE: Cremeans et al. (1975) and Segel and Rutledge (1976).

TABLE 4.11 Ratios of Employment of Full-time Equivalent Environmental Personnel in the U.S. Chemical Industry to Environmental Operation, Maintenance, and Research Expenditures

	Manpower Ratios per Million Dollars of Expenditures			
Control Program	1962	1967	1972	1975
Air pollution	50.0	31.8	23.6	14.8
Water pollution	38.8	30.2	24.0	14.3
Solid waste			27.5	20.1
Ratios for total environmental employment	42.9	30.9	24.4	15.1

SOURCE: Manufacturing Chemists Association (1975).

OPERATION AND MAINTENANCE OF INDUSTRIAL POLLUTION CONTROL FACILITIES

Substantial demand for workers exists in those industries that are now investing or have recently invested substantial sums in new pollution control equipment. The Bureau of Economic Analysis found that $6.5 billion was spent for new plants and equipment for pollution control in 1975 (Segel and Rutledge 1976). The distribution of that spending by control category is shown in Table 4.10.

A number of industries have examined their ratios of employment to operation, maintenance, and research costs for pollution control. A fairly typical set of figures is presented in Table 4.11.

A recent EPA study (U.S. EPA 1976a) suggested that operation and maintenance costs for industry during the early stages of developing environmental systems average about 40 percent of capital costs (see Tables 2.1 and 2.2). On that basis, and using the capital cost figures given in Table 4.10 for 1974, private industry employment for pollution abatement would appear to be as follows:

Air	19,790
Water	10,730
Solid Wastes	3,200
Total	33,720

This estimate is probably a conservative one, based as it is on reports to the Commerce Department of actual pollution control expenditures by industry in 1974. EPA expenditures estimates, such as those in Tables 2.1 and 2.2, usually are higher. Also, it should be stressed that the employment estimates are in terms of full-time equivalent positions. Several times as many persons could have some direct involvement in industrial pollution control, but on a part-time basis.

SOLID WASTES MANAGEMENT

Private sector involvement in solid waste management is extensive. Private contractors provide much of the waste collection and disposal services used by households and private firms, often as a contracting agent of a municipal or other local government. In addition, many industries have substantial solid waste problems that are inherent in the production process and that require the commitment of human and capital resources for their successful management. These problems are particularly common in agriculture, mining, and industrial operations.

The 1972 study[3] cited earlier of solid waste management personnel surveyed 11,000 private contractors doing collection and disposal of solid wastes to determine total employment and the occupational distribution of workers. Table 4.12 presents those data.

Assuming a similar rate of growth in employment as occurred in the public sector, the distribution of workers employed in 1974 by private firms for the collection and disposal of municipal solid wastes would have been as follows:

Managerial	20,632
Clerical	10,392
Supervisory	6,241
Skilled Laborers	76,667
Unskilled Laborers	36,654
Total Employment	150,586

[3]See note 2 above.

TABLE 4.12 Distribution of Solid Waste Management Personnel in the Private Sector, 1972

Job Categories	Number Employed	
Managerial		*17,113*
General	16,856	
Other	257	
Clerical		*8,619*
Supervisory		*5,177*
Collection/transportation	4,323	
Disposal/other	854	
Skilled Laborers		*63,591*
Maintenance	6,788	
Collection/transportation	52,873	
Disposal/other	3,930	
Unskilled Laborers		*30,402*
Collection/transportation	28,385	
Disposal/other	2,017	
Total		*124,902*

SOURCE: Applied Management Sciences, Inc. (1972) Solid Waste Management Manpower: Profile and Analysis. Prepared for the Office of Solid Waste Management Programs. Washington, D.C.: U.S. Environmental Protection Agency. (Unpublished report.)

Reliable data on private employment for industrially produced solid wastes are not generally available. The Commerce Department estimated capital spending for this purpose at about $400 million in 1974. However, a national study by the County Sanitation Districts of Los Angeles County estimates potential employment for solid waste management at a much higher rate than this spending level would suggest.[4] The study estimates that employment may be as high as 52,700 in industrial waste streams, 81,750 in agricultural waste streams, and 33,000 in mining waste streams.

[4]Los Angeles County Sanitation Districts (1976) Study on Manpower Requirements for Solid Waste Management - Municipal, Industrial, Agricultural, and Mining. Not Published.

DRINKING WATER SUPPLY AND DISTRIBUTION

As discussed earlier in of this chapter, private firms play a large role in the distribution of drinking water in the United States. Based on an assumption that about 25 percent of the distribution facilities of the country are in private hands,[5] and using the same proportionate occupational distribution as in government-owned systems, the Committee estimated this distribution of the water supply labor force in the private sector:

Private Water Utility Employment Total	*45,000*
Treatment plant and specialized distribution personnel	*17,500*
Professional	1,500
Operator/technician	13,000
Unskilled	3,000

SUMMARY OF PRIVATE SECTOR EMPLOYMENT

These data, although incomplete and inconclusive, indicate that there is substantial employment in the private sector directly related to pollution control. The following working estimates of 1974 full-time equivalent employment are derived from these studies and are the basis of the overall estimates for private sector pollution control employment in 1974: consulting (27,000); equipment manufacture (24,000); operation and maintenance of industrial equipment (34,000); solid waste management services (150,000); and water supply services (45,000), for a total of 280,000.

In addition to this direct employment, the pollution control program indirectly has generated many more private sector jobs through the purchase of nonspecialized goods and services. A study by the Bureau of Labor Statistics (DOL 1975) indicated that about as many jobs were created indirectly as directly by federal spending on pollution control. However, because many of these jobs do not involve highly specialized skills in pollution control itself, they were of less concern to the Committee.

[5]See note 1 above.

EMPLOYMENT IN RESEARCH AND DEVELOPMENT

One of the major sources of employment for environmental scientists and engineers in 1974 was in research and development programs. While concentrated in private industry, R&D employment also occurred in the federal government and to a lesser degree in state and local governments. This report examines R&D as a unit rather than in government and private industry sectors.

It should be emphasized that because of the conceptual and practical difficulties in estimating private sector employment for pollution control, the estimates for R&D may fall far from the actual mark. Estimates presented in the panel report on Industry and Private Sector Aspects (Appendix E) are generally higher than those given here, but in many cases the lines between direct and indirect employment or between part-time and full-time involvement have not been clearly drawn. On the other hand, the estimates given in this section include only direct full-time or full-time equivalent employment in pollution control.

FUNDS FOR RESEARCH AND DEVELOPMENT

Research into our physical environment and on ways to protect it has expanded significantly in recent years. For example, in the fiscal years 1969 to 1977, federal government support for research and development in this area has tripled (NSF 1976a). Industry, especially the automobile industry, also has made major and growing commitments to R&D programs for pollution control. Taken together, the government and private programs represent substantial outlays: National Science Foundation figures suggest a total of $1.6 billion in FY 1976—probably the single largest source of direct employment for scientific and technical personnel in the pollution control field.

Table 4.13 indicates the dimensions of federal spending on pollution control research and development. This table is based on a determination by the NSF of what constitutes environmental research and development. Total federal R&D spending, as shown in this table, has risen dramatically since FY 1969. It is projected to decrease slightly in FY 1977 in part owing to a reduction in funding of EPA research programs related to pollution effects and energy, as well as air and water quality.

Altogether EPA and its predecessor agencies have provided greater support than any other agency for environmental R&D, particularly in pollution control technology. However, FY 1977 EPA expenditures are expected to constitute only 24 percent of the total federal outlay for this purpose. Other agencies that will make significant environmental R&D

TABLE 4.13 Distribution of Federal Environmental R&D Expenditures by Program and Agency, Fiscal Year 1969-1977

	Fiscal Year			
	1969	1975	1976	1977
TOTAL ENVIRONMENT, (dollars in millions)	$315.2	$837.4	$974.6	$974.0
	Percent Distribution			
Environmental health and safety	37.9%	33.8%	40.1%	41.3%
Biomedical and environmental research (ERDA)	28.2	17.0	17.9	18.8
Pollution effects research (EPA)	–	4.9	9.8	9.1
National Institute for Occupational Safety and Health (CDC, HEW)	4.8	3.5	3.2	3.7
Health and safety research (Bur. of Mines, Interior)	.7	3.8	3.6	3.6
Environmental and fuel cycle research (U.S. NRC)	–	.3	1.5	1.6
Food safety research (FDA, HEW)	–	1.2	1.1	1.1
Other	4.2	3.1	3.0	3.4
Understanding, describing, and predicting the environment	36.4%	28.7%	27.1%	29.4%
Environmental satellite programs (NASA)	23.3	12.1	10.9	11.1
Environment-related programs (NSF)	3.4	5.9	6.2	8.0
Environmental programs (NOAA, Commerce)	7.3	6.2	5.4	5.7
Other R&D programs (NOAA)	.9	2.0	2.4	2.3
Other	1.5	2.5	2.2	2.3
Pollution control and environmental protection	25.8%	37.4%	32.8%	29.1%
Energy-related environment control programs (EPA)	–	9.6	10.7	6.0
Water quality control (EPA)	10.7	5.9	4.9	3.8
Environmental quality monitoring (NASA)	–	4.7	3.3	4.1
Air quality control (EPA)	10.2	5.7	3.9	3.1
Nuclear materials security and safeguards (ERDA)	.8	.7	1.4	2.6
Interdisciplinary studies (EPA)	–	2.3	1.8	2.3
Other	4.1	8.5	6.8	7.2

SOURCE: National Science Foundation (1976a).

expenditures include the National Aeronautics and Space Administration (NASA), the Energy Research and Development Administration (ERDA), the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF).

National Science Foundation estimates of industry commitments, some supported by federal funds, to environmental research from 1973 to

TABLE 4.14 Industrial R&D Expenditures for Pollution Abatement, 1973-1976

Type of Pollution Abatement	1973 Federal Funds	1973 Private Funds	1973 Total	1974 Federal Funds	1974 Private Funds	1974 Total	1975 Federal Funds	1975 Private Funds	1975 Total	1976 Estimate Total
					(dollars in millions)					
Air	$[a]	$[a]	$461	$[a]	$[a]	$488	$16	$466	$482	$492
Auto emissions							a	a	345	361
Other							a	a	137	131
Water	a	a	76	a	a	74	a	a	71	76
Solid waste	a	a	10	a	a	18	a	a	22	21
Other	21	35	56	29	37	66	23	53	76	74
Total	$35	$568	$603	$52	$594	$646	$44	$607	$651	$663

[a]Not separately available but included in total.

SOURCE: NSF (1976b) and unpublished NSF data.

1976 are shown in Table 4.14. This is a difficult topic to measure and collection of data is still in a developmental stage. The data show that industry spending has been relatively high and sustained, but it should be noted that the automobile industry alone accounted for about one-half of the more than $600 million spent by the private sector for pollution control in 1975. Spending levels for industrial air pollution control, water quality, and solid waste management appear to be relatively modest.

R&D EMPLOYMENT

Research and development, such as that funded by government and industry, employ large numbers of scientists and engineers. The NSF Survey of Scientists and Engineers, discussed earlier in this report, found that in 1974 35,000, or about 26 percent, of the 135,000 scientific and technical personnel engaged in pollution control worked primarily in either the management or execution of research and development. Table 4.15 shows that of those engaged in research and development some 60 percent were employed by private firms. The federal government was the next largest employer of scientists and engineers directly engaged in research and development and it led other sectors in the number of employees doing basic research. It should be noted that these data do not delineate employment by universities and colleges. Other data by type of employer show that a large proportion of the persons who are employed in basic research are on the staffs of academic institutions. Basic research, however, received the least attention in terms of manpower among all R&D functions. Management and administration of R&D was the single largest activity, followed by development. Clearly, an emphasis on developing practical hardware underlies this distribution.

The NSF Survey also reveals that of those devoting significant professional time to environmental protection or pollution control, about 12,000 had received some financial support from EPA in 1974. A substantial portion of this support is assumed to have been for R&D. Such an assumption also must recognize the appreciable amount of support provided by EPA for non-R&D activities, such as for state air and water implementation plans, air pollution monitoring, and the like. It is, therefore, pertinent to examine the group of scientists and engineers supported by EPA.

Table 4.16 indicates that the largest number of this group, 4800, was employed in private industry. In contrast, only about 1000 professionals in educational institutions reported EPA support in 1974. Nearly three-fourths of the entire supported group was made up of engineers, and almost all of those supported in private industry were engineers. Most

TABLE 4.15 Primary Work Activity by Type of Employer for Scientists and Engineers in Pollution Control, 1974

	Type of Employer					
Primary Work Activity	Private Company	Federal Government	State Government	Local Government	All Other	Total
R&D Total	21,754	6,072	3,248	1,069	3,003	35,146
Basic research	746	1,371	642	112	698	3,569
Applied research	3,068	1,773	1,364	341	552	7,098
Development	8,890	798	58	111	627	10,484
R&D management and administration	9,050	2,130	1,184	505	1,126	13,995
All other activities	58,171	14,308	9,816	7,217	9,892	99,404
Total	79,925	20,380	13,064	8,286	12,895	134,550

SOURCE: 1974 National Survey of Scientists and Engineers.

TABLE 4.16 EPA Supported or Sponsored Scientists and Engineers, by Field and Type of Employer, 1974

	Field of Science or Engineering							
Type of Employer	Computer Specialists	Engineers	Mathematicians	Life Scientists	Physical Scientists	Environmental Scientists	Social Scientists	Total
Educational institutions	0	281	18	407	228	54	18	1,006
Federal government	0	701	67	328	319	52	184	1,651
State government	13	775	0	163	136	28	0	1,115
Local government	35	1,330	0	50	222	58	17	1,712
Other government	16	71	0	0	0	0	0	87
Nonprofit	0	191	36	26	145	88	17	503
Industry or business	18	4,430	13	27	216	22	74	4,800
Self employed	0	791	0	0	0	12	17	820
No support	0	0	0	0	12	0	0	12
Total	82	8,570	134	1,001	1,278	314	327	11,706

SOURCE: 1974 National Survey of Scientists and Engineers.

TABLE 4.17 Agency of Federal Support by Type of Employer for Doctoral Scientists and Engineers in Pollution Control, 1975

Agency of Federal Support	Type of Employer: Private Companies	Educational Institutions	Federal Government	State Government	Local Government	Nonprofit	Other or Unknown	Total
Environmental Protection Agency	709	877	689	162	76	247	0	2,760
National Science Foundation	87	1,361	38	20	0	98	0	1,604
Interior Department	106	649	516	41	2	15	0	1,329
Agriculture Department	14	546	701	26	0	0	10	1,297
Defense Department	309	442	423	8	0	76	0	1,258
Health, Education, and Welfare	118	571	100	42	0	116	2	949
Energy Research and Development Administration	293	367	109	0	0	149	0	918
National Aeronautics and Space Administration	91	295	197	12	0	17	0	612
Other or unknown	385	650	531	82	30	115	27	1,820
Total receiving support[1]	1,439	3,723	2,792	318	108	524	39	8,943

[1] Columns do not add to totals because some individuals reported receiving support from more than one agency; however, the total counts each individual only once.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

R&D government employees receiving funding from EPA also were engineers, but support for R&D scientists and engineers in educational institutions tended to be concentrated in the life and physical sciences.

The 1975 National Research Council Survey of Doctoral Scientists and Engineers provides a further perspective as to the impact of federal R&D support on allocation of human resources for pollution control. Of the 16,000 respondents in this survey who devoted a significant proportion of their time to environmental protection or pollution control, 8900 (56 percent) received some financial support or sponsorship from at least one federal agency. Table 4.17 shows the pattern of federal support by agency and type of employer. From this it is seen that EPA provided about one-third of the total support for doctoral scientists and engineers, a somewhat larger proportion than its share of the federal environmental R&D budget. The EPA support is divided more or less evenly among scientists employed in private companies, educational institutions, and the federal government. The National Science Foundation, which supported the next largest number of doctoral scientists and engineers, concentrates its activities almost entirely within educational institutions.

Overall, most doctoral scientists doing environmental research with federal funds are employed by colleges and universities, followed by the federal government and private industry.

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5 Demand for Pollution Control Manpower, 1974–1985

This chapter presents the Committee's estimates of how the employment of environmental manpower is likely to change during the coming decade. The Committee was handicapped by absence of a reliable economic or programmatic scenario for pollution control activities through 1985. The difficulty of estimating future levels of economic activity is compounded by the heavy regulatory and financial support roles played by the federal government. With its ability to cause massive shifts in resources from one purpose to another in a short time, the federal government has a unique capability to accomplish goals of enhanced environmental quality. At the same time, this ability to quickly alter priorities and resource allocations for a wide variety of discretionary programs makes any long-range projection, no matter how sophisticated in design, purely speculative when much federal participation is involved. This is one reason the Committee decided not to present a unified set of projection results based on manpower modeling techniques. Additional problems with that approach are discussed in detail in Appendix B.

The Committee considers it more useful and enlightening to approach the separate sectors of environmental activity individually and to discuss the factors most likely to change manpower demand and how great those changes are likely to be. For example, demand for environmental manpower within the federal government may decline slightly during the decade if, as expected, the EPA operating budget remains essentially constant through 1985. State and local governments will assume a growing responsibility for monitoring and enforcing environmental regulations. State regulatory agencies are expected to grow by as much as half their 1974 size as they assume new responsibilities, although their overall size will remain small.

The largest increase in demand for manpower will be by local governments as they staff up to operate the new system of wastewater treatment plants that is supposed to be in operation by 1983. These plants will require mostly skilled experienced operators and blue-collar workers, plus some people with entry-level skills. Despite the surge in demand for skilled operators, the number of new positions open each year is unlikely to go beyond the capacities of local training institutions to meet if they have suitable planning and programs. Industry and educational institutions are unlikely to have an increased overall demand for environmental manpower, although there undoubtedly will be considerable shifting of specific activities among their existing personnel.

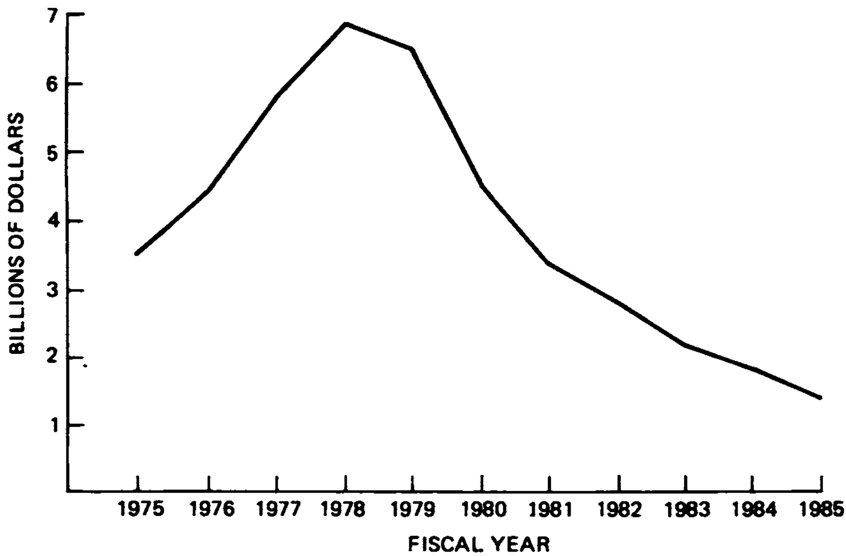
Even maintaining a large work force at static levels, however, requires the continual infusion of new entrants to replace losses due to attrition. Maintaining the 1974 total direct pollution control work force, estimated at about 700,000, would require 14,000 new entrants annually to replace a 2 percent annual loss from deaths and retirements. Losses due to people switching occupations are impossible to estimate, but they could be greater than losses from normal attrition.

In addition, there must be continued availability of updated training for persons already employed to assure that the more complicated systems of the future are operated efficiently. For example, specific demand studies cited in Appendix D identified about 15,000 scientists and engineers working on pollution control for local governments in 1974. However, the National Science Foundation's 1974 National Survey of Scientists and Engineers indicated that there were only 8000 scientists and engineers, employed by local governments, who meet the minimal degree requirements and other criteria defined by NSF for the sample survey. Thus, it is possible that substantial numbers of local government agency personnel may not have entirely appropriate educational backgrounds and will require additional training.

The following sections deal in more detail with expected demand in the federal, local regulatory, local operating, and private sectors through 1985.

PROJECTED FEDERAL GOVERNMENT DEMAND

Of the three leading categories of federal spending for pollution control, the largest is the Construction Grants Program, which essentially is a



SOURCE: Based on Table C.23 in Appendix C.

FIGURE 5.1 Estimated total federal expenditures on pollution abatement and control, FY 1975 through FY 1985.

pass-through of funds to other jurisdictions without large-scale involvement by federal personnel. The second category is for EPA operating costs. The third is the control of pollution generated by various federal operations, where costs are divided between capital and personnel requirements.

Figure 5.1 summarizes projected federal expenditures for pollution control in these categories during the next decade. The total federal outlays shown in this figure are expected to increase from approximately \$3.5 billion annually in 1975 to a high of almost \$7 billion in 1978, when the Construction Grants Program should be at its height. Then, federal spending for pollution control is expected to fall to about \$1.5 billion for annual "maintenance" by 1985.

Most of the variations in the total for federal spending are caused by the Construction Grants Program, which is a "one-shot" program with a definite beginning, middle, and end. While there is some debate as to the amount that will have to be invested in this program, the flow of federal dollars for this purpose is likely to stop completely, probably before 1985 if current federal policies in this area continue. In any case, the main employment impact will occur in the construction and environmental control equipment industries and for operation of wastewater treatment plants, and will have little, if any, effect on federal employment.

Although the Office of Management and Budget (OMB) projects a slight decrease in EPA funding from the 1976 level, it seems unlikely that any major shifts will occur soon in the Agency's composition, spending patterns, or number of personnel. As new priorities and concerns arise, EPA will have to shift resources away from old-line programs to newer ones. An example has been the shift of resources in the past year away from air and water pollution programs to water supply programs. Passage of a toxic substances law would cause a similar internal shift.

Other federal agency abatement and control expenditures are expected to rise unsteadily and then, after 1978, to decline until 1983 as the construction phase of work on federal installations gives way to normal operation and maintenance. Again, the main employment impact of the capital investment is on the construction and equipment industries, not on the federal establishment. However, increased federal employment of operational personnel is likely. EPA estimates that about 1200 more workers will be needed for water quality activities by 1977 (Kauffman 1975), with proportionately fewer persons required for air pollution control. Altogether, it seems reasonable to project an incremental demand for 3000 to 5000 new federal workers in pollution control operations, but these increases at the operational level may be cancelled by decreased attention to environmental research and development throughout the federal system.

The picture that emerges is one of environmental funding channeled through a federal establishment that will grow very little as a result. Little, if any, increase is anticipated in the regulatory or enforcement areas. In the absence of any major policy shifts, it is expected that EPA and other federal pollution control employment will remain at about its present size and funding level through the next decade.

PROJECTED STATE AND LOCAL REGULATORY DEMAND

The demand for manpower by state and local governments to plan, monitor, and enforce national and local pollution control programs is bound to increase over 1974 levels. However, the increases may not be large because of program and budgetary constraints. A matter of greater consequence than the numbers of people needed may be the quality of the regulatory labor force; this is especially acute at the local level because of generally lower pay scales than are found in the federal establishment.[1]

EPA has studied state agency manpower needs in some detail because these agencies, under pollution control legislation, have major regulatory responsibilities. Recently, EPA completed studies on state water supply agency needs and on state water pollution control agency needs (U.S. EPA 1975b, 1975c). The studies included a definition of the legally required functions of state agencies, the development of measures for their anticipated work load, and estimates of their personnel requirements. Table 5.1 summarizes the results. Although these data do not indicate that a large number of new environmental workers will be needed at the state level, it is likely that new employees will require highly specialized training because they will be responsible for complex regulatory tasks.

Similar data are not available to project regulatory employment for solid waste management. Although nearly nonexistent at this time, the uniform regulation of solid waste disposal is a likely development in the next 10 to 20 years. New technology for handling waste materials and resource recovery currently is being developed and could become economically viable within this decade, but there is no firm basis on which to project the growth of regulatory activity for solid wastes.

In the field of air pollution control, EPA has sponsored an ongoing program to assess future manpower requirements of state and local control agencies. To project personnel requirements under the 1970

[1]Median annual salaries for all scientists and engineers in 1974 by type of employer were reported by the National Science Foundation (1975) as follows:

Federal Government	$21,700
Universities and Colleges	19,400
Business and Industry	19,000
Local Governments	18,900
State Governments	16,400

For doctoral scientists and engineers median annual salaries in 1975 were higher but the federal government remained the highest paying type of employer, with state and local governments being the lowest. As determined by the National Research Council (1976) the median salaries were:

Federal Government	$26,231
Business and Industry	25,999
Educational Institutions	21,370
State and Local Governments	20,839

TABLE 5.1 EPA Estimates of Personnel Needs in State Water Supply and Water Pollution Control Agencies to Meet the Requirements of the Safe Drinking Water Act and the Water Pollution Control Act

	Professional	Technical	Other	Total
State Water Supply Agencies				
Full-time positions	1,666	619	663	2,948
Shared positions	633	4	215	852
Estimated work years[a]	1,983	621	771	3,374[b]
State Water Pollution Control Agencies				
Full-time positions	4,846	837	1,380	7,063
Shared positions	395	22	144	561
Estimated work years[a]	5,044	848	1,452	7,344[b]

[a]Shared positions counted as ½.
[b]Totals affected by rounding.

SOURCE: Adapted from U.S. EPA (1975b) and U.S. EPA (1975c). For more detail see Tables D.12 and D.17 in Appendix D.

legislation, the EPA Office of Air Quality Planning and Standards (OAQPS) continued efforts begun earlier to develop a manpower planning model. The most recent model uses two matrices to estimate needs—the number of air pollution sources and the number of monitors (Lynn and Deane 1975). It is currently undergoing some modifications and improvement (Sherman et al. 1975) and is being extended to relate occupational categories to the basic parameters of the model.

The Committee's conclusion, based on the best available data, is that there will be a need for about 8000 full-time equivalent positions for air pollution control in state and local agencies by 1980. Adjusted projections based on OAQPS interpolation of the model data are shown in Table 5.2.

The leveling of demand from 1980 to 1985 assumes that there will be no changes in future federal legislation that add significant new programs. Earlier programs also may be phased out in those years. Hence, the estimates for 1980 to 1985 represent, as best as can be determined at this time, a plateau that probably will be met by about 1982, rather than in 1980, because of the lag between actual employment and authorized positions.

State and local regulatory agencies will stimulate only a modest demand for specialized environmental manpower; however, there may be some positions that agencies will have difficulty filling, largely because of inadequate salary offers.

TABLE 5.2 Personnel Needs for State and Local Air Pollution Control Agencies

Category	1974	1980	1985[a]
Professional	2,650	3,925	3,925
Technical	2,600	3,860	3,860
Other	150	215	215
Total	5,400	8,000	8,000

[a]Estimated to be the same as 1980.

SOURCE: Unpublished EPA estimates. For additional detail see Table D.28 in Appendix D.

PROJECTED LOCAL GOVERNMENT DEMAND FOR OPERATING MANPOWER

The demand for environmental manpower by local governments is entirely dependent upon the availability of financial resources for capital investment and for the operation and maintenance of pollution control facilities. As there are more than 62,000 local government units other than school districts in the United States (U.S. Bureau of the Census 1974), with each unit exercising considerable discretion about the nature and timing of its environmental spending, it is risky to project local government environmental manpower needs for the nation through 1985. Nevertheless, the Committee thinks it is important to prepare and to continually update projections as a tool for formulating an effective manpower development policy.

WASTEWATER TREATMENT

National objectives for water pollution control have been set by the Water Pollution Control Act. That Act provides for federal financing of 75 percent of the capital cost of new or improved wastewater treatment facilities needed by local governments to comply with the technical aspects of the law. It is this funding, set at a preliminary $18 billion, that is the basis for projections of sharply increased local demand for water quality manpower.

Federal funds are allocated to local governments for wastewater facilities according to determinations by EPA of each state's needs for such facilities (U.S. EPA 1975a). The summary results of the latest survey to determine needs are presented in Table 5.3. The broad spectrum of problems associated with water pollution control is estimated to require

TABLE 5.3 Summary of Cost Estimates for Local Wastewater Facilities

		1974 Survey				
		(A)	(B)	(C)	(D)	
		State	State	EPA	1973	Change
Category		Preliminary Data	Corrected Data	Adjusted Data	Survey Data	(D to C)
				(millions of 1973 dollars)		
I	Secondary treatment	$ 11,679	$ 12,628	$ 12,629	$16,639	$ −4,010
II	More stringent treatment required by water quality	21,311	20,330	15,776	5,650	+10,126
IIIA	Correction of sewer infiltration/inflow	5,355	5,348	5,287	691	+4,596
IIIB	Major sewer rehabilitation	7,070	7,330	7,287	–	+7,287
IVA	Collector sewers	23,090	24,583	17,458	10,825	+6,633
IVB	Interceptor sewers	19,932	19,758	17,923	13,621	+4,302
V	Correction of combined sewer overflows	26,070	31,192	31,076	12,697	+18,379
VI	Treatment and/or control of stormwaters	235,006	235,006	235,006	–	+235,006
	Totals	$349,513	$356,175	$342,442	$60,123	$+282,319
	Totals for categories I, II, and IVB combined:	$ 52,922	$ 52,716	$ 46,328	$35,910	$ +10,418

SOURCE: U.S. EPA (1975b).

some $350 billion, the largest segment of it for stormwater control. But the first priority, and the only categories expected to receive substantial funding through 1985, involve advanced wastewater treatment facilities and interceptor sewers (categories I, II, and IVB). This aspect of the program alone may cost $46 billion (1973 dollars).

At present, Congress has authorized spending up to about one-half of the federal share of the capital requirement for wastewater facilities. The rate of actual cash expenditures has been slow. When this capital program does develop, it will have strong impacts on the local government labor force. The immediate impact will be on planning and construction manpower, mostly in the private sector, and eventually there will be substantial and sustained impacts on local operational manpower as new facilities begin to function.

It is reported by the Census Bureau that 1974 operating expenditures by local governments for wastewater treatment came to about $1.5 billion (U.S. Bureau of the Census 1976). Such expenditures are expected to rise rapidly by 1985. The Council on Environmental Quality (1975) estimated 1974 state and local government operation and maintenance costs for water pollution control at nearly $1.6 billion. In 1975 CEQ projected state and local 1983 operation and maintenance costs at double their 1974 level, or $3.2 billion annually. By 1976, however, CEQ had raised substantially its estimates for state and local government operation and maintenance costs to $6.2 billion in 1984 for the control of water pollution alone (CEQ 1976).

Clearly, these expected increases in expenditures will have a major effect on local employment needs. Employment is not likely to increase proportionately and double or triple with the increase in expenditures because of economies of scale and the increased productivity associated with new equipment, but it is hard to conceive of such expanded responsibilities being carried out without at least a 50 percent increase in manpower.

DRINKING WATER SUPPLY

The Safe Drinking Water Act of 1974 requires EPA to promulgate drinking water regulations for all water supply systems serving 25 persons or more. The regulations regarding contaminants will be administered largely by the states, following the pattern established for wastewater pollution control. The process of developing regulations still is in its early stages and the potential hazards of contamination are too little understood to estimate the nature or size of the future water supply program.

As yet there are no substantial commitments of federal funds for improved water supply technologies. Industry, except suppliers to public systems, is not affected by the Act in any substantial way. For these reasons, the immediate impacts of the Safe Drinking Water Act on operational manpower will be minimal.

Because of increased awareness and concern for the quality of our water supplies, the manpower engaged in public and private water works probably will increase steadily over the next decade. While no direct causal connection is implied, it is unlikely that employment in this field will grow faster than the population as a whole. This would suggest that the growth of overall water supply employment will probably be less than 10 percent between 1974 and 1985.

SOLID WASTES MANAGEMENT

Historically, solid wastes management has been shared by private enterprise and municipal governments at the local level. Sometimes private enterprise has acted under contract to local governments, and often it has been a contractor to the producers of solid wastes in industry, agriculture, and mining.

Potentially, solid wastes management may be one of the most significant areas requiring personnel training. About 4.5 billion tons of municipal, agricultural, industrial, and mining wastes are produced annually in the United States.[2] The trend toward an annual increase in solid wastes appears to be leveling off, partly because of recycling and resource recovery efforts which reduce the amount of solid wastes that require disposal. Recycling, however, may require more manpower than disposal by conventional means. Also, the actual production of solid wastes probably is controlled more by the level of activity of the national economy than by any other single factor.

Continuing environmental programs for air, water, and land use control are expected to add significantly to the burden of solid wastes management. This already is evident with enactment of the Water Pollution Control Act and the Ocean Dumping Act, which preclude disposal of wastewater treatment residuals into the water environment. Implementation of the Clean Air Act and the Safe Drinking Water Act also will produce a similar problem of residuals for which there is no

[2]Los Angeles County Sanitation Districts (1976) Study on Manpower Requirements for Solid Waste Management Municipal, Industrial, Agricultural and Mining. March. Not Published.

apparent means of disposal other than on land. Land-use control programs, stimulated by concern over contamination of both land and water, undoubtedly will place severe restrictions on future use of land for solid wastes disposal. Essentially, this eliminates options that have been available in solid wastes management, and it leaves the future disposal of toxic and hazardous wastes—including the increasing agricultural wastes—subject to conjecture.

Solid wastes management legislation has been minimal except for a token effort for manpower training and demonstration grants. This avoidance seems to be based on the concept that solid wastes are properly the concern of local and state governments. However, it should be noted that, by increasing federal authority over air, water, and land use, Congress in effect has dictated to some degree what may not be done with solid wastes. Meanwhile, legislation has been enacted by several states as an acknowledgement of the solid wastes management problem and to stimulate comprehensive planning at the local level. California, for example, has enacted legislation requiring each county to prepare a comprehensive plan which must be approved by the State Solid Waste Management Board before its implementation.[3] The law also restricts implementation of local facilities until the comprehensive plan has been prepared and approved on a countywide basis.

During the past decade, solid wastes management has made a successful transition from open and burning dumps to the modern sanitary landfill. Although this method has proved eminently more acceptable than earlier means of disposal, the use of sanitary landfills now is being questioned on the basis that landfills are only burial grounds and should be replaced by recycling and other resource recovery. An exception is the development of energy recovery from methane produced by the decomposition of organic matter under anaerobic conditions in deep sanitary landfills (Dair and Schwegler 1974). In some areas, the availability of acceptable sites already has severely restricted the use of landfills for future consideration and has given rise to recycling programs and resource recovery as a replacement.

However, although new technologies are emerging to deal with solid wastes management problems, the quantities of wastes requiring disposal in landfills will be only fractionally reduced in the near future. Although national data are not available and will vary from locality to locality when available, it seems reasonable to assume that not more than a 25

[3]California (1974) California Government Code 66700 et seq. (Nejedly-Z'berg-Dills Solid Waste Management and Resource Recovery Act of 1972).

percent reduction in solid waste volume will occur over the next 10 years as a result of the development and implementation of new technology.

The number of people needed to collect municipal solid wastes is not expected to change appreciably, although there may be a slight reduction as collection systems become more automated and the one-man collection vehicle is commonly used. Future collection systems probably will be designed around salvaging and recycling of usable materials at the source and keeping them separated until they are delivered to a processing station. As the processing of collected solid wastes becomes more automated, personnel will be required who are capable of conceiving, designing, constructing, and managing automated systems based on developing technology. The personnel needed to operate final disposal facilities—largely, sanitary landfills—may decrease slightly as a result of the reduction in materials brought to the site, but specifically trained manpower will be needed to select, design, and manage these ultimate disposal sites.

The local government demand for municipal solid wastes manpower in 1985 probably will differ little from the 123,000 indicated for 1974 in Chapter 4. As shown in Chapter 4, about 151,000 persons also were employed by the private sector in 1974 for solid waste management, for a total of some 274,000 workers. It is likely that there will be more managerial personnel, plus a significant addition of scientific and technical personnel, as experimentation with advanced resource recovery and wastes handling systems increases.

PROJECTED INDUSTRY DEMAND

Despite the increase in pollution control activity by production industries, much of the direct environmental employment in the private sector in 1974 was related to the design, fabrication, and installation of new pollution control equipment. Moreover, there will be a shift to new and inherently less polluting production methods which also will tend to keep industrial needs for pollution control manpower from growing by any significant amount. The internalization of the clean-up costs mandated by legislation often provides the economic incentive for industry to shift to a cleaner but previously more expensive process and reduces the need for environmental manpower *per se*.

On the other hand, new technology, new products, and new regulations will assure that the overall private involvement with pollution control continues after the current phase of regulation and response is completed. Also, the "public utility" aspect of industry's involvement in such fields as solid wastes management and water supply will continue to grow moderately and offer employment to less skilled workers. In 1985 the net result of these shifts is likely to be basically similar to the level of employment in 1974, although the functional and occupational mix may change. Further discussion of this aspect is to be found in Appendix E.

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6 The Supply of Pollution Control Manpower

Thus far in the report the Committee has focused on current employment of pollution control manpower and how the manpower demand is likely to change in the future. Even though the projections do not show a large net increase in the demand for environmental personnel through 1985, there are many serious and unresolved issues in this area. The absence of a dramatic surge in manpower needs should not be allowed to obscure facets of human resource policy that will profoundly affect the nation's environmental programs. This chapter examines the channels through which manpower demands are met and the adequacy of future flows of competent personnel for pollution control.

THE DIMENSIONS OF MANPOWER SUPPLY

Forecasting the flow of qualified workers into such a new and complex field as environmental control is difficult. Conceptual models of the labor market usually involve static data; they subtract likely separations from the current labor force in terms of past experience and then add increments from standard education and training sources, related occupations, and immigration. These conceptual models are imperfect at best; in new fields such as environmental control, where there are various unknowns in terms of future policies and new approaches to control problems, the limitations of a static conceptual model can be enormous. For these reasons, it has not been possible for the Committee to estimate all possible increments to the environmental work force and the

Committee has focused its attention on expected additions from regular academic and vocational training sources.

But even in making estimates of manpower supply from these sources, there are many uncertainties inherent in the estimates. The actual occupational destination of new entrants, as well as that of people in the existing labor force, depends largely on the relative remuneration offered by industry and government for their services. In the long run, the national pollution control program will have full access to a high quality labor force only if wages for environmental activities are maintained at a level equal to or exceeding those for general manufacturing, service activities, or other national programs.

OCCUPATIONS DIRECTLY INVOLVED IN POLLUTION CONTROL

A 1974 National Science Foundation (NSF) Survey of Scientists and Engineers provides an insight into the total skill mix of environmental personnel. The results of the survey are shown in Table B.2, Attachment B, of the Appendix on Methodology and National Data. Some 135,000 persons from various academic disciplines in science and engineering reported working in environmental protection or pollution control. The preparation and orientation of this group of workers is perhaps the most important in terms of the technical quality of the national environmental effort.

The occupation with the largest number of persons was engineering. About 60 percent of the professionals were working as civil, mechanical, environmental and sanitary, chemical, electrical, and industrial engineers and in other engineering categories. Others were working as chemists, agricultural and biological scientists, earth and other physical scientists, and social scientists. Also, a large number of scientists and engineers were employed as managers and administrators.

SUPPLY-DEMAND BALANCE

Requirements for pollution control manpower have been met primarily through the employment of people from other fields and from a variety of educational and training backgrounds. This has been the case not only for persons in jobs with modest skill demands but also up through the highest professional positions demanding scientific and technical skills. There is every reason to believe that, for the bulk of future requirements, this situation will continue.

The supply of highly trained manpower at any time in the field of pollution control is, of course, related to the supply of such people in the economy as a whole and is affected by specific demands from competing national programs such as energy, defense, and health. The NSF 1974 survey found that, of the nearly 1.75 million persons now employed as scientists and engineers, about 12 percent are working in pollution control; of those with doctorates, the proportion is about 6 percent.[1]

Projections by NSF, the National Center for Education Statistics, and others indicate that for the next decade an average of 400,000 degrees in science and engineering will be awarded annually, a potentially sizable addition to the pool of professionals now at work in science and engineering. However, the number of newly-trained scientists and engineers at any time has always been considerably larger than the number actually drawn into those specialties in the labor force. Many graduates with a bachelor's degree enter nonscience/engineering jobs such as teaching; others continue into graduate study or transfer to another field. In any event, it appears that the education system can produce, without special stimulation, enough science and engineering graduates overall to meet the nation's requirements, including those in pollution control.

The primary manpower problems facing pollution control planners are: how to plan and provide for the unique requirements for selected pollution control jobs; how to upgrade the quality of training for those who require it; and how to provide training to upgrade or reorient skills of people who are already at work in pollution control. Such training includes direct and specific instruction on pollution control operations and on pollution control management.

While the total number of scientists and engineers may be more than adequate to meet pollution control needs, the numbers of persons available with certain specialties may be more significant. The NSF survey shows the specialties that are now employed in this field. When the survey data are compared to data on the numbers of persons in specific scientific and engineering fields in the U.S. labor force, the disproportionate employment of some groups of specialists becomes apparent. For example, while 12 percent of all U.S. scientists and engineers are working in environmental control, the proportion of civil engineers in this field is 24 percent; chemical engineers, 28 percent; chemists, 19 percent; biological scientists, 22 percent; and environmental or sanitary engineers, 88 percent.

One measure of the impact of pollution control activities on doctorate

[1]The 1974 National Survey of Scientists and Engineers and the 1975 Survey of Doctoral Scientists and Engineers. Greater detail is provided in Appendix B.

TABLE 6.1 Doctoral-Level Scientists and Engineers Working in Pollution Control, as a Percentage of All Scientists and Engineers with Doctorates

	Academic Field	Employment Field
Total	6	6
Physics	4	2
Chemistry	11	10
Earth sciences[1]	15	26
Engineering	8	8
Life sciences	8	7
Social sciences[2]	2	2
Other[3]	1	2

[1] Includes environmental and marine sciences.
[2] Includes psychology.
[3] Includes mathematics, other specialties, and no report.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

level scientists and engineers is indicated by the proportion of all doctorates in such employment. Whereas the environmental field employs an average of only about 6 percent of all scientists and engineers who have doctorates (16,200 out of 263,000), according to the 1975 Doctorate Survey, the proportion varies both by field of study and by area of employment in pollution control, as shown in Table 6.1.

These data indicate that the earth sciences may be particularly affected by changes in pollution control programs. This may also be true of chemistry, engineering, and the life sciences, where the proportion of persons with doctorates is relatively high. Increased needs for such workers in pollution control might give rise to some imbalances between the supply and demand in these academic fields.

This potential problem also is illustrated by the 1975 study of the National Science Foundation, "Projections of Science and Engineering Doctorate Supply and Utilization 1980 and 1985." The study indicates increasing imbalances between supply and use of science and engineering doctorates. The NSF projections of changes in doctorate use show considerable variations, with the most drastic shift from academic employment evident in the physical sciences and engineering, while an increase in academic use is anticipated for the life sciences. The projected imbalances in terms of nonscience/engineering use are smallest for the life sciences and greatest in the social sciences. A relatively large imbalance also is indicated for engineering, but this may be diluted because of strong requirements for less-than-doctorate level engineers.

MANPOWER QUALIFICATIONS

Thus, the magnitude of supply is only part of the environmental manpower problem. Of major concern are the quality and efficiency and the long-run cost effectiveness of manpower employed in the environmental program. There is no evidence one way or the other that positions in pollution control programs are or will be filled by people who are fully qualified and prepared for their responsibilities. But it is clear that the needs for technical expertise are substantial if the nation is to develop and maintain a viable research and development program, have competent facility design engineers, and build an industry capable of producing the hardware required for pollution control.

Unfortunately, the belief is widespread that if the level of expenditures and the timing can be coordinated properly, any level of technology can be provided. It takes years to develop the specialty designer, to translate science into workable technology, and to develop a manufacturing capability that has the expertise to maintain a viable product line.

EDUCATION AND TRAINING

There is no simple solution through federal or other national action to possible problems of shortages in specialized occupations, general shortages in some geographic areas, or needs to improve the quality of the environmental work force. Except for some research and regulatory personnel, most environmental employment is in local facilities and subject to local labor market conditions. Therefore, most solutions to the problems of quality and isolated shortages of manpower should come through local management and educational institutions, although the federal government can encourage and help to develop local initiatives.

Educational facilities are close to the location of most environmental employment and offer diverse kinds of training to respond to employment needs. Local leaders in pollution control should take advantage of every opportunity for training manpower that their local circumstances offer. EPA should play a role in assisting local institutions in environmental educational programs as much as possible.

COOPERATIVE ARRANGEMENTS

Cooperative education offers many benefits in training pollution control workers. It is a training method in which students work part-time during the period that they are receiving formal occupational education in school. Their employment gives them an opportunity to learn on the job;

to deal with up-to-date industry methods and with real rather than theoretical work problems; to obtain some pay while learning, which enables many students who could not otherwise do so to continue their education; and, often, to get full-time employment at the cooperative training work site when they finish school. The cooperative effort also opens up an avenue for continuing communication between the schools and organizations involved in pollution control.

The cooperation between educational institutions and pollution control organizations should extend beyond cooperative education arrangements for students. In the case of higher educational institutions, programs for the exchange of university teachers with scientific personnel in the control agency or industry working on control problems should be set up. Practical knowledge and experience with the field problems in pollution control are valuable and can be obtained through faculty leaves of absence to the pollution control industry and government agencies. At the university level, the competence of faculty teaching in environmental control areas should be judged on the basis of this practical experience as well as on such criteria as academic degrees and research publications. Similarly, agency and industry personnel could both benefit and contribute by spending a semester or so teaching.

PERFORMANCE-ORIENTED INSTRUCTION

Performance-oriented education is recognized as an effective way to structure teaching. It has a great potential and should be encouraged in the environmental pollution control area, particularly for operator training. Self-paced instruction and teaching machines, using the latest electronic teaching aids, should be evaluated and used when feasible.

LICENSING AND CERTIFICATION

Licensing of environmental pollution control workers takes several forms. For water and wastewater treatment plant personnel, each state has a mandatory or voluntary state certification board which sets the standards for education, experience, and examination for all levels of personnel. Licensing is valuable in assuring minimum qualifications. However, licensing examinations should stress the skills and practical training necessary to carry out the operational assignment as well as theory.

TABLE 6.2 Examples of EPA-Sponsored Curriculum Development Projects

Subject Area	Producer	Products
Air pollution control	EPA/Research Triangle Park, N.C.	Two-year technician curriculum; instructional materials
Wastewater treatment plant operations	Charles County Community College, LaPlata, Md. Greenville, Tech., Greenville, S.C. Linn-Benton Community College, Albany, Oreg. Clemson University, Clemson, S.C.	Two-year technician curriculum; sixteen instructor's guides; operating procedures
Laboratory skills and procedures (wastewater)	Charles County Community College, LaPlata, Md. in cooperation with the EPA National Training Center, Cincinnati, Ohio	Instructor and student guides
Monitoring and surveillance (wastewater effluent)	Ulster County Community College, Stone Ridge, N.Y.	Two-year technician curricula
Wastewater technology	University of Maryland, College Park, Md. and Clemson University, Clemson, S.C.	Four-year bachelor of wastewater engineering technology curriculum
Wastewater treatment plant management	Michigan State University, Lansing, Mich.	Correspondence course materials
Operator training, wastewater (under development)	Charles County, other colleges and state agencies	Series of courses at 4 levels as identified in ABC certification classifications

PROFESSIONAL SOCIETIES

Professional and technical societies involved in pollution control activities are a valuable resource and should be encouraged to use their breadth of experience by helping to develop practical teaching manuals and other materials and methods for pollution control training, especially on a local basis. EPA should take the lead in formulating programs which will help to develop teaching materials, when needed, and should encourage the use of all available assistance.

CAREER LADDERS

Methods to provide an opportunity for technical advancement and career mobility for workers who have pursued a program of terminal type training should be examined. While the Committee has no simple solution to this problem, it feels that universities should consider carefully the experience and training of pollution control technicians and operators who qualify for continuing their studies toward scientific or other professional careers.

EDUCATIONAL TECHNOLOGY

A 1972 report (Carnegie 1972) pointed out that developments in electronics are bringing about a revolution in education and that a large part of training will make use of a variety of such media as radio, television, tape recorders, and computers. In addition, instructional technologists have been applying earlier research in behavioral psychology to the design of instructional systems. EPA has supported projects in these areas and it now may be time to coordinate some of these efforts to improve the training process.

CURRICULUM DEVELOPMENT

EPA has been active in the development of curricula for use in pollution control education and training programs. Table 6.2 summarizes some of these projects and indicates the scope of EPA's activities. Other curriculum materials have been prepared for use in air pollution control training and for the pesticides certification programs. The Committee believes that curriculum development is an appropriate activity for EPA and that the Agency should expand its development of prototype training materials. Economies of scale in these activities can be realized at the

TABLE 6.3 EPA Obligations to Universities and Colleges, FY 1974, by Size of Obligation and Number of Institutions Involved

	Size of EPA Obligation (dollars in thousands)					
	$1,000 or more	$500–999	$250–499	$100–249	$99 or less	Totals
Number of institutions	3	13	18	50	123	207
Total value of obligations	$4,073	$8,040	$6,553	$7,844	$4,409	$30,919

SOURCE: National Science Foundation (1976).

federal level. However, care should be taken to account for regional differences in environmental conditions in developing curricula.

RESEARCH AND DEVELOPMENT TRAINING

The concentration of funding by both EPA and industry of applied research and development in private firms may or may not result from a conscious manpower policy. However, money spent on research and development can serve two purposes: to add to the base of knowledge and develop innovations; and, especially when conducted in educational institutions, to provide the means for high-level training of future scientists and engineers. Over the long run the training function of research can have a greater impact than the outcome of a particular experiment or study.

The design of any publicly-supported research program carried out in an academic setting should explicitly include provisions for the ongoing training of new workers by involving students or young workers in the investigative research process. EPA has no satisfactory policy for using its research program as a means of stimulating the development of human resources in the technical aspects of pollution control. It is a serious omission by EPA and one that the Agency should remedy as soon as possible.

The distribution of EPA funds to educational institutions in FY 1974 is shown in Table 6.3. More than 200 schools received funding from EPA in FY 1974. Sixteen schools received over $500,000 each and accounted for $12 million of the $30 million obligated by EPA that year; 123 schools each received less than $100,000, accounting for a total of $4 million.

A possible strategic approach for EPA would be to increase the share of research that is contracted to colleges and universities. At the same time the Agency should seriously consider allocating its R&D financial support so as to create or maintain high-quality centers of research and learning where critical skills can be developed and passed on. Such centers should be dispersed geographically, but not to the point that "critical masses" needed for study and instruction are lost.

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7 Quality of Manpower

Quality is a widely used word that conveys different meanings, depending on the user and the circumstances. Frequently it means essential nature or kind. Those meanings would apply in connection with either manpower or facilities but usage of the word here is intended to convey the degree of excellence, that is, the ability to perform. As related to manpower, the performance valuation is less in terms of intellectual capacity than it is related to training characteristics or educational background and to proper placement in a position requiring the type of training a job demands. The capability of operating personnel is a major factor in determining the performance and efficiency of pollution control facilities.

The quest for a cleaner environment will cost billions of dollars. But no matter how large the capital investment for pollution control, environmental quality cannot be achieved without an able manpower component. People with a wide variety of knowledge and skills are essential if we are to have the technological expertise required to develop control methods capable of dealing with pollution problems and if we are to operate control programs, plants, and equipment efficiently.

MANPOWER QUALITY AND TREATMENT PLANT EFFICIENCY

Operators of treatment plants, either for water supply or wastewater, are good examples of the need for manpower quality. Both great responsibilities and great demands are made upon their ability to perform necessary duties with versatility and competence. There are times when they face the problems of a chemist, mechanic, biologist, and electrician. They must be able to apply principles of physics, mathematics, bookkeeping, bacteriology, and hydraulics in their daily routines. At the same time, they need to work effectively with municipal officials and the public.

Skill development must apply horizontally, vertically, and diagonally through the entire personnel structure. The key operating staff of a large plant needs to develop competency in more than one skill area in order to move upward in the personnel structure to supervisory positions of increasing responsibility. On the other hand, the individual operator of a one-person plant must successfully meet the challenge of that job.

The country's wastewater treatment program illustrates the danger inherent in emphasizing investment in capital plant without adequate accompanying development of trained personnel. In the years from 1956 to 1972, approximately $9 billion were allocated by the nation for construction of some 12,000 wastewater treatment plants. Since 1972, the allocation of funds has proceeded at a greater rate both by the federal government under the Federal Water Pollution Control Act and by industry. Unfortunately, over this entire period, specialized technical training programs for operators have not kept pace (Rademacher 1972). One manifestation of this is to be found in reviews of plant records, which indicate that a large percentage of treatment plants in those years were not regularly operated at their designed levels of efficiency owing to a shortage of skilled operators. In fact, there were many instances where plants operated at levels far below design efficiency. The variations occurred not only among plants but within individual plants where biochemical oxygen demand removal was as low as 60 percent (Thomann 1970). Low performance in treatment facilities causes various equipment and process failures and reduces stream water quality.

Further evidence of poor plant performance, and indications that operator training plays an important part in adequate plant management, is found in the annual reports of EPA to Congress over the past five years. These documents result from periodic operation and maintenance inspections and evaluations of existing wastewater treatment facilities across the nation (U.S. EPA 1974).

It would be erroneous to place the blame for poor treatment plant performance entirely upon manpower. The reasons for such performance include inadequate laboratory facilities, lack of operation and maintenance manuals, lack of spare parts, poor records, and overloading of the system. But each of these problems relates at least in part to manpower and to poor management practices. Significant savings and improvement in efficiency could be realized if operators and managers were better trained. In fact, data show that while labor accounts for the largest proportion of municipal plant operating costs, only a low percentage of operating funds is spent to maintain or upgrade the quality of personnel through training. Even among the better-run treatment plants, it frequently is the smaller plants that spend the largest proportion of funds for training as compared to wages, although the larger plants may spend a greater total amount for training.

It has been observed that in treatment plants that are of good design and have adequate operating equipment, operating efficiency primarily will be determined by the ability of the operating personnel to handle the plant in accordance with design specifications. A study on wastewater treatment operations found that there is a risk to capital investment when expensive treatment facilities are placed in the hands of poorly-trained personnel (McLanahan and Tefft 1972). The study also shows that a well-organized operator training program can avoid these difficulties and provide a substantial return on investment. It concludes that, on a conservative average, each operator is responsible for at least $64,000 in plant capital investment, a figure that can rise to more than $100,000. By comparison, industrial production workers in the United States, on the average, individually are entrusted with about $10,000 in capital investment.

The study concludes that investment in operator training is well justified in order to protect capital investment in terms of improved plant efficiency. Effluent quality also can be expected to improve appreciably over pre-training levels. A carefully organized and well-executed training program also will lead to increased job interest by operators and help to sustain a high performance level.

Another action program needed in the environmental pollution control manpower sector is comprehensive planning for a continuing supply of quality manpower. This could include licensing and certification of personnel as well as developing and implementing instructional systems that employ a variety of techniques for training new workers, upgrading current staff, and retraining personnel who can benefit.

There must also be closer cooperation among planners, plant designers, regulators, and operators of pollution abatement and control facilities if employee effectiveness and plant operating efficiency are to be improved. While it is true that cooperation can be promoted and encouraged by instructional programs and technological demonstrations, EPA can play a significant role by paying judicious attention to how funds are allocated. Performance criteria can be employed in certification or licensing and to determine the content and quality of instructional programs. Similarly, equipment performance, process analyses, and planning efforts can serve as the basis for allocation of funds. By these means, EPA can establish the necessary performance criteria to be met by participating agencies, firms, and individuals before payment is made. Certainly, if EPA provides the necessary leadership to promote and develop sound training programs at state and local levels, the environmental protection program will have a much better chance for success.

QUALITY OF MANPOWER IN EPA

The competency or "quality" of personnel in every public agency is a much discussed subject. EPA is no exception in this regard. Partly because of the difficult task it must handle and because problems and controversy have existed in environmental protection since long before passage of organic pollution control legislation, there is a wide range of opinion on the caliber of the Agency's manpower. The Committee considers it potentially useful to examine and clarify the issues involved and, if possible, to resolve them.

A clear understanding of EPA's mission is not easy to obtain. This makes it difficult to establish a firm basis for assessing the performance of its employees. Consequently, gaining the objectives of cleaning up the environment and maintaining the improvements achieved are going to require major changes in the American way of life.

The program approach scarcely can avoid being negative in nature because its basic elements are the conception of regulatory functions, the issuance of performance standards, and the initiation of enforcement proceedings. Even so, the statutes prescribing the Agency's activities are very different from those that guide the operations of old-line federal organizations such as the Federal Power Commission and the Interstate Commerce Commission. In addition to its prime regulatory function, the Agency serves as a conduit for federal funds intended to ease the impact of regulations on individual polluters. A good example is the Construction Grants Program administered by EPA to provide capital for local governments, and indirectly to many industries, for construction of new facilities. Also, the Agency is engaged in substantial research and development work in order to devise appropriate standards and to demonstrate feasible technology for achieving them.

In each of these cases, the activity is essentially supportive of a primarily regulatory orientation. This orientation will continue as the Construction Grants Program and the development of standards and a feasible technology peak and then decline, leaving a relatively bare-bones enforcement agency to maintain the resultant clean environment. While this is an intentionally overstated description of EPA functions, it emphasizes a fundamental characteristic of the Agency that is easily overlooked when one carefully examines its technical makeup. Whether or not it is the wisest approach to the complex problems of pollution control in our society is debatable. But for the time being, EPA operates essentially along the lines discussed and this has clear implications for the set of expectations against which the effectiveness of its employees and its performance must be measured.

The requirement for formulating and establishing standards for a large number of industries in a short time is likely to cause any agency to draw heavily upon the resources of consulting firms that already have the technical competence for the task at hand. This is a reasonable strategy, but it creates an urgent need for personnel in the Agency who have substantial and recent experience in the administration and oversight of research rather than in its actual execution. Even where a government scientist manages to maintain an active research program, a major and increasing share of his time is likely to be consumed with contract management and performance evaluation rather than with his scientific speciality.

The inherently temporary nature of large-scale setting of standards and equipment development also tends to increase dependence on outside rather than in-house scientific effort. It might be a short-sighted policy on the part of EPA to develop an extensive scientific capacity which would have to be dismantled after completion of the first major round of standard-setting and equipment development.

Thus, one can establish the profile of an "ideal" EPA scientific employee as primarily a technically competent administrator of contracts and grants to consulting firms and academic researchers. Beyond a limited but crucial role, theoretical scientists would have little to contribute in getting EPA's immediate job done. Any qualitative evaluation of the effectiveness of Agency scientists should take these factors into account, rather than to measure them arbitrarily against the same criteria as are appropriate for consultants or academicians. It also seems reasonable to assume that standards appropriate for academic researchers, such as publication or citation data, do not apply to employees of an agency like EPA. Furthermore, it is not easy to derive a standard by which EPA employees can be compared qualitatively with their counterparts in federal agencies with different missions.

In this report, Agency personnel characteristics have been examined in terms of selected variables for which comparable data do exist. Several patterns are apparent. First, EPA employs nearly half of its personnel in scientific and engineering occupational categories—some 45 percent of its 10,000 or so full-time employees. This compares with only slightly more than 20 percent in these categories for the federal government as a whole. Second, the educational level among EPA scientists and engineers is reasonably high, with 10 percent of the total holding Ph.D. degrees and 32 percent with Master's degrees. In research and development, these percentages increase to 30 percent who have a Ph.D. and 27 percent who have a Master's degree. Third, EPA scientists and engineers are comparatively well-paid, with mean salaries exceeding $24,000 per year.[1] This compares with a business and industry median salary for scientists and engineers of $19,000, and a state government median salary of $16,400 (NSF 1975).

Such data have limitations and require careful evaluation in drawing conclusions. For example, nothing is indicated or implied regarding the effective use or assignment of EPA personnel. Nor can any inference be made from this information about the role of scientists and scientific data in the Agency decision-making process. The data do indicate that EPA has a substantial proportion of highly trained people on its staff and that, if a problem exists in the "quality" of the Agency's output, it may well be caused by factors other than Agency manpower.

In summary, two points should be emphasized. First, it is vitally important that goals and limitations of an organization be defined explicitly before establishing standards against which to measure effectiveness or "quality" of its personnel. Although the various committees in the NAS/EPA study project are in a unique position to provide fresh insight on this issue, the complex task of human resource evaluation should not be underestimated. Second, there is no a priori evidence, based on an aggregate view of the Agency's personnel, that high-level technical competence is lacking to any substantial degree. The point which should not be overlooked is whether that competence is in the right places and whether the personnel involved are being used most effectively.

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APPENDIXES: REPORTS OF THE PANELS

APPENDIX A Legal Aspects

INTRODUCTION

This report is focused on the legal aspects of EPA's role in developing environmental personnel. While statutory authority is extensive, there are few judicial and formal administrative decisions on the subject of environmental personnel. Therefore, much of the analysis deals with the numerous statutory provisions of environmental legislation and the formulation of personnel development policies by EPA, the Office of Management and Budget, and other governmental and private organizations. It was not possible for the Panel to consider in this report actions which became effective after mid-1976.

The first section introduces the federal statutes which constitute the primary sources of EPA authority to develop environmental personnel, and reviews governmental processes and decision making for the funding of EPA's personnel development programs.

The second section summarizes and reviews the major environmental statutes applicable to EPA and its personnel development functions. These include statutes for air, water, and noise pollution control; for the regulation of pesticides, radiation, solid wastes, and ocean dumping; for the provision of safe drinking water; and for the development of EPA environmental impact statements and EPA review of such statements developed by other agencies.

The third section identifies and evaluates some of the personnel development responsibilities imposed on EPA by the activities of other federal agencies and the courts. Two examples of such activities have been chosen: the development of the Liquid Metal Fast Breeder Reactor Program by the Energy Research and Development Administration and the Nuclear Regulatory Commission; and the judicial decisions on "no significant deterioration" of air quality.

The fourth section identifies several environmental responsibilities of EPA which have not been expressly conferred by statutes, but which are implicit in the achievement and maintenance of environmental quality, and which have implications for EPA personnel development. The environmental responsibilities chosen relate to land use, resource conservation, and international cooperation.

The fifth section reviews the nondiscriminatory requirements regarding minorities and women that are applicable to EPA personnel development, and assesses EPA policies for implementation.

The final section presents conclusions and recommendations derived from the foregoing analyses and reviews. An extensive attachment, in matrix format, describes key provisions of relevant federal legislation which expressly and/or implicitly require personnel development by EPA.

SOURCES OF AUTHORITY AND FUNDING PROCESSES FOR EPA DEVELOPMENT OF ENVIRONMENTAL PERSONNEL

Environmental Protection Agency (EPA) development and training of environmental personnel require statutory authority and appropriate funding. This chapter examines Congressional provision of statutory authority to EPA and procedures for budgeting and funding EPA programs for the development of environmental personnel.

EPA SOURCES OF AUTHORITY

The Environmental Protection Agency was established by Reorganization Plan No. 3 of 1970, transmitted by the President to Congress on July 9, 1970 (U.S. Office of the President 1970). Various functions vested by previously enacted statutes in other executive agencies and departments were transferred to EPA, and include:

1. all functions vested in the Secretary of Interior under the Federal Water Pollution Control Act;
2. all functions vested in the Secretary of Interior under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which relate to studies of the effects of insecticides, herbicides, fungicides, and pesticides upon the fish and wildlife resources of the United States;
3. all functions vested by law in the Secretary of the Department of Health, Education, and Welfare (DHEW) which were exercised by these components of the Environmental Health Service (with certain express exceptions): the National Air Pollution Control Administration; and the Bureau of Solid Waste Management, the Bureau of Water Hygiene, and the Bureau of Radiological Health of the Environmental Control Administration;
4. the advisory functions of the Federal Radiation Council [42 USC 2021(h)];
5. the functions of the Atomic Energy Commission relating to the establishment of "generally applicable environmental standards for the protection of the general environment from radioactive material";
6. the functions of the Water Pollution Control Advisory Board (33 USC 466f); and
7. the functions of the Air Quality Advisory Board (42 USC 1857e).

The transfers to the EPA Administrator by Section 2 of the Reorganization Plan (U.S. Office of the President 1970) were "deemed to include the transfer of . . . authority, provided by law, to prescribe regulations relating primarily to the transferred functions." In addition, the transfer included "so much of the functions of the transferor offices and agencies referred to in or affected by the foregoing provisions of this section as is *incidental to or necessary for the performance* by or under the Administrator of the functions transferred by those provisions or relates primarily to those functions" (e.g., environmental personnel training and development).

The second section and the Attachment to this Panel report contain an analysis of the presently applicable provisions of statutory authority, under major environmental legislation as of January 1976, for personnel development by EPA. Statutory provisions are analyzed for personnel development requirements which are either expressly or implicitly authorized. Legislation analyzed includes these Acts: Clean Air Act, as amended in 1970; Noise Control Act of 1972; Federal Insecticide, Fungicide, and Rodenticide Act; Federal Environmental Pesticide Control Act of 1972; Resource Recovery Act of 1970; Federal Water Pollution Control Act Amendments of 1972; Safe Drinking Water Act; Marine Protection, Research, and Sanctuaries Act; and the National Environmental Policy Act of 1969.

These Acts fall under that broad sector of federal environmental law pertaining to EPA regulatory control of pollution. Two important features of such legislation are: the establishment of criteria and standards for sources of pollution and for the ambient environment; and the establishment and enforcement of control programs. The legislation also provides for research, training, monitoring, and other elements of pollution control. There is, at the minimum, an implicit authorization in the legislation for EPA development and training of environmental personnel necessary for the performance of the Agency's functions, including personnel for research, development, enforcement, monitoring, and program administration. Several of the statutes also contain provisions expressly requiring environmental personnel development through training and other educational programs.

In addition to these statutory sources of authority, EPA is subject to judicial decisions which may impose new types or levels of personnel requirements on the Agency. This and other sources of EPA responsibilities are discussed in the third and fourth sections of this Appendix.

EPA FUNDING PROCESSES

Section 4 of Reorganization Plan No. 3 provided for the incidental transfer of allocations, appropriations, and other funds to be used in carrying out the functions transferred to the EPA Administrator under Section 2 of the reorganization:

Sec. 4. Incidental transfers. (a) So much of the personnel, property, records, and unexpended balances of appropriations, allocations, and other funds employed, used, held, available or to be made available in connection with the functions transferred to the Administrator or the Agency by this reorganization plan as the Director of the Office of Management and Budget (OMB) shall determine shall be transferred to the Agency at such time or times as the Director shall direct.

(b) Such further measures and dispositions as the Director of the Office of Management and Budget shall deem to be necessary in order to effectuate the transfers referred to in subsection (a) of this section shall be carried out in such manner as he shall direct and by such agencies as he shall designate (U.S. Office of the President 1970).

As indicated in Section 4, the OMB Director was provided with discretionary power over the allocation and transfer of funds to implement the vested functions in EPA. Since 1970, OMB has played an integral role in the process of budgeting and funding EPA functions, and is thereby implicated in any assessment of EPA performance on personnel development matters.

OMB exerts control over three major functions of Executive Branch agencies: (1) coordination and control of budget proposals; (2) coordination and management of fiscal allocations; and (3) coordination of Administration proposals on desired legislation. Thus, OMB serves the Executive Office of the President through both top-level policy formulation and the design and monitoring of policy execution. Each year, EPA prepares its budget request and accompanying justifications for submittal to OMB. OMB then proceeds to redefine the Agency's budgetary request according to Executive Office policy priorities and criteria, many of which are not publicly articulated. In addition, EPA is under continual scrutiny by OMB budget examiners. Duties of the examiners are intended to insure OMB control of final budgetary preparations as well as regular overview of EPA fiscal management functions. With regard to Administration legislative proposals, the testimony of EPA officials before Congress on pending legislation must receive pre-clearance approval from OMB to make certain that such testimony will be consistent with Executive Office policy.

A classic example of OMB/Executive Office fiscal decision making and its influence over EPA program development, with significant environmental personnel implications, involved the impoundment of appropriations for wastewater treatment plant construction grants. The 1972 Amendments to the Federal Water Pollution Control Act made available (under Sections 205 and 207), through the mechanism of EPA contract authority, a total of $18 billion for FY 1973, 1974, and 1975 for the construction grant program. On December 1, 1972 and on January 18, 1974, former President Nixon directed the EPA Administrator to defer allocation of $9 billion of these authorized funds.

Two suits, *Train* v. *City of New York* (1975) and *Train* v. *Campaign Clean Water* (1975), reached the U.S. Supreme Court, challenging the withholding of such funds. On February 18, 1975, the Court ruled that the impoundment of such funds for sewage treatment plant construction violated the Federal Water Pollution Control Act. The Court, in considering only the specific requirements of the Act, stated:

> as conceived and passed in both Houses, the legislation was intended to provide a firm commitment of substantial funds within a relatively limited period of time in an effort to achieve an early solution of what was deemed an urgent problem. We cannot believe that Congress at the last minute scuttled the entire effort by providing the Executive with the seemingly limitless power to withhold funds from allotment and obligation.

On February 24, 1975, President Ford authorized FY 1976 allocation of the deferred $9 billion for construction of publicly-owned sewage treatment facilities.

Congress responded to the Executive impoundment of these funds by passing the Congressional Budget and Impoundment Control Act of 1974. The relevant sections limiting Executive impoundment authority are 1002, 1012, and 1013. Section 1002 further defines the scope of the "Antideficiency Act" by prohibiting the use of reserves for fiscal policy purposes which will result in achievement of less than the full objectives and scope of programs enacted and funded by Congress. Section 1012 provides that if Congress does not complete action on all or part of the amount specified on a recision bill (transmitted by the Executive) within a prescribed 45-day period, then the total amount shall be made available for obligation. Section 1013 provides that if either House of Congress passes an impoundment resolution disapproving a proposed deferral (transmitted by the President), then the full amount shall be made available for obligation. The thrust of these sections is to provide more substantial assurances that Executive fiscal policy will not frustrate the accomplishment of previously legislated objectives of Congress without subsequent express agreement of Congress.

The impoundment of construction grant funds is but one example of the significant influence which OMB/Executive Office decision making has exerted on EPA program formulation and implementation. OMB has influenced the conduct of other EPA functions as well, including personnel training and development. However, such EPA functions, as they may be expressly or implicitly authorized by Congress, generally are not specified by legislation in terms of deadlines, dollars, or specific duties, and much is left to the discretion and good faith of the Agency. Hence, it is more difficult to measure the extent of OMB or Executive Office actions on Congressional objectives in such areas of broad agency discretion as personnel development. The strictures of the Budget and Impoundment Control Act are intended to improve the overall situation but may be difficult to apply as to specific Congressionally-designated purposes.

The OMB role ought to be more clearly defined and publicly examined. Furthermore, the criteria for fiscal and program decisions of OMB need to be better understood to assure that office's accountability. Therefore, any current assessment of EPA performance, particularly in the development of environmental personnel and in the conduct of other broad discretionary functions of the Agency, will be incomplete. Central pieces of the Agency decision-making puzzle are missing, and this condition will continue to exist until Congress addresses the matter.

ENVIRONMENTAL PERSONNEL DEVELOPMENT: STATUTORY REQUIREMENTS AND EPA IMPLEMENTATION

Eight comprehensive pollution control programs directed by EPA are analyzed in this chapter for their consequences on the development of environmental personnel. "Environmental personnel" is defined as all personnel employed by EPA, state pollution control agencies, other governmental bodies, academic institutions, consulting firms, or private industry who are required for the implementation of the federal pollution control programs considered in this report. Each of these programs—air pollution control, noise pollution control, pesticides regulation, radiation control, solid waste management, water pollution control, regulation of drinking water quality, ocean dumping regulation—is discussed in general terms for its personnel requirements and then presented in the Attachment. In addition, this chapter discusses the personnel implications of EPA review of environmental impacts of other federal agencies and EPA development of environmental impact statements for its own major actions affecting environmental quality.

Personnel development requirements of the eight pollution control programs are organized into two categories: those "expressly authorized" by statute, and those "implicitly required" by statute. The first category includes sections of a statute which have as their explicit purpose the training or development of personnel to implement the program in question. Typically, such provisions include authorizations for EPA to award training grants, research fellowships, or grants to state agencies for the planning and implementation of a pollution control program. Statutory provisions which "implicitly" require" personnel development, on the other hand, usually make no mention of personnel. They have been determined, nevertheless, to require substantial numbers of people for their implementation. One such provision is an authorization for research and development projects in which personnel will be needed to undertake the research. Other typical provisions with implied or indirect personnel development consequences are those establishing pollution control standards and programs for their application, such as emission limitations (with concomitant monitoring and enforcement responsibilities), permit requirements, or obligations to apply certain control methods or technologies. Implicit requirements often make it necessary for several sectors of society to engage in the needed personnel development: EPA personnel are required to develop appropriate standards and to administer the federal aspects of the control program; state administrative staff ultimately are expected to share in or to take over implementation of program elements; federal and state personnel often share in enforcement of the standards; personnel are needed to conduct ongoing research and development so that the program reflects current technology; and private industry must commit human resources in order to comply with pollution control standards and monitoring requirements.

Each of the statutory mandates is treated only in general in this narrative, with details left to the relevant section of the Attachment. Emphasis has been placed on the two most comprehensive statutes, the Clean Air Act and the Federal Water Pollution Control Act, as amended. Evaluation covers significant personnel development provisions as well as the mandatory or discretionary character of the provisions and their associated time frames.

AIR POLLUTION CONTROL

EXPRESSLY AUTHORIZED PERSONNEL DEVELOPMENT

The Clean Air legislation explicitly provides for personnel development in Section 103, which establishes a national research and development program for the prevention and control of air pollution. As part of this program, the EPA Administrator is authorized to award grants to, and contract with, public or private agencies; to provide direct training or award training grants; and to establish research fellowships. The Administrator has used this authority to establish several types of academic training activities: fellowships, training grants, curriculum development, and special training. Most of the fellowship funds have been spent on engineering and science fellowships awarded to employees of air pollution control agencies who are doing full- or part-time research in these agencies. The training grants, in the past, have been distributed among technicians, under-graduates, and graduate students, but a major part of these grant funds is now being spent at the graduate level. The funds for curriculum development and special training have been used in a variety of training and instructional activities, including the upgrading of academic faculty, and the full- and part-time training of students.

The EPA authorization to perform direct training of air pollution control personnel typically is conducted by OAPS in facilities provided by EPA regional offices to improve skills of people who are already employed in the air pollution control field. Courses such as Engineering and Enforcement, Laboratory and Surveillance, and Air Quality Management are offered for this purpose.

Two other sections of the legislation provide for personnel development, though not specifically for training activities. Section 105 authorizes the Administrator to make grants to air pollution control agencies for amounts up to two-thirds of the cost of planning, developing, establishing, or improving, and up to one-half of the cost of maintaining, programs for the prevention and control of air pollution or implementation of national ambient air quality standards. Grants to certain state and joint municipal agencies may comprise up to three-fourths of the cost of developing, and three-fifths of the cost of maintaining, such programs. Section 210 provides for funding state agency programs for the purpose of developing effective vehicle emission control devices and for establishing inspection and testing of vehicle emission systems. Section 210 thus ties into Title II of the legislation, which deals with control of motor vehicle pollutants.

IMPLICITLY REQUIRED PERSONNEL DEVELOPMENT

The most significant personnel development implications of the Clean Air legislation stem from the comprehensive system for control of air pollution from both stationary and mobile sources, as set forth in Sections 108 through 114. In brief, the legislation provides for the establishment by EPA of maximum allowable pollution levels in the ambient air (national primary and secondary ambient air quality standards). These standards must be achieved within a given time by the complying stationary and mobile sources through a "state implementation plan" (SIP) that has received EPA approval. In certain cases, portions of the SIP may have been promulgated by EPA, particularly the transportation control plan. Each state's SIP must include any measures necessary to achieve the standards; typically, these will be emission limitations, timetables for compliance, and perhaps land-use and transportation control plans. The SIP also must include procedures for monitoring the ambient air.

This system has substantial personnel implications for both public and private sectors. EPA needs research personnel, both in and outside the Agency, to develop the data base on which to promulgate ambient air quality standards. EPA staff also is required to formulate regulations governing the SIP and for review and continuing supervision of the state programs. State personnel needs are substantial, not only for technical staff but for planners, interdisciplinary and systems personnel, and administrative staff. The states and EPA share the responsibility of monitoring, inspection, and enforcement. Private industry, the primary source of pollution subject to SIP regulations, also faces new personnel needs as it seeks to comply with emission limitations, control methods, and record-keeping requirements.

Analogous personnel requirements are raised by Sections 111 and 112 of the Clean Air legislation. Under Section 111, EPA is to promulgate performance standards (emission limitations based on available control technology) for certain new sources of air pollution. This provision also is implemented by the states, under EPA supervision, through pre-construction review of the location of each new source to which Section 111 applies. Under Section 112, EPA issues emission standards for "hazardous air pollutants." These standards may be enforced by the state if EPA approves the state enforcement procedure.

Title II of the Clean Air legislation, which establishes a program for the control of air pollution from moving sources, also has personnel development implications for EPA, the states, industry, and other sectors of society. Under Section 202, the EPA Administrator promulgates emission limitations for pollutants from motor vehicles. The law prescribes a 90 percent reduction of carbon monoxide and hydrocarbon emissions within five years (e.g., by 1975, although that deadline has been extended and interim standards set). This stringent requirement has led to a commitment of personnel resources by the automobile manufacturing industry to develop emission control equipment for attainment of limitations set by EPA and the states. The law places record keeping, testing, and warranty responsibilities on industry.

Another aspect of the Clean Air legislation with potentially significant personnel implications is its stated intent to protect and enhance the nation's air resources. This has led to the explicit regulatory requirement of nondeterioration of air quality in areas where the air quality already is better than ambient air quality standards. This policy of nondeterioration and its personnel implications are discussed in the third section of this Appendix.

NOISE POLLUTION CONTROL

EXPRESSLY AUTHORIZED PERSONNEL DEVELOPMENT

The federal noise control statute does not expressly provide for personnel training and development. The only reference in the Noise Control Act of 1972 to personnel development is that, as part of federally-supported noise control research, EPA may provide technical assistance to state and local governments to facilitate their development and enforcement of ambient noise standards, including "advice on training of noise control personnel." Thus, it appears that any training activities for the purpose of noise control are at the discretion of the states.

IMPLICITLY REQUIRED PERSONNEL DEVELOPMENT

The Act has personnel implications for EPA in carrying out its substantive regulations and for research institutions in carrying out the research it authorizes.

It requires EPA to set noise emission standards for new products that are major sources of noise. Significant research activities must, of course, precede standard setting, and the Act authorizes EPA to conduct, or to finance by contract, research on the effects, measurement, and control of noise. These research activities may be undertaken by other federal agencies, such as the U.S. Department of Transportation (DOT), in which case EPA serves as coordinator, or by other public or private agencies and organizations.

Further personnel requirements for EPA stem from sections of the Act under which EPA promulgates noise emission standards for railroads and motor carriers. The Act also generates additional personnel needs in industries that manufacture products which are subject to the noise emission standards promulgated under this legislation. Manufacturers are required to give notice and warranties to consumers with respect to their product's emission of noise. They also may be required by the EPA Administrator to keep records on product noise emission characteristics.

PESTICIDES REGULATION

EXPRESSLY AUTHORIZED PERSONNEL DEVELOPMENT

The Federal Environmental Pesticide Control Act of 1972 (FEPCA) expressly provides for the training of personnel to enforce and administer the Act. The EPA Administrator is authorized to enter into cooperative agreements with states, to which EPA has delegated the power to enforce the Act, for the support of training programs on the state level. The cooperative agreements may be designed for training both enforcement personnel and certified pesticide applicators. Training of certified applicators also may be undertaken by federal and state agencies under contracts with EPA.

IMPLICITLY REQUIRED PERSONNEL DEVELOPMENT

Implementation of federal pesticide control legislation necessitates the development of personnel from several sectors of society. These persons include research personnel to investigate the environmental effects of pesticides; EPA staff to administer the registration and classification of pesticides; state or federal certified applicators; state and federal enforcement and monitoring personnel; and private industry personnel for compliance with the legislation.

Development of research personnel stems from the power of the EPA Administrator to undertake, by grant or contract, research activities for the purposes of carrying out FEPCA. This research, which may be performed by federal agencies, universities, or other institutions, is to give priority to the development of biologically-integrated alternatives for pest control.

The substantive regulations under the pesticide control statutes will require personnel development in EPA and in state agencies for administration and enforcement. The most significant duties placed upon EPA are the "registration" and "classification" of all pesticides. EPA staff is needed to process applications for pesticide registration, which involves an investigation of the pesticide's environmental effects. Moreover, this investigation is likely to continue beyond initial EPA approval of a registration, since EPA is empowered to suspend or cancel registration upon finding that a pesticide causes unreasonable environmental damage. Vigorous enforcement will require ongoing monitoring and evaluation of pesticide effects.

EPA also classifies each pesticide for general or restricted use, depending on its environmental effects. Restricted-use pesticides, those which may cause "unreasonable adverse effect on the environment," may be applied only under the supervision of a certified applicator. EPA prescribes regulations for the certification of applicators. The power to certify applicators may be delegated to the states upon the EPA Administrator's approval of a state certification program.

FEPCA also provides for monitoring, inspection, and enforcement activities. These duties, to some extent, will be undertaken by the states pursuant to the EPA Administrator's power to cooperate with state agencies (as well as with other federal agencies) to carry out the purposes of the Act. Statutory analysis, however, indicates that the states are not required to commit state personnel and resources to implement the legislation, but they may do so if they wish, and if EPA agrees to delegate the necessary authority and to provide funding.

The pesticide manufacturing industry will need additional personnel to comply with the registration and reporting requirements of the statutes. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the organic legislation, requires that all pesticides be registered with the EPA Administrator. An application for registration must include a statement of all claims as to the effectiveness of the pesticide and, if requested by EPA, a description of the test results upon which claims are based. The registration requirement will necessitate additional administrative staff and perhaps more research personnel.

Furthermore, the Act requires pesticide producers to register their "production establishment" with EPA. This entails reporting types and amounts of pesticides being produced or sold. The Administrator also may prescribe other record-keeping obligations for pesticide producers.

RADIATION CONTROL

EXPRESSLY AUTHORIZED PERSONNEL DEVELOPMENT

Federal radiation control legislation does not expressly provide for EPA programs for the training and development of personnel.

IMPLICITLY REQUIRED PERSONNEL DEVELOPMENT

EPA's responsibility in the area of radiation control derives from Reorganization Plan No. 3 of 1970, which established the Agency (U.S. Office of the President 1970). Section 2(a)(6) vested in EPA

> the functions of the Atomic Energy Commission (AEC) . . . administered through its Division of Radiation Protection Standards, to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material.

In 1973, when EPA was about to issue standards for radiation emissions from nuclear plants that, in most instances, were considerably more stringent than existing AEC standards, the Director of OMB instructed EPA to drop its plans for regulating such emissions. EPA complied and told AEC to issue specific uranium fuel-cycle source standards. EPA was left with the responsibility of issuing standards for limiting the total quantity of radioactive materials entering the general environment, while AEC (later, the Nuclear Regulatory Commission) retained responsibility for developing, implementing, and enforcing effluent or source standards for individual nuclear facilities.

In keeping with this division of responsibility, the EPA in May 1975, proposed standards for limiting the total quantity of radioactive materials in the general environment arising from the entire uranium fuel cycle (i.e., from fuel fabrication, reactors, transportation of nuclear fuels, and so on). Implementation and enforcement of the standards would be the responsibility of the Nuclear Regulatory Commission under this proposed program.

In this setting, EPA's responsibilities for radiation control implicitly require the Agency to develop personnel for research and setting of generally applicable environmental radiation standards. Additional radiation control personnel development may be implicitly required of EPA by the Federal Water Pollution Control Act, in which the definition of "pollutant" includes "radioactive materials." This definition has been administratively interpreted to mean only those materials not regulated by the Nuclear Regulatory Commission. The interpretation was challenged in *Colorado PIRG* v. *Train* (1974), and was recently argued before the U.S. Supreme Court. The Court ruled that the current interpretation is correct and EPA is not required to regulate nuclear power plants and other sources of similar radioactive effluents under the Water Pollution Control Act. Should a change occur in this situation at some future time, there would be a substantially increased need for EPA, state, and industrial control personnel.

SOLID WASTES MANAGEMENT

EXPRESSLY AUTHORIZED PERSONNEL DEVELOPMENT

The Resource Recovery Act of 1970, which amended the Solid Waste Disposal Act of 1965, expressly provides for federally-supported personnel training programs. The EPA Administrator is authorized to support, by grant or contract, projects designed to train persons for occupations involving the management, operation, or maintenance of solid waste disposal and resource recovery equipment and facilities. Such projects may combine training, education, and employment. In addition, EPA is authorized to support programs for the training of instructors and supervisory personnel to train persons in the occupations involved. Grants or contracts may be made to state or interstate agencies, municipalities, educational institutions, or any other organization capable of effectively carrying out such a training project.

IMPLICITLY REQUIRED PERSONNEL DEVELOPMENT

The Resource Recovery Act authorizes the EPA Administrator to make three other kinds of grants with personnel development implications: research and development grants (Sec. 3253); grants for state, interstate, and local planning (Sec. 3254a); and grants for demonstration or construction of resource recovery systems (Sec. 3254b).

Research and development grants are authorized for the purpose of promoting investigations, training, demonstrations, and studies relating to the environmental effects of solid waste. The EPA Administrator is authorized to make grants-in-aid, or to contract with public or private agencies, institutions, and individuals for these purposes.

Planning grants may be made to state, interstate, and intermunicipal agencies for the purpose of developing solid waste disposal plans for the area under the jurisdiction of the agency receiving the grant. The federal grant may not exceed 75 percent of the cost of the planning program and activities. Personnel requirements generated by these grants will be on interstate, state, or local levels, and will involve engineers, other technical personnel, and persons skilled in fields such as land-use planning and economics.

Demonstration and construction grants may also be made on interstate, state, and local levels. The agency receiving the grant is to use the funds to demonstrate resource recovery systems or to construct new or improved solid waste disposal facilities. These grants, in addition to requiring state and local personnel to administer them, will generate needs for personnel for the construction, operation, and maintenance of facilities and systems.

WATER POLLUTION CONTROL

EXPRESSLY AUTHORIZED PERSONNEL DEVELOPMENT

Personnel training and development are expressly provided for by the Federal Water Pollution Control Act of 1972 as part of a national program for the reduction and prevention of water pollution. The most significant personnel development projects authorized by Section 104 of the Act are programs for training personnel to operate and maintain waste treatment works. The EPA Administrator is authorized to support such training programs by grant or contract with public or private agencies, institutions, and individuals and through research fellowships for the education or training of personnel. Sections 109 and 111 of the Act give the Administrator further authority to support the development of personnel to operate wastewater treatment works. Under Section 109, grants may be made to institutions of higher education to assist in the establishment of projects to prepare undergraduate students for entering occupations that involve wastewater treatment works. Section 111 empowers the Administrator to award scholarships to undergraduates who plan to enter such occupations.

IMPLICITLY REQUIRED PERSONNEL DEVELOPMENT

The Federal Water Pollution Control Act has personnel development implications for many sectors of society, as is evident in the structure of the statute: Title I, Research and Related Programs, primarily affects personnel needs in research and development; Title II, Grants for Construction of Treatment Works, will generate the need for personnel at state and municipal levels for planning, construction, and operation of waste treatment systems; Title III, Standards and Enforcement, has personnel implications for EPA and state agencies in setting and enforcing standards and for private industry in meeting the standards; Title IV, Permits and Licenses, has personnel implications for both public agencies and private industry.

Title I of the Act authorizes the EPA Administrator to make grants for furtherance of a comprehensive research program to prevent water pollution. The purposes of these grants are many and varied. In general, the authorized research and demonstration activities range from pure scientific research to major engineering projects, and draw upon the skills of natural scientists, ecologists, engineers, economists, planners, and interdisciplinary personnel. Similarly, those who may receive Title I grants are a varied group of educational and research institutions, public agencies, institutions, and governments.

Grants under Title II have significant personnel effects for states and municipalities. Section 201(g) authorizes the EPA Administrator to make grants to any state, municipality, or intermunicipal or interstate agency for the construction of publicly-owned wastewater treatment works which meet certain treatment standards promulgated by EPA. This requires EPA personnel to prescribe standards, to review grant applications, to supervise the use of grant monies, and the like, and it generates significant needs for the employment of planning, administrative, technical, and construction personnel at state and local levels. Section 208 gives rise to broad personnel needs because it requires designated regional agencies to develop plans for areawide waste treatment management, which encompasses the siting of facilities and land-use considerations, treatment techniques, water supply and aquifer considerations, and other aspects of large-scale planning on a regional basis.

Title III of the Act requires point sources of pollution to achieve by 1977 effluent limitations which require application of the "best practicable control technology," as determined by EPA; and to achieve by 1983 effluent limitations which require the application of the "best available technology economically achievable." This title casts a significant burden for trained personnel on EPA and its consultants to develop both effluent limitations and definitions of control technologies for different categories of point sources (industrial, agricultural, municipal, and so on). In addition, private industry—a source category significantly affected by the effluent limitations and control technology requirements—will have to commit human resources to achieve and maintain these requirements. Title III also contains several other provisions which will require personnel in EPA, state governments, and industry.

Title IV establishes a permit system for discharge of pollutants. The program is primarily administered by EPA, unless the state desires to administer its own program and gets EPA approval to do so. It requires federal or state personnel to set standards, to issue permits, to review permit applications, to monitor and inspect discharges, and to enforce permit conditions. This program also places personnel burdens on potential dischargers who apply for permits; their needs will range widely, from mechanical engineers to aquatic ecologists.

REGULATION OF DRINKING WATER QUALITY

EXPRESSLY AUTHORIZED PERSONNEL DEVELOPMENT

The Safe Drinking Water Act expressly provides for training personnel needed to meet the public health requirements of providing safe drinking water. The EPA Administrator is authorized to make grants to any public agency, educational or other institution, in order to: train personnel for public health occupations involved in providing safe drinking water; and train inspectors and supervisory personnel for public health aspects of providing safe drinking water.

IMPLICITLY REQUIRED PERSONNEL DEVELOPMENT

Implementation of the Safe Drinking Water Act will require development of environmental personnel in several sectors. The personnel needed will include EPA and state staff to administer, do research, set standards, and enforce primary drinking water regulations; EPA and state staff to promulgate, administer, and enforce regulations for the protection of underground sources of drinking water; research and regulatory personnel to establish maximum levels for each contaminant that may have an adverse effect on human health; and medical and health personnel to conduct research relating to the prevention of water-borne diseases.

Section 1412 of the Act requires the Administrator, within a relatively brief period, to promulgate national interim primary drinking water regulations and maximum contaminant levels. Meeting the objectives of this section will require research personnel in such fields as public health, medicine, and chemistry.

Sections 1413 through 1416 establish administrative and enforcement responsibilities of state and EPA officials. Once the EPA Administrator has approved a state plan, the state will have primary responsibility for enforcement and supervision of public water supply systems within its jurisdiction. Implementation of these sections will result in significant demand for EPA administrative and review personnel and for state administrative and enforcement personnel.

Sections 1421 through 1424 establish unique administrative and enforcement responsibilities of state and EPA personnel for the regulation of underground water supplies and injections. Implementation of these sections will require new enforcement personnel and specialists at state and federal levels in groundwater systems.

Under Section 1442, the Administrator is authorized to conduct research, studies, and demonstrations relating to the prevention of diseases and other human impairments resulting directly or indirectly from contaminants in water, and to the provision of a dependably safe supply of drinking water. The required research studies will exert significant demand for research and engineering personnel in several fields.

Section 1443 authorizes the EPA Administrator to make grants to states to carry out public water system supervision programs and underground water source protection programs. Grants authorized under this section will require and serve to develop state personnel, as well as EPA personnel, to review state applications and to maintain oversight of grant programs.

Finally, under Section 1444, the EPA Administrator is authorized to make grants for two purposes: to assist in the development and demonstration (including construction) of any project that will demonstrate a new or improved method, approach, or technology for providing a dependably safe supply of drinking water to the public; and to assist in the development and demonstration (including construction) of any project that will investigate and demonstrate health implications involved in the reclamation, recycling, and reuse of wastewater for drinking purposes, and the processes and methods for the preparation of safe and acceptable drinking water. Conduct of the grant program under this section will require the use of environmental personnel in such fields as public health, chemistry, chemical engineering, water resources, and a variety of other engineering and health disciplines.

REGULATION OF OCEAN DUMPING

EXPRESSLY AUTHORIZED PERSONNEL DEVELOPMENT

The Marine Protection, Research, and Sanctuaries Act does not expressly provide for EPA development of skilled personnel.

IMPLICITLY REQUIRED PERSONNEL DEVELOPMENT

Section 102 of the Act authorizes the Administrator to issue permits for dumping pollutants at sea, upon a finding that the dumping will not unreasonably endanger human health or the environment. To perform this regulatory function, EPA will need personnel to conduct environmental and health research, to establish sites and criteria, and to administer its permit program. The industrial sector will need personnel for permit application and to comply with permit conditions.

EPA REVIEW OF ENVIRONMENTAL IMPACTS OF ACTIONS (EIA) OF OTHER FEDERAL AGENCIES

EPA's responsibility to review and comment on the environmental effects of federal activities stems from two sources: the National Environmental Policy Act of 1969 (NEPA), and Section 309 of the Clean Air Act, as amended in 1970.

EPA ROLE UNDER NEPA

NEPA Section 102(2)(C) requires all federal agencies to prepare a detailed environmental impact statement (EIS) on "major federal actions significantly affecting the quality of the human environment." The same section requires the federal agency preparing an EIS to consult with and obtain the comments of any federal agency which has "jurisdiction by law or special expertise" on any environmental impact of the proposed action. This obligation to comment on the environmental impacts of federal actions involves significant personnel responsibilities on the part of EPA.

The responsibilities of the commenting agencies are specified in guidelines (40 CFR paragraph 1500 et seq.) issued by the Council on Environmental Quality (CEQ) pursuant to its authority under NEPA and Executive Order 11514 (1970). The legal force of CEQ guidelines on federal agencies is not entirely clear; several courts have maintained that the guidelines, while not having the strict force of law, are nevertheless entitled to great weight under accepted legal principles. The guidelines require each agency preparing an EIS to circulate it in draft form to appropriate commenting agencies and to interested members of the public. They acknowledge that EPA has "jurisdiction by law or special expertise" not only with respect to the areas designated by Reorganization Plan No. 3 of 1970 (air and water quality, noise control, solid waste disposal, pesticide regulation, radiation standards) but also to many other fields. Specifically, the CEQ guidelines call for federal agencies to submit to EPA for review and comment any EIS with impacts in these additional areas: waterway regulation and stream modification; fish and wildlife; toxic materials; food contamination; transportation and handling of hazardous materials; development and transmission of electric energy; development, extraction, refining, transport, and use of petroleum; development, production, transmission, and use of natural gas; development, mining, conversion, processing, transport, and use of coal and minerals; development, production, management, harvest, transport, and use of renewable resources; energy and natural resources conservation; land-use changes; planning and regulation of land development; protection of environmentally critical areas; land use in coastal areas; mitigation of density and congestion; soil and plant conservation and hydrology; and outdoor recreation.

Once a draft EIS is circulated, commenting agencies and members of the public are urged to compare the environmental impacts of the proposed action with environmental impacts of reasonable alternatives.

Comments may recommend modifications in the project or new alternatives; they also may indicate the nature of any monitoring of environmental effects that should be undertaken. Agencies with special expertise on the environmental effects of a proposed action are encouraged to assist the sponsoring agency in appropriate environmental monitoring.

EPA ROLE UNDER SECTION 309 OF THE CLEAN AIR ACT

Section 309 requires the EPA Administrator to review and comment in writing on "any matter relating to his duties and responsibilities" under the Clean Air Act and on any other provisions giving EPA authority which are contained in federal legislative proposals, any newly-authorized federal construction projects and NEPA-triggering federal actions other than construction projects, and administrative regulations proposed by federal agencies. To some degree, Section 309 is merely declarative of NEPA's requirement that agencies with jurisdiction by law or with special expertise comment on appropriate EIS. But this section does broaden the EPA review and comment duties beyond the NEPA requirements by specifying three classes of EPA action for which NEPA impact statements may not be required: proposed legislation, proposed administrative regulations, and newly-authorized federal construction which would not be deemed "major Federal actions significantly affecting the quality of the human environment." The duty to comment on legislative proposals is mentioned in NEPA, but the legislative clearance process of the OMB has substantially reduced the commenting procedure. Moreover, the category of newly-authorized federal construction will not expand EPA responsibilities significantly, since nearly all such construction involves the preparation of an EIS.

EPA has adopted guidelines for the implementation of Section 309 which clarify the commenting procedure. In the review of environmental impact statements, EPA will focus its comments on two distinct areas: the environmental impact of the proposal, and the adequacy of information contained in the EIS. If either of these categories is deemed by reviewers to be unsatisfactory, the guidelines require the proposal to be reviewed again at the final EIS stage. In most cases, the reviewing and commenting are performed at a regional EPA office rather than by EPA headquarters staff.

In June 1973, EPA adopted the practice of examining the *Federal Register* for federal regulations warranting Section 309 comments.

However, this procedure was inhibited by limitations of time and personnel and by the tendency of federal agencies to publish major regulatory schemes a segment at a time. As a result, EPA has requested the agencies to send to EPA semiannual lists of environmentally significant draft or revised regulations.

A survey of EPA commenting procedures between December 1972 and June 1973 (Healy 1973) showed that EPA implementation of Section 309 was less than vigorous. While draft impact statements were duly reviewed, EPA made no comment at all on proposals that did not trigger the EIS requirement by NEPA. Only six administrative regulations were reviewed during this period and legislative proposals were completely ignored. Of 385 projects warranting a second review at the final EIS stage (according to EPA's own guidelines), EPA commented on only 19. This deficiency of comment can be partially explained by the fact that many agencies neglected to send a final EIS to EPA. The final CEQ guidelines, which expressly require that each final EIS be sent to EPA, should reduce this problem.

A development that has increased EPA's commenting role is the expansive list of EPA special expertise areas in the CEQ guidelines. It appears that these guidelines, which have been in effect since January 1973, have expanded the EPA commenting role by requiring that more draft and final impact statements be sent to EPA for review either under NEPA or under Section 309. In fact, CEQ often fails to distinguish between NEPA and Section 309 comments by requiring EPA to submit only a single set of comments that will fulfill the EPA responsibilities under both statutes.

Section 309(b) requires the EPA Administrator, upon finding that any legislation, project, or regulation that was reviewed is unsatisfactory from the standpoint of environmental protection, to publish his finding and refer the matter to CEQ. EPA has implemented this provision by having its reviewer at the final EIS stage prepare a comment for publication in the *Federal Register* if the reviewer has reservations about the environmental effects of the proposal. The comment is screened by the EPA Administrator and Deputy Administrator and, upon approval of the Administrator, is published in the *Federal Register* and referred to CEQ.

In summary, both NEPA and Section 309 of the Clean Air Act have served to place review responsibilities on EPA which extend far beyond the pollution control areas designated by Reorganization Plan No. 3 of 1970 and subsequent pollution control legislation. The EPA review staff must now include specialists in land use, energy, resource conservation, and other areas necessitating new personnel needs for EPA.

DEVELOPMENT OF EPA ENVIRONMENTAL IMPACT STATEMENTS

In addition to its role in commenting on impact statements prepared by other agencies, EPA is required under NEPA to prepare EIS for its own "major . . . actions significantly affecting the quality of the human environment." The EIS requirement has been interpreted by U.S. Courts of Appeals to apply only to EPA nonregulatory activities and not to its regulatory functions.

EPA has instituted procedures for preparing impact statements for its major nonregulatory activities, as specified in 40 CFR Sec. 6 (1975). The preparation of such an EIS involves five steps, with all but the first performed by EPA personnel: an environmental assessment must be submitted to EPA by its grantees and contractors; EPA reviews the environmental assessments it receives to determine whether any significant impacts are anticipated, whether adverse environmental impacts can be minimized, and whether an EIS is required for the project; when environmental review indicates that an EIS is necessary, the "responsible EPA official" in charge of the project publishes a notice of intent describing the action and announcing the preparation of a draft EIS (if the environmental review indicates no significant impacts are anticipated, this official issues a negative declaration describing the project and the expected environmental impacts. and no EIS is prepared); EPA prepares a draft impact statement and distributes it for comment to CEQ and to federal, state, and local agencies with special expertise or jurisdiction by law over the project, as well as to interested members of the public; after evaluating comments, EPA prepares and distributes a final EIS. The body of each final impact statement has several sections, the most significant of which are a detailed description of the environmental impacts of the project, adverse impacts which cannot be avoided if the project is implemented, alternatives to the proposed action, and a discussion of the objections raised by government agencies and the public in the review process.

The preparation of these impact statements applies to the major nonregulatory actions of EPA, including the development of EPA legislative proposals, actions under Title II of the Federal Water Pollution Control Act (approval of Sec. 208 plans and award of step 2 and step 3 grants), approval of EPA Office of Research and Development projects, and certain programs of the EPA Office of Solid Waste Management (demonstration grants and sole-source contract proposals).

Although there is general agreement that EPA regulatory activities are exempt from NEPA's EIS requirement, EPA has voluntarily decided to prepare impact statements for some of its major regulatory actions. The Agency has specified that actions taken under the following regulatory statutes will be accompanied by the preparation of impact statements:

- Clean Air Act [national ambient air quality standards under Sec. 109, regulations significantly affecting state implementation plans under Sec. 110, standards of performance for new stationary sources under Sec. 111, emission standards for hazardous air pollutants under Sec. 112, motor vehicle emission standards under Sec. 202, and paragraph 211(c) regulations controlling fuel or fuel additives];
- Noise Control Act (noise emission standards under Sec. 6, railroad emission standards under Sec. 17, and motor carrier noise emission standards under Sec. 18);
- Federal Insecticide, Fungicide, and Rodenticide Act [cancellation of pesticide registrations under Sec. 6(b), and pesticide disposal regulations under Sec. 19];
- Atomic Energy Act (generally applicable radiation standards); and
- Marine Protection, Research, and Sanctuaries Act [criteria for evaluation of permit applications under Sec. 102(a), and designation of sites for dumping under Sec. 102(c)].

The procedure for preparing an EIS for such EPA regulatory actions differs from the procedure previously discussed for major nonregulatory EPA activities in that the initial environmental assessment of a proposed regulatory action is undertaken solely by EPA. The further development of the EIS, and the commenting process, follow the same procedures as those for all other EPA impact statements.

EPA staff involved in the Agency's categorical pollution control programs are needed for EIS development, which necessitates additional staff in these categories. Further, new types of staff specialists are necessitated by the EPA responsibility for assessing environmental implications beyond those contained in the pollution control categories.

ADDITIONAL CONSIDERATIONS AND CONCLUSIONS

The field of environmental law created by statutes, EPA regulations, and judicial decisions is complex and dynamic, and personnel requirements in terms of skills and numbers are difficult to establish and are subject to redefinition by rapidly occurring and unforeseeable developments, such as judicial decisions and the identification of new pollution problems. The need to deal with new developments, many of which require urgent responses, undoubtedly has been a factor that has kept EPA from formulating carefully designed, long-range personnel development programs.

To keep this study within practical boundaries, the only statutes that have been assessed for their personnel development implications and requirements are those which provide EPA with regulatory and review functions and related duties for environmental protection. Other statutes—particularly those involving energy, health, housing, urban programs, and offshore resource development—directly authorize EPA activities which require personnel development or they indirectly create EPA responsibilities for developing environmental personnel through the establishment of new or enlarged or diminished programs in other agencies. Statutes promoting environmental education programs for pre-college students and other members of the general public have also not been treated in this report because they are not designed to promote the development of personnel necessary to implement federal pollution control programs.

Also excluded from this report is any discussion of interagency agreements and their personnel implications, although such agreements can result in more efficient environmental programs and uses of federal and state personnel. EPA has entered into a number of interagency agreements with the Nuclear Regulatory Commission and the Army Corps of Engineers for purposes of clarifying responsibilities, formalizing use of interagency expertise, and diminishing duplicative efforts. However, EPA remains responsible for the several pollution control sectors discussed earlier, and must therefore maintain its ability to conduct independent, quality studies of problems in these sectors. It is particularly important that EPA maintain its self-sufficiency when its partner in an interagency agreement is a "developer" agency, or an agency with a tradition of inadequate concern for environmental and health matters when such matters conflict with other agency objectives. Therefore, it is doubtful whether interagency agreements do provide or should provide a basis for reducing EPA personnel development responsibilities.

In an assessment of EPA performance, it should be noted that Congress, like OMB, is heavily involved. It is clear, following review of pertinent statutes, that the availability and development of environmental personnel do not figure significantly in the legislative history of these statutes. Further, the few provisions expressly dealing with personnel training and development are broadly and vaguely stated, contain no affirmative agency duties for the development of personnel, and afford no basis for enforcement by those seeking to promote EPA conduct of its personnel development functions. Insufficient Congressional consideration of the personnel development issue has continued, despite various studies of EPA pollution control efforts in which the findings repeatedly indicate that lack of adequately trained personnel has contributed to the Agency's inability to meet various statutory requirements.

In light of the experience to date, new legislation which would enable EPA to deal with two remaining environmental problems of federal significance—toxic substances control and solid waste management—may be unwarranted unless Congress gives considerable attention to personnel development needs, includes explicit provisions in the statutes for meeting these needs, and follows through with timely funding. If the large toxic substances and solid waste regulatory programs that have been envisioned for EPA implementation do not contain appropriate provisions for personnel development, they will flounder. The task of determining personnel development requirements for these potential programs could be delegated to the Congressional Office of Technology Assessment, in order to establish a procedure to ensure that such personnel requirements are adequately and systematically considered in the enactment and funding of legislation.

Finally, it should be noted that the issue of personnel development seems to elude the courts. Since the statutory authorizations regarding EPA personnel functions are broad, vague, and provide considerable Agency discretion, there is little basis for suits by citizens to force administrative action. Moreover, in another setting, the matter has come before the courts only to be disposed of inadequately. The Clean Air law provides EPA with authority to approve the state implementation plan (SIP), if the state has provided the "necessary assurances that the State will have adequate personnel, funding and authority to carry out such implementation plan." Suits challenging EPA approval of Rhode Island, Massachusetts, and New York SIPs were brought in the First and Second Circuit Courts (*Natural Resources Defense Council et al.* v. *U.S. Environmental Protection Agency* 1973, *Friends of the Earth* v. *Carey* 1976). The petitioners, in part, claimed that the approved SIPs failed to provide the "necessary assurances" concerning the adequacy of state personnel, funding, and authority.

The courts concluded that Congress had left to the Administrator's discretion the determination of what assurances are "necessary," and that the Administrator, in the promulgation of EPA regulation 40 CFR Section 51.20, had realistically concluded that an inventory of state resources constitutes "the best practical 'assurances' he can obtain." Thus, the Administrator may then "make a reasoned judgement whether, in light of the resources shown to exist, and his best estimate of future federal and state resources, the necessary assurances requirement has been met." The courts reasoned that gubernatorial assurances to obtain adequate personnel and resources (by filing special acts before the state legislature, for example) would have little more than symbolic effect, "since a governor or even a present session of the legislature cannot make binding commitments on behalf of their successors, nor would such representations seem to be enforceable."

Limitations have been imposed by OMB on EPA in its personnel development, and as a result of Congressional unconcern, judicial leniency, and other relevant aspects of the legal and federal decision-making systems. But a large share of the responsibility for the situation still lies with the Agency. EPA has, by any measure, paid little attention to the personnel requirements associated with the large regulatory programs it tries to implement. Indeed, the Agency has made itself virtually unaccountable on the environmental personnel issue. No short- or long-range plans or studies of any detail and coherence have been made publicly available. The Agency has failed to establish advisory committees on personnel development matters, and recently terminated the single advisory committee of relevance, the Air Pollution Manpower Development Advisory Committee, which it inherited from the Department of Health, Education, and Welfare. Despite these unfortunate circumstances, personnel development is a critical feature of Agency implementation of statutory authority, and Congress must initiate necessary reforms or recognize that its legislative initiatives on societal problems will continue to be inadequate.

PERSONNEL DEVELOPMENT RESPONSIBILITIES IMPOSED ON EPA BY OTHER INSTITUTIONS

This section discusses "exogenous" or unanticipated forces resulting from developments in other federal agencies and in federal courts which subsequently impose environmental personnel responsibilities on EPA. Since these EPA duties must be carried out within the scope of applicable legislation and funding, the assumption may be made that EPA is not required to develop new types of personnel or personnel to meet new functions. There are, of course, exceptions to this assumption. Moreover, EPA is required to meet new levels of responsibility for the same types of personnel and functions discussed in the second section of this Appendix.

A wide variety of unanticipated forces can be used to illustrate the significance of such influences on EPA's role in developing environmental personnel. This role obviously consists in part of responsiveness to new developments outside EPA. For example, judicial decisions construing legislation may constitute such a force, as in the case of the nondeterioration of air quality discussed later in this section. Also, the development of major new programs or projects by other federal agencies, with approval of Congress, may have similar side effects on EPA even though the Congress may not concurrently provide EPA with new personnel development authority or funds. Examples include the Energy Research and Development Administration (ERDA) and Nuclear Regulatory Commission (U.S. NRC), Liquid Metal Fast Breeder Reactor Program (LMFBR), and the Department of the Interior program for leasing portions of the outer continental shelf for purposes of exploration and extraction of fossil fuels. A discussion of the LMFBR program with respect to its personnel implications for EPA is presented in this section. Other major developments, such as the Alaska Pipeline and surface mining for coal in the Great Plains and Rocky Mountain regions, might also have been considered. Indeed, it is easy to conclude that many "major" federal actions, as this term has been construed by the courts and agencies under NEPA, have personnel implications for EPA, as do judicial decisions and many activities in the private sector and at state and local levels of government.

Following are two case studies, which are covered briefly, and a short discussion of the issues involved and possible preventative and remedial measures.

FEDERAL AGENCIES: ENERGY RESEARCH AND DEVELOPMENT AGENCY (ERDA) AND THE LMFBR CASE

The Liquid Metal Fast Breeder Reactor (LMFBR) Program demonstrates how EPA's personnel development responsibilities may be expanded by the activities of another agency. The name reveals characteristic features of the reactor: the coolant is a liquid metal (sodium) instead of the "light" water used in conventional U.S. reactors; the neutrons used in the chain reaction are not slowed down, as in conventional reactors, but remain at a relatively high speed; and, most importantly, the process breeds more reactor fuel than it burns and this fuel can be processed and used to power another reactor. The ability to produce new fuel is an important reason why the AEC studied breeder reactors intensively, and subsequently selected the sodium-cooled LMFBR as the highest priority type of breeder reactor for research, development, and demonstration. The present light water reactor industry, due to its dependence on U-235 as its sole uranium-based fuel, may encounter difficulties in the foreseeable future owing to shortages of "economically" extractable uranium reserves. This federal conclusion is supported by a recently completed joint study by the Organization for Economic Cooperation and Development and the International Atomic Energy Agency. The proposed breeder reactor industry, through its ability to breed plutonium 239, which will sustain a chain reaction, from presently abundant supplies of U-238, should be able to extend appreciably the availability of fuel supplies well into the future.

At present, the LMFBR program includes three major testing facilities, two experimental breeder reactors, and a small LMFBR, with ERDA proceeding into the next developmental stage of constructing a full-size (1000 megawatt) LMFBR. AEC, acting under order of the U.S. Court of Appeals for the District of Columbia Circuit (*Scientists' Institute for Public Information, Inc.* v. *Atomic Energy Commission et al.* 1973), issued a seven volume, proposed final EIS on the entire LMFBR program, entitled *Proposed Final Environmental Statement: Liquid Metal Fast Breeder Reactor Program* (U.S. AEC 1974). The programmatic nature of this EIS (as compared to the project-oriented EIS developed with regard to the application of NEPA to the AEC—now U.S. NRC—licensing procedures) was dictated by the Court of Appeals' reasoning that,

> NEPA's objective of controlling the impact of technology on the environment cannot be served by all practicable means . . . unless the statute's action-forcing impact statement process is applied to ongoing federal agency programs aimed at developing new technologies which, when applied, will affect the environment.

In its required review of the EIS on the LMFBR program, EPA has already felt the first personnel needs effect of this program. It will have to react to subsequent, project-oriented EIS on specific facilities and program elements as the program, if it is approved, progresses. When the

Nuclear Regulatory Commission licenses the first LMFBR reactors for construction and operation, and necessitates many EIS and their review, EPA will face new environmental personnel requirements with regard to its own staffing, the needs of the nuclear industry, and of relevant state government authorities. There are three categories of environmental personnel needed to implement the proposed LMFBR program: planning, base-line and operational monitoring, and radiation control.

With respect to planning, the most important feature of a LMFBR is that it results in a fuel cycle centered about plutonium. It is a well-known fact that substantial health hazards are associated with the handling and use of plutonium. Consideration must be given to personnel requirements for the support of a plutonium fuel cycle such as the recruitment of security personnel, personnel for in-transit and site-specific radiological monitoring, and for various other duties. Industry will be involved through its operation of the reactor power plants. The states will be responsible for protecting public health and for regulating land use, and the federal government will have responsibilities as the regulator of nuclear energy and the provider of national support.

Once a fuel cycle facility is built, emissions must be monitored regularly to ensure compliance with relevant standards and to determine environmental impact. The Nuclear Regulatory Commission has established extensive monitoring system requirements that depend on the industry to make measurements and to file periodic reports. Base-line and operational personnel requirements for aquatic monitoring, terrestrial monitoring, and radiological monitoring have traditionally been borne by industry and its consultants, which include both environmental and engineering consulting firms and the academic community.

EPA is required to regulate the thermal discharge from all power plants (33 USC 1326). The thermal effects of a LMFBR are expected to approximate those of a light water reactor. Accordingly, new types of personnel will probably not be needed to regulate thermal effects of such plants, and the number of personnel required will depend on the total generating capacity of a plant, regardless of whether it uses fossil or nuclear fuel. Extensive research has been done on ways to alleviate the effects of thermal discharge; application of that research to the licensing process for breeder reactors probably will require more environmental personnel in both the public and private sectors, with a particular need for environmental engineers for thermal design engineering.

While the use of LMFBR plants will increase EPA's personnel development responsibilities, the magnitude of the increase and the categories of personnel involved are highly uncertain at present. The results will depend not only on other agencies at federal and state levels, but also on court decisions, and are not under EPA's control. A case in point is the recent Supreme Court decision in the suit of *Colorado PIRG* v. *Train* (1974) that the EPA is *not* required to regulate radioactive effluents. The programmatic results of future court actions are one of the more significant features of EPA manpower planning which need projection. This is so because the factors involved do not depend on population growth or some other measurable, reasonably predictable variable, but on the essentially unpredictable decisions of the states, Congress, the Executive, and the courts. This exerts severe limitations on the accuracy of any predictions about personnel requirements.

JUDICIAL DECISIONS: THE SIGNIFICANT DETERIORATION OF AIR QUALITY CASE

Following the enactment of the 1970 Amendments to the Clean Air Act, the EPA Administrator began to perform his mandatory duties under this Act. These duties included promulgation of national primary and secondary ambient air quality standards and review of the state implementation plans (SIPs) designed to achieve those standards.

The Sierra Club filed suit against the Administrator on May 24, 1972, alleging that he had failed to perform a mandatory duty under the legislation by neglecting to require the states to prevent significant deterioration of existing clean air areas (areas with pollution levels lower or "cleaner" than the secondary standard). The Administrator had promulgated a regulation that permitted states to submit plans which would allow clean air areas to be degraded, provided the secondary standard would not be exceeded. The plaintiffs contended that such action was contrary to the intent of the Congress, as stated in the Clean Air Act, to "protect and enhance the quality of the Nation's air resources. . . ." The Administrator maintained that he lacked the power to compel states to prevent significant deterioration of clean air areas. His claim appeared to be well founded because the "protect and enhance" language was stated only in the general purposes of the law, and was apart from the specific and detailed duties given to the EPA Administrator. Nevertheless, the U.S. District Court for the District of Columbia Circuit on May 30, 1972 issued a preliminary injunction restraining the Administrator from approving those SIPs which would permit a "significant" deterioration of presently existing air quality. The court's action was affirmed *per curiam* by the District Court of Appeals and affirmed by an equally divided vote of the U.S. Supreme Court (*Sierra Club* v. *Ruckelshaus* 1973).

On November 9, 1972, in response to the court action, EPA disapproved all state plans insofar as they failed to provide for prevention of significant deterioration of existing air quality. EPA then set about drafting regulations, as required by judicial decree, to guide the states in preparing new implementation plans which would include provisions to prevent significant air quality deterioration (U.S. EPA 1973b). This task involved a new commitment of EPA staff and the services of consultants, and it involved considerations of land use, population growth and migration, and economic development, as well as those of clean air. On July 16, 1973, EPA published proposed regulations which set forth four alternative plans for preventing significant air quality deterioration. This action was followed by widespread public involvement in all aspects of the significant deterioration issue. EPA conducted many public hearings throughout the country and received nearly 400 oral or written presentations, many of them highly detailed. In addition, the EPA Administrator and his staff consulted with a variety of individuals and groups who have special expertise or interest in this issue. The persons who were consulted included state officials, representatives of local governments, Congressional staff, members of environmental groups, representatives from industry, and officials of other federal agencies.

On December 5, 1974, EPA promulgated new regulations dealing with significant deterioration of air quality (U.S. EPA 1974). These place primary implementation responsibility, and corresponding primary personnel requirements, on the states rather than on EPA. The regulations provide that areas within states will be designated under three classes: Class I areas are those where only a small increment of deterioration, as specified by the states, is allowable; Class II areas have a larger deterioration increment "compatible with moderate, well-controlled development in a nationwide context"; Class III areas are those which are likely to experience rapid and major industrial or commercial expansion, and they will be permitted to become more polluted, but only up to the secondary ambient air quality standard.

The states are charged with enforcing the nondeterioration regulations by a systematic process of pre-construction review of major emission sources and reclassification of designated areas. For the sake of convenience, EPA has classified all areas (which generally include several counties) as Class II. States may redesignate any area after a public hearing is held and the EPA Administrator approves the redesignation. The Administrator normally will approve any reclassification unless it was done arbitrarily, was based on inaccurate technical data, or was done using improper procedures.

Before any major new or expanded emission source, as listed in EPA regulations, can be constructed in Class I or II areas, the state must undertake a pre-construction review designed to insure that the deterioration increment for that area will not be exceeded by the introduction of the source. The state also must determine that the new source is applying the "best available control technology (BACT)" for reducing emissions. In order to conduct this review, the state may require the source owner to supply site information, plans, and specifications showing the design of the source; calculations and models of the amounts and subsequent dispersion of emissions; and other necessary information. If the introduction of the new source will cause increment levels to be exceeded, the state must either deny permission to construct the source or may reclassify the area to a higher classification, again subject to EPA review.

States are also charged with meeting monitoring requirements through an accounting procedure that uses the results of models of individual sources rather than by physical measurement of the ambient air.

As of January 1976, both the Senate Public Works Subcommittee on Environmental Pollution and the House Commerce Subcommittee on Public Health and Environment had completed work on their respective draft amendments to the Clean Air Act, as amended in 1970, and had sent the proposed legislation to full committee. Both House and Senate drafts include measures to establish certain automatic Class I designated regions, including national parks, wilderness areas, wildlife refuges, monuments and preserves, and international parks. Under the House proposal, designation or redesignation of these regions could occur only after a public hearing and an analysis of the health, environmental, economic, social, and energy effects of the proposed action. Although the final substance of these amendments is unknown at this writing, there is a clear impetus to provide a legislative restructuring of the discretionary role EPA took in its promulgation of regulations dealing with significant deterioration of air quality. Establishment of mandatory Class I areas, and buffer zones of 60–100 miles around them as called for in the draft amendments, will result in additional environmental personnel needs. In particular, EPA, state environmental regulatory agencies, and private industry will require increased numbers of personnel for air pollution modeling and monitoring of ambient air quality.

In summary, the unanticipated court decision on the Sierra Club suit has imposed both new levels and new types of personnel requirements upon EPA, state and local agencies, and private industry. Issuance of the injunction had primary personnel implications for EPA because a staff was needed to formulate the necessary regulations, including the development of technical data such as increment levels. After promulgation of the final regulations, the primary personnel requirements have become the responsibility of the states as they implement the procedures for redesignation of areas and for pre-construction review of new sources. Also, EPA has to date made delegations of authority in this area to four states and one state has set standards. Additional personnel burdens will fall upon industry and commerce, as staff will be needed for industry to comply with the regulations, particularly to supply information and modeling results, and to negotiate with Agency officials over preconstruction review. Finally, in the long term, it appears probable that future amendments to the Clean Air legislation with respect to nondeterioration of air quality will result in significantly expanded demands for personnel qualified in the field of air pollution monitoring, modeling, and prediction.

CONCLUSIONS FROM CASE STUDIES

The two case studies reviewed here demonstrate how activities of other agencies or institutions impose personnel development responsibilities upon EPA. The LMFBR program was chosen as an example of a major new program promoted by a sister federal agency, ERDA, which had this effect. The magnitude of the increase and the categories of personnel involved are still difficult to determine. This uncertainty with respect to personnel projection is a fundamental characteristic of all major, large-scale technologies whose development is supported by other federal agencies.

The case study on nondeterioration of air quality was chosen as an example of an unanticipated judicial decision which significantly influenced EPA's role in developing environmental personnel, but the final level of personnel required in this area is still highly uncertain because of the essentially unpredictable outcome of Congressional efforts to amend Clean Air legislation.

Both case studies, although dissimilar with respect to institutional context, demonstrate how highly uncertain are the final levels of environmental personnel requirements. Yet, there is an important distinction to be made between the two cases: one concerns scheduling of personnel development. The inherently long lead-times associated with implementation of a major, large-scale technology that is still in the developmental stage (10–15 years or more, for example, with respect to the LMFBR) allow for both the necessary decision making and the orderly development of the required environmental personnel if there is sufficient impetus on the part of the Executive Branch and Congress.

On the other hand, legislative resolution of the significant deterioration issue, with potentially significant effects on certain environmental personnel sectors, could occur by the end of 1976. The shortness of this lead-time almost certainly will result in a significant lag in regulatory accomplishment.

Admittedly, the two case studies are at opposite ends of a spectrum of lead-times. However, the importance of the principle that is involved should not be disregarded: the institution of effective, anticipatory decision making and allowing significant lead-times can ameliorate the predictive uncertainty associated with environmental personnel projections.

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS PLACING OTHER PERSONNEL DEVELOPMENT RESPONSIBILITIES ON EPA

This section discusses three environmental subjects for which Congress has not provided EPA with direct, express authority: land use, resource conservation, and international cooperation. These areas are considered to represent important environmental functions meriting consideration by EPA in its role as the nation's primary environmental agency. Whereas various legislative enactments applicable to EPA indicate that such subjects deserve EPA consideration, existing legislation generally is inadequate to provide guidance, program design requirements, enforceable authority, or affirmative duties. Nevertheless, these subjects represent fundamental problem areas which ought to be addressed by the nation and for which there is considerable public anticipation of EPA action.

LAND USE

Environmental legislation that applies to EPA has *not* provided the Agency with express authority and detailed requirements to control directly or determine the use of land per se—whether public lands, private lands, or submerged lands of the territorial sea and continental shelf. However, broad pollution control laws certainly provide EPA with authority to regulate the design and performance of various facilities and land-related activities (such as the construction of facilities and the extraction of minerals), provided that the regulation is confined to the air and water pollution and other external characteristics. In general, the statutes direct that EPA regulation of such facilities or land-related activities be directed at the control of discharges or emissions, and that general environmental (ambient) standards are to be employed as an overall framework for source regulation.

Within this legislative context, EPA influences land use indirectly by imposing conditions or requirements of a technological and operational nature on such facilities and activities and thus influencing site selection by adding "costs" which are site-specific; and by requiring comprehensive state planning to achieve and maintain air and water quality. As an example of EPA influence on siting, consider its thermal discharge limitations on nuclear power plants. Once-through cooling may be a feasible technological control on thermal effluent from a nuclear power plant located on a coast or offshore because of the dilution capacity of the receiving ocean waters, but an inland plant may be required to install the costlier closed-cycle cooling technology. Thus, siting of such plants and subsequent land use and secondary developments are indirectly influenced by EPA through application of its thermal discharge limitations.

Although EPA could, within the existing legislation, translate its pollution control requirements for specific facilities into siting criteria and regulations, it has chosen, perhaps wisely, not to do so. Such a direct approach to land-use control is clearly not contemplated by the statutes and could give rise to constitutional issues as to state and local authority over land use.

Another way that EPA influences land use is through state planning requirements under several pollution control statutes. Air and water pollution control acts give EPA a mandate for guiding the development and review of state efforts at environmental planning, including land-use features, to the extent that these state efforts are necessary to ensure the integrity of ambient air and water quality standards. Congress and the courts have recognized that state planning subject to EPA review and criteria is a central feature of pollution control programs and that land-use control elements of such plans are necessary to ensure achievement and maintenance of ambient standards. Such plans are now evolving under EPA guidance. They may result in programs for siting new facilities in designated regions and other land-use controls. There will be obvious implications for population growth and the regional economy if the plans are sufficiently specific and enforceable.

Major provisions of the air and water acts and judicial decisions relevant to EPA and state land-use planning under such acts are given in detail below.

THE CLEAN AIR ACT

Development and application of SIP should contain "such measures . . . necessary to ensure attainment and maintenance of such primary and secondary standard, including, but not limited to, land-use and transportation controls" [Sec.110(a)(2)(B)]. It should be noted that on July 15, 1975, EPA indefinitely suspended the management of parking regulations contained in various transportation control plans. Recent decisions in the Fourth and Ninth Circuit Courts indicate that, with respect to the Clean Air Act, EPA does not have authority to require a state, under civil sanctions and penalties, to enforce transportation control measures as part of their SIP (*Brown* v. *U.S. Environmental Protection Agency* 1975; *Maryland* v. *U.S. Environmental Protection Agency* 1975). The Senate Public Works Subcommittee on Environmental Air and Water Pollution and the House Interstate and Foreign Commerce Subcommittee on Public Health and Environment have completed work on respective draft Clean Air Act amendments and have sent proposed legislation to full committee. Both House and Senate drafts contain provisions that will clarify the EPA land-use planning and enforcement role with respect to transportation control plans and indirect source review of parking-related facilities.

The EPA Administrator is required to review all SIPs and to disapprove those plans that do not provide adequate measures for maintenance of primary and secondary standards (*Natural Resources Defense Council* v. *U.S. Environmental Protection Agency* 1973a, 1973b). On July 3, 1975, EPA indefinitely suspended those portions of indirect source regulation covering parking-related facilities.

The EPA Administrator is required to promulgate regulations to insure that air quality higher than that to be achieved by ambient standards will not suffer "significant deterioration," as discussed in the third section of this Appendix in *Sierra Club* v. *Ruckelshaus* (1973).

FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972

Development of areawide waste treatment management plans by designated regional agencies should include explicit provisions for control of significant nonpoint source pollution resulting from agriculture, silviculture, and other land uses (Sec. 208 of the Federal Water Pollution Control Amendments of 1972). Development of Phase II plans with respect to the statewide continuing planning process should include explicit provisions for the control of significant nonpoint source pollution [Sec. 303(e)].

It is clear that EPA, however tentatively it chooses to approach the issue of land-use control, exercises considerable influence on growth and other socioeconomic aspects of land use. It also should be noted that the Agency has recognized its considerable and growing influence on land-use decision making in establishing its new land-use office. In light of its influence, EPA has growing responsibility to develop internal staffing in order to understand fully the land-use impacts of its regulations and other actions, and to provide sound guidance for, and rigorous review over, the plans required of state and other levels of government by the air and water laws. But while EPA will need several land-use and other planners, applied economists, and other social scientists, more substantial personnel requirements will exist at the state level as a result of the requirements imposed on states.

RESOURCE CONSERVATION

The Clean Air Act, as amended in 1970, and the Federal Water Pollution Control Act Amendments of 1972 (FWPCA) give EPA express or implied authority to promote air and water resource conservation.

The Clean Air Act states that it is the intent of the Congress to "protect and enhance the quality of the Nation's air resources. . . ." *Sierra Club* v. *Ruckelshaus* (1973) initiated an EPA regulatory process dealing with the prevention of significant deterioration. The extent to which the promulgated regulations will actually promote resource conservation of relatively pure air is yet to be determined.

The stated objective of FWPCA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters [Sec. 101(a)]. To achieve this and other objectives, FWPCA provides that the water quality standards established shall be appropriate to protect the public health or welfare, enhance the quality of water, and serve the purposes of this Act [Sec. 303(a)(b)]. EPA has adopted the following as general policy:

> Water quality standards should be designed to "*enhance* the quality of the water." In no case will standards providing for less than existing water quality be acceptable except those satisfying the approved antidegradation provision.

On February 6, 1973, the EPA Administrator's Decision Statement No. 5 on Subsurface Emplacement of Fluids by Well Injection (U.S. EPA 1973a) stated that,

> EPA will oppose emplacement of materials by subsurface injection without strict controls and a clear demonstration that such emplacement will not interfere with present or potential use of the subsurface environment, contaminate ground water resources or otherwise damage the environment.

Similarly, on March 20, 1973, EPA issued a Statement of Policy on the Protection of the Nation's Wetlands (U.S. EPA 1973c), which stated that,

> In its decision processes, it shall be the Agency's policy to give particular cognizance and consideration to any proposal that has the potential to damage wetlands, to recognize the irreplaceable value and man's dependence on them, to

maintain an environment acceptable to society, and to preserve and protect them from damaging misuses.

EPA also indirectly promotes water conservation in its establishment of point source categories under Sections 301 and 304 of the 1972 FWPCA amendments. For example, on May 20, 1975, EPA promulgated effluent limitations and guidelines for the petroleum refining point source category (U.S. EPA 1975). EPA based its BAT (best available technology) and BPT (best practicable technology) (1983 and New Source) limitations on the flow bases of refineries "employing good water conservation practices." Although the flow base used is not a flow limitation (that is, a refinery can meet the pollutant allocations allowed by the regulations with a higher base flow if its effluent concentrations are lower than those used by EPA), the overall thrust of the regulations, when established in this manner, is to push for the employment of good water conservation practices.

Further, EPA is using research and development contracts and cost-sharing grants with industry to develop in-process technologies (as compared to traditional add-on devices for pollution control) which, in addition to reducing effluent discharges, may also conserve or even eliminate water consumption, recycle process or waste materials, or result in improved energy conservation. Examples of these industrial process developments include: fluidized-bed coal consumption; development of a new, dry caustic peeling process in the fruit and vegetable processing industry; and the substitution of chemical rinse for water rinse in the electroplating industry.

EPA's policies have significant personnel development implications with respect to EPA funding of new industrial process developments oriented toward resource conservation. Approximately $60 million has been allocated in federal cost-sharing grants under an EPA R&D program authorized by the FWPCA Amendments of 1972 to demonstrate technology for eliminating water pollution in every major processing industry. These personnel development implications extend to numerous categories of point sources, as well as to firms and academic institutions needed to conduct research for EPA on point sources.

INTERNATIONAL COOPERATION

EPA's role in international environmental activities primarily consists of organizing and coordinating bilateral agreements between the United States and other nations, arranging agency-to-agency programs with counterparts in other nations, and participating in visits and exchanges of information between nations. These activities are directed by the EPA

Office of International Activities, established in 1972 and consisting of four divisions: multilateral activities, bilateral activities, international technology, and information and visitor exchange.

The multilateral activities division directs EPA's liaison with international and multilateral organizations such as the United Nations, the Organization of Economic Cooperation and Development, the Inter-Governmental Maritime Consultative Organization, and the North Atlantic Treaty Organization. For example, EPA is participating in the United Nations Environment Program (UNEP), whose goals are to coordinate the environmental activities of UN specialized agencies and to create action plans for global environmental protection. UNEP's governing council first met in June 1973 and approved several projects, in some of which EPA is a participating member. EPA also maintains a liaison with the World Health Organization, whose International Reference Center is located at EPA's National Environmental Research Center at Research Triangle Park, North Carolina.

The bilateral activities division directs EPA participation in negotiating agreements with foreign organizations and in implementing bilateral environmental agreements. Often, EPA is the lead agency for environmental bilateral agreements, such as the Agreement Between the United States and the U.S.S.R. on Coordination in the Field of Environmental Protection (1972). Pursuant to this agreement, EPA arranged for the exchange of visits and information by working groups from the U.S. and U.S.S.R. on the subjects of reducing emissions from transportation sources, water pollution abatement techniques, and health effects of radioactivity and heavy metals. Bilateral agreements for environmental protection have also been negotiated with France and Germany. Informal exchanges of information, which usually consist of exchanges between the EPA Administrator and his counterparts in the other nations, are conducted with the United Kingdom, Argentina, Brazil, and Mexico.

In addition, the governments of the United States and Canada entered into the Great Lakes Water Quality Agreement on April 15, 1972, which authorized the establishment of a Great Lakes Quality Board to assist and advise the International Joint Commission, United States and Canada (Great Lakes Water Quality Agreement 1972). The United States also has reached water quality control agreements with Mexico under the auspices of the International Boundary and Water Commission, United States and Mexico.

The international technology division of the EPA Office of International Activities promotes the exchange of technical information and the implementation of environmental control technology. The division has developed a foreign currency program to use foreign expertise as an aid to EPA domestic activities. It also works in conjunction with the National Science Foundation and the Departments of Commerce and State in assessing the ability of U.S. industry to compete in international markets. The division advises industry on the implications of environmental regulations on international trade, and analyzes foreign programs with respect to pollution control.

The information and visitor exchange of the EPA Office of International Activities arranges for the exchange of information and visits of individuals active in the field of environmental protection. In addition, the division promotes the training of foreign personnel in EPA facilities.

The quantitative personnel implications of these EPA responsibilities for international cooperation depend on these factors: the extent to which this cooperation is pursued by the Executive and other federal departments or agencies primarily involved in international affairs for national purposes, which frequently are not based on environmental quality; and the extent to which it becomes apparent that national efforts to control pollution of certain types (such as oil spills, long-range transport of atmospheric contaminants, and global stratospheric ozone destruction) is futile without enforceable international agreements. At present, probably the most significant international agreement with environmental personnel implications is the Great Lakes Water Quality Agreement between the United States and Canada. This document requests the International Joint Commission to undertake two major water quality investigations, one to evaluate the quality of Lakes Superior and Huron and to make recommendations for pollution prevention and control, and the other to determine the extent to which pollution in the Great Lakes can be attributed to agriculture, silviculture, and other land uses, and to make recommendations for prevention and control of this pollution.

The International Joint Commission has designated the Great Lakes Water Quality Board to conduct the investigations. United States participants include EPA, other federal agencies, the eight Great Lakes states, and several universities. EPA funding for FY 1974 in support of the Water Quality Agreement included $2.1 million for the Upper Lakes investigation, and $2.3 million for the land-use water quality study. In addition, demonstration project funding for the Great Lakes area, authorized under Section 108 of the Federal Water Pollution Control Act, amounted to $2.7 million in support of the Water Quality Agreement. Expenditures in FY 1974 for this purpose were agreed to by OMB, which authorized release of $3.5 million in May 1974 for pollution control in the Great Lakes. EPA's proposed budget for FY 1975 included $6 million for Great Lakes activities for support of the Water Quality Agreement.

Qualitative personnel implications of the international agreements are not thought to differ from those of purely domestic pollution control problems because the broad, analytical features of the problems do not differ simply on the basis of national origin or the international waters involved. However, it should be noted that certain new types of personnel needs may arise from other international activities, such as deep-ocean mining, with its unique environmental effects. Types and quantities of personnel required under international agreements will be determined by a variety of political, economic, and social circumstances that transcend traditional Agency criteria for decision making.

NONDISCRIMINATORY REQUIREMENTS

Training and employment programs of the public and private sectors are subject to national requirements designed to correct the effects of past racial and sex discrimination. This chapter reviews relevant statutes and executive orders, and EPA policy and operations, with respect to minorities and women, but does not analyze relevant developments in constitutional law and judicial decision making which are of generic applicability to all federal agencies and contractors.

RELATED STATUTES AND EXECUTIVE ORDERS

The controlling statute with respect to discrimination in training and employment is the Civil Rights Act of 1964. The Act contains provisions dealing with discrimination by the recipients of federal funds in a program or activity assisted by the federal government (Title VI, Sec. 601); and with discrimination in employment [Title VII, Sec. 703(a)], and training [Title VII, Sec. 703(d)].

There has been little litigation under Title VI on the subject of training; therefore, this analysis is based upon Title VII provisions relating to employment. Because considerations and problems in training are not necessarily the same as those in employment, and because Title VI is controlling with respect to EPA-funded, external training programs, it should be noted that the analogy between the Title VII employment provisions and training under Title VI should not be overextended. The relevant sections of the Civil Rights Act, as amended by the Equal Employment Opportunity Act of 1972, are:

Title VI: NONDISCRIMINATION IN FEDERALLY ASSISTED PROGRAMS

Sec. 601. No person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance.

Title VII: DISCRIMINATION BECAUSE OF RACE, COLOR, RELIGION, SEX, OR NATIONAL ORIGIN

Sec. 703. (a) It shall be an unlawful employment practice for an employer—

(1) to fail or refuse to hire or to discharge any individual, or otherwise to discriminate against any individual with respect to his compensation, terms, conditions, or privileges to employment, because of such individual's race, color, religion, sex, or national origin; or

(2) to limit, segregate, or classify his employees or applicants for employment in any way which would deprive or tend to deprive any individual of employment opportunities or otherwise adversely affect his status as an employee, because of such individual's race, color, religion, sex, or national origin.

. . . . . .

(d) It shall be an unlawful employment practice for any employer, labor organization, or joint labor-management committee controlling apprenticeship or other training or retraining, including on-the-job training programs, to discriminate against any individual because of his race, color, religion, sex, or national origin in admission to, or employment in, any program established to provide apprenticeship or other training.

In addition to the Civil Rights Act, Executive Orders 11246 (1965) and 11478 (1969) govern EPA policy with respect to the development and employment of minority and female personnel.

Executive Order 11246, signed September 24, 1965 (as amended by Executive Order 11375, signed October 13, 1967) prohibits employment discrimination by federally-funded contractors and subcontractors with respect to color, religion, sex, and national origin. The Executive Order is administered and enforced by the Office of Federal Contract Compliance (OFCC), U.S. Department of Labor. The Director of the OFCC has also been delegated authority for coordinating with the Equal Employment Opportunity Commission and the Department of Justice on issues related to Title VII of the Civil Rights Act.

Although the OFCC has overall responsiblity for ensuring nondiscrimination by federal contractors, each federal contracting office and agency has the primary responsibility for securing compliance on its own contracts. In certain cases, a federal agency may be designated as being responsible for compliance by all federal contractors in a given industry or a geographical area. Regulations promulgated by the Secretary of Labor state that each federal agency must require every contractor or subcontractor with 50 or more employees and a contract or subcontract of $50,000 or more to develop a written affirmative action compliance program for each of its establishments as a condition for obtaining such contract. The guidelines to be used by nonconstruction contractors in developing affirmative action programs are subject to the equal employment opportunity requirements of 41 CFR 60-1.40 and 41 CFR 60-2 (Revised Order No. 4).

Federal contracting agencies are required to conduct various types of compliance reviews to determine if their contractors and subcontractors are maintaining nondiscriminatory hiring and employment practices and are taking affirmative action steps to ensure compliance with the equal opportunity clause of Executive Order 11246. The compliance review consists of a comprehensive analysis and evaluation of each aspect of the contractor's employment practices and policies. Standardized contractor evaluation procedures for all agencies were promulgated by the Secretary of Labor on July 12, 1974, as 41 CFR 60-60 (Revised Order No. 14). This established a three-step process for the conduct of a compliance review: a desk audit, an on-site analysis, and, where necessary, an off-site analysis.

Discrimination against federal employees and job applicants to federal agencies because of race, color, religion, sex, or national origin is prohibited by Executive Order 11478, signed August 8, 1969. The broad policy statement of the Executive Order provides:

> Section 1. It is the policy of the Government of the United States to provide equal opportunity in Federal employment for all persons, to prohibit discrimination in employment because of race, color, religion, sex, or national origin, and to promote the full realization of equal employment opportunity through a continuing affirmative program in each executive department and agency. This policy of equal opportunity applies to and must be an integral part of every aspect of personnel policy and practice in the employment, development, advancement, and treatment of civilian employees of the Federal Government.

Section 2 requires that the head of each executive department and agency establish and maintain an affirmative program of equal employment opportunity for all civilian employees and applicants for employment within his or her jurisdiction.

Sections 3, 4, and 5 assign to the Civil Service Commission overall leadership and guidance in the review and evaluation of agency program operations, consideration of complaints, and the issuance of regulations, orders, and instructions deemed necessary and appropriate to carry out the Executive Order.

EPA ORGANIZATIONAL POLICY AND OPERATIONS

Equal employment opportunity efforts within EPA are in two general categories: (1) actions to ensure that contractors receiving EPA grant monies pursue affirmative action principles in recruitment, employment, and promotion procedures; and (2) actions to ensure that each component of EPA adopts plans and programs to ensure equal employment opportunities within the Agency. Prior to September 1974, the EPA locus for both policy and operations with respect to these two categories was the Office of Civil Rights and Urban Affairs (OCRUA).

In September 1974, the EPA equal employment opportunity program underwent extensive reorganization. The characteristics of the reorganization were as follows:

- in-agency EEO compliance activities and staff were transferred to the Personnel Management Division;
- EEO aspects of EPA's Women's Program were transferred to the Personnel Management Division;
- the public affairs aspects of the Women's Program were transferred to the Office of Public Affairs;
- EEO contract compliance activities and staff were transferred to the Grants Administration Division;
- the Minority Business Enterprise Program under the Urban Affairs staff was transferred to the Contracts Management Division;
- the Office of Civil Rights and Urban Affairs was relegated to serving an overview and advocacy function, along with the processing of EEO complaints; and
- all other activities of the Urban Affairs staff were transferred to the Land Use Office.

The effective result of the reorganization was to disperse EEO program responsibility and coordination among several organizational divisions. The 1974 reorganization was modified by a January 1976 Memorandum of Understanding, which agreed to a shift of responsibility for affirmative action plan development back to the EPA Office of Civil Rights from the Personnel Management Division.

An internal study of EEO activities in EPA entitled, "A Study of Equal Employment Opportunity Program Responsibilities in the EPA," was conducted in early 1976 by the Management and Organization Division, Office of Administration of the Office of the EPA Assistant Administrator for Planning and Management. The study found that the reorganization had resulted in inordinate confusion due to conflicting staff directives and to the separation of the Compliance Division Director in the Office of Civil Rights from the rest of the compliance staff in the Grants Administration Division. In addition, the study found that several EPA regional civil rights directors perceived the reorganization as a "conspicuous downgrading of EPA's commitment to EEO goals and efforts" and "a diminishing of the emphasis on contract compliance."

In order to eliminate this dual policy condition, the study proposed three organizational alternatives. One was to return the contract compliance function and staff to the Office of Civil Rights, with the Director of the Office of Civil Rights remaining the Agency Contract Compliance Officer. The study also recommended that OCR be the focal point for Women's Program matters.

In addition, the internal study included an examination of regional and laboratory EEO program responsibilities. The study found that in eight out of ten EPA regions, external contract compliance functions are placed in the Office of Civil Rights. Most regions divide internal EEO responsibility so that the regional OCR has responsibility for the Women's and Spanish-speaking programs, the Affirmative Action Plan, and discrimination complaints, while the Management Division-Personnel Branch handles the Upward Mobility Program, training, and the recruitment of minorities. In general, the Regional Civil Rights Office has a policy overview and monitoring role, while the Personnel Branch is assigned implementation and day-to-day operations responsibility. With respect to EPA laboratory EEO responsibilities, the study found that present EEO program responsibility within facilities at the National Environmental Research Center at Research Triangle Park, North Carolina, and the Cincinnati Laboratory facilities lies within their respective Offices of Administration. The internal study recommended that EEO reporting relationships in the Research Triangle Park and Cincinnati facilities be transferred to the national EPA Office of Civil Rights, and that a full-time, independent EEO Officer be established at EPA's Las Vegas Laboratory facilities.

In summary, the internal EPA study recommended a broad revision of existing EEO program responsibility in order to improve the efficacy and accountability of regional and national EPA affirmative action efforts. Overall, the recommended measures include:

- organizational restructuring;
- redefinition of lines of authority;
- revision of position descriptions; and
- revision of relevant directives.

SIGNIFICANT EEO PROBLEMS RELATED TO EPA DEVELOPMENT OF ENVIRONMENTAL PERSONNEL

The environmental personnel market is characterized by the training and employment of diverse groups in small, segmented fields. Therefore, the extent and efficacy of EEO-related activities in EPA for the development of personnel will vary according to the special attributes which each field possesses. An especially critical area with respect to personnel development is in the physical sciences (e.g., air pollution meteorology, sanitary engineering, and so on), where the skills availability of women and minorities is low. The importance of personnel development in the physical sciences is emphasized by the broad air and water pollution control programs mandated by the Clean Air Amendments and the 1972 Federal Water Pollution Control Act Amendments.

EPA personnel training activities in the physical sciences fall into four major categories:

- short-term technical training programs designed to assist in upgrading the qualifications of present employees of federal, state, and local agencies;
- graduate educational opportunities to increase the number of personnel qualified and available for employment in control agencies;
- assistance to states in personnel development; and
- career development for environmental personnel employed by federal agencies.

With respect to highly-skilled personnel development in the air and water pollution areas, the major EPA activity has been focused on the use of professional training grant programs in water pollution control and in air pollution control. Federal support of these grant programs is now being phased out and early termination is expected. The termination of this funding will not only reduce the number of adequately skilled professional trainees in these two environmentally-critical areas, but it will have a significant impact on the EEO efforts of EPA in these fields. Reductions in the availability of traineeships and fellowships will have a decidedly detrimental impact on individuals from minority groups, since it is only through financial support of this nature that many of them would acquire the opportunity to become qualified for highly-skilled professions in the environmental field. In addition, with the withdrawal of major financial support for study at the graduate level, individuals from minority groups will lack the necessary expertise to qualify for positions of leadership in research organizations and educational institutions.

Other training and personnel development programs in the environmental field (e.g., short-term technical training programs contracted out to private consulting firms) will fall within the purview of EPA's contract compliance and grants-in-aid EEO programs. The extent to which such programs result in increased employment opportunities for minorities and women will be a direct function of EPA's policy commitment to equal employment opportunity, and the translation of that commitment to effective operations on both national and regional levels.

SUMMARY

EPA's equal employment opportunity efforts are guided by the Civil Rights Act of 1964, Executive Order 11246 (1965), and Executive Order 11478 (1969). EEO efforts within EPA divide into two general categories: actions to ensure that contractors receiving EPA grant monies pursue affirmative action principles in recruitment, employment, and promotion procedures; and actions to ensure that each organizational component of EPA adopts plans and programs to ensure equal employment opportunities within the agency. EPA's national EEO program responsibility and coordination is presently dispersed among several segmented, organizational divisions, with a resultant lack of effective policy and operations overview. Proposed alternatives to the existing EEO organizational structure are being evaluated at the national headquarters level. With respect to personnel development in the environmentally-critical areas of air pollution and water pollution control, the present phaseout and termination of EPA's professional training grant programs could seriously undermine equal employment opportunity efforts for the development of highly skilled, minority professionals in these two areas.

CONCLUSIONS AND RECOMMENDATIONS

1. The Office of Management and Budget (OMB) plays a critical role in the formulation and implementation of EPA programs, since Congress has provided EPA with considerable discretion on personnel development matters.

- *The OMB role must be closely evaluated by Congress, and OMB should articulate its criteria and procedures applicable to EPA's personnel development proposals to ensure OMB and EPA accountability to the public.*

2. Congress has provided detailed statutory requirements for most aspects of EPA pollution control and other environmental programs, but has failed to provide sufficient direction to EPA on personnel development matters. Typically, federal legislation on EPA's extensive environmental programs is either silent, vague, or too general on personnel development aspects.

● *Congress should amend such legislation to ensure that EPA will pursue vigorous personnel development policies as an affirmative duty, as such personnel are determined to be essential to the achievement of the environmental objectives of the statutes.*

3. In enacting future legislation imposing new responsibilities for environmental quality on EPA, such as expected legislation on toxic substances and waste management, there will be a need for appropriately explicit provisions in such statutes which impose affirmative duties on EPA for personnel development and which provide a basis for judicial review of EPA performance.

● *Congress should seek the assistance of its General Accounting Office and Office of Technology Assessment in determining the nature and dimensions of such personnel needs and statutory requirements.*

4. Judicial decisions and developing programs in other agencies can be expected to impose new environmental responsibilities on EPA.

● *EPA should determine the types and numbers of environmental personnel required to implement such decisions and programs, interagency and intergovernmental and private sector responsibilities for such personnel, funding and training elements of personnel development, and should report on such findings to Congress and the public.*

5. EPA is authorized to review and approve various state pollution control programs under several statutes, and, following approval, to delegate key functions to such states. EPA has accepted many state programs without adequately assessing current and future levels of manpower available to those states or state commitments to deploy adequate manpower.

● *Since the courts have accepted EPA decisions premised on vague assurances from the states, the Agency needs to make every effort to improve its review of the manpower features of such state programs and to employ its manpower findings as criteria in its review of state programs.*

6. The personnel development issue is one which has been inadequately considered by Congress, inadequately prescribed in legislation, subject to fund-limiting criteria applied by OMB, treated as a low-priority issue by EPA, and barely susceptible of recognition in proceedings seeking court action.

● *Since personnel development is a critical feature for Agency implementation of statutory authority, Congress and EPA ought to initiate necessary reforms and recognize that legislated initiatives dependent upon manpower be adequately implemented.*

AIR POLLUTION CONTROL

(42 USC §1857 et seq.–Clean Air Amendments of 1970)

Personnel Development Authorized by the Statute

In this section, the provisions of the Clean Air Act which explicitly authorize personnel development are listed and excerpted, along with a discussion of the mandatory or discretionary nature of the provision.

Citation (cited as sections of PL 91-604)	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§103 (a)	The Administrator shall establish a national research and development program for the prevention and control of air pollution. . .	Research, training and education.	Mandatory in that EPA shall establish a national research program, but discretionary as to the extent of grants, contracts, and fellowships to be provided. Discretionary as to the type of research undertaken and by whom performed.	
(b)	In carrying out the provisions of the preceding subsection, the Administrator is authorized to– (3) make grants to air pollution control agencies, to other public or nonprofit private agencies, institutions, and organizations, and to individuals, for purposes stated in subsection (a) (1) (4) contract with public or private agencies, institutions, and organizations, and with individuals. . . (5) provide training for, and make training grants to, personnel of air pollution control agencies and other persons with suitable qualifications.			

	(6) establish and maintain research fellowships in the Environmental Protection Agency and at public or nonprofit private educational institutions or research organizations. . .		
§103 (c) (continued)	. . .the Administrator shall conduct research on, and survey the results of other scientific studies on, the harmful effects on the health or welfare of persons by the various known air pollutants.	Research and technical analysis.	(See comment above)
(d)	The Administrator is authorized to construct such facilities and staff and equip them as he determines to be necessary to carry out his functions under this Act.		
§104 (a)	The Administrator shall give special emphasis to research and development into new and improved methods for the prevention of air pollution resulting from the combustion of fuels. In furtherance of this research and development program, the Administrator shall–	The grants made pursuant to Section 104 will lead to recruitment of research and development personnel, both in-house and outside of EPA.	Discretion granted to the Administrator to decide how much and what kind of research to support.
	(1) conduct research programs for the development of combustion by-products, control of emissions of fuels, etc. (2) provide for Federal grants to agencies and institutions and contracts with agencies, etc., for	This section ties into Title II of the Act, which deals with control of pollution from moving sources (chiefly the automobile).	

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
	(A) acquiring new devices or methods for controlling discharges; (B) developing low emission alternatives to the internal combustion engine; (C) purchasing vehicles and engines for testing and research.			
(b)	As part of this research program, the Administrator may – (3) establish and operate necessary facilities and test sites at which to carry on the research, testing, and development.	Research, testing and development.		
§105 (a)(1)(A)	The Administrator may make grants to air pollution control agencies in an amount up to two-thirds the cost of planning, developing,. . .improving, and up to one-half the cost of maintaining programs for the. . .control of air pollution or implementation of national primary and secondary. . . standards.	Planning and development.	Discretionary in language. EPA may make grants. . ., but in practice EPA establishes regulations for eligibility of states for the funding.	
(c)	Not more than 10 per cent of the total of funds appropriated. . .for purposes of subsection (a). . .shall be granted for air pollution control programs in any one state. . .			

§210	The Administrator is authorized to make grants to appropriate state agencies in an amount up to two-thirds of the cost of developing and maintaining effective vehicle emission devices and systems inspection, and emission testing and control programs. . .	Inspection and testing.	Discretionary, except that the Administrator can make no grants under this section unless the Secretary of Transportation certifies that the state program is consistent with any highway safety program developed pursuant to 23 USC §402.

Personnel Development Implicitly Required by the Statute

This section analyzes the personnel implications of the Clean Air Act for the EPA itself, as well as for state air pollution control agencies and for private industry. No attempt has been made to specify the degree of personnel required in each case. Only those provisions of the Act which have a significant effect with respect to public or private personnel requirements are included herein.

Citation (cited as sections of PL 91-604)	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§108	The EPA Administrator shall publish a list of air pollutants and issue air quality criteria for each pollutant. The list, originally drawn up in 1971, shall be revised by the Administrator from time to time. The air quality criteria are also reviewed and revised by the Administrator. The criteria must "reflect the latest scientific knowledge" of the effects of the pollutant on public health and welfare.	Research and development activities by EPA, for example, on potentially hazardous pollutants such as sulfates from coal burning, freon, acid aerosols, etc.	Mandatory to issue a list of air pollutants and air quality criteria for each pollutant.	The list of air pollutants was first issued in 1971. Air quality criteria for each pollutant must be issued within 12 months after the pollutant appears on the list. Revisions in the list and the criteria shall be made from time to time to accurately reflect the latest data on air pollution.
§109	The Administrator shall publish national primary and secondary ambient air quality standards for all air pollutants for which air quality criteria are issued. The primary standards are, in the Administrator's judgment, "requisite to protect the public health," while secondary standards are designed to protect the public welfare (elsewhere defined in the Act to include effects on soils, water, wildlife, climate, and property).	Continuing research and development obligations on EPA.	Mandatory to promulgate ambient air quality standards for each pollutant for which §108 criteria have been issued, as well as for pollutants for which air quality criteria were issued prior to the enactment of the 1970 amendments to the Clean Air Act.	Most primary and secondary standards to be issued within 30 days after enactment of the 1970 amendments to the Clean Air Act. For any pollutant newly appearing on the list, the air quality standards must be proposed simultaneously with the air quality criteria.

		Each standard is initially proposed by the Administrator and, after reasonable opportunity for public comment, is promulgated by regulation. The standards may be revised in the same manner as promulgated.			
§110	(a)(1) (a)(2)(A)	Each state must, within 9 months after promulgation of a national primary or secondary ambient air quality standard under §109, adopt and submit to the Administrator for approval a State Implementation Plan (SIP) which provides for implementation, maintenance, and enforcement of the standard within the state. The SIP must provide for the attainment of the primary standard within 3 years of the date of EPA approval of the plan; attainment of the secondary standards is required within a "reasonable time."	State personnel needed to draft the SIPs. EPA personnel needed for review and approval of the SIP's.	Mandatory for states to submit SIPs for each ambient air quality standard promulgated by EPA.	The SIP must be submitted to EPA within 9 months after the promulgation of a national ambient air quality standard, but EPA may allow an extension for plans dealing with secondary standards. EPA approval or disapproval must follow within 4 months. The state must attain the national primary standard within 3 years of EPA approval of the SIP. However, under limited circumstances, EPA may grant a 2-year extension for attainment.
	(a)(2)(B)	The SIP must include measures "as may be necessary" to insure attainment and maintenance of the standards, such as emission limitations, timetables for compliance, and land use and transportation control plans.	Sections (B), (C), (D) and (E) place obligations on state air pollution control agencies for personnel at all levels. These sections also place indirect manpower requirements on private industry because of the emission limitations and other measures imposed by the SIP.		
	(a)(2)(C)	The SIP must include procedures for monitoring the ambient air quality.			

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
(a)(2)(D)	The SIP must include a procedure for preconstruction review of the location of new sources to which a performance standard will apply.	An uncertain, but potentially large source of manpower development in both public and private sectors is the provision for transportation control plans.		
(a)(2)(E)	The SIP must contain measures adequate to insure intergovernmental cooperation between states and regions so that air pollution in one state or region will not interfere with attainment of the standards in another.			
§110 (a)(2)(F)	The SIP must provide assurance that the state will have adequate personnel, funding, and authority to carry out the SIP.	State personnel to carry out SIP.	Mandatory	Some SIPs, e.g., R.I. and Ma., were challenged for non-compliance with §110(a)(2)(F). The Fifth Circuit Court held that EPA has some discretion in deciding what state "assurance" is necessary on personnel and other elements of a state program. *NRDC* v. *EPA* (1973) 478 F. 2d 875 (5th Cir.)
(a)(2)(G)	The SIP must provide "to the extent necessary and practicable" for periodic inspection and testing of motor vehicles for compliance with emission standards under the Clean Air Act.	Periodic emission inspection and testing.	Mandatory	
§111	The Administrator promulgates standards of performance (emission	Research obligations for EPA.	The Administrator has some discretion in composing the	The list of sources to be composed within 90 days after the

	limitations based on equipment standards) for new stationary sources in a category of sources which, in the Administrator's judgment, "may contribute significantly to air pollution. . ." These standards are enforced by EPA or by the state if EPA approves the state enforcement procedure. The states must also establish emission standards for any air pollutant for which no air quality criteria have been issued but to which a standard of performance would apply if the source were a new one.	Enforcement personnel required by EPA or states. Research obligations for states.	list of sources to which §111 will apply. But once he determines that a category of sources "may contribute significantly" to air pollution, that category must be listed. Once a category of sources is listed, it is mandatory for the Administrator to establish standards of performance.	enactment of the 1970 Clean Air Act Amendments. Within 120 days after the inclusion of a category on the list, the EPA must issue proposed standards of performance. Final standards issued within 90 days after publication of proposed standards. The list of sources may be revised from time to time.
§112	The Administrator shall publish a list of "hazardous air pollutants." The EPA will issue proposed emission standards for any such pollutant within 180 days after inclusion of the pollutant on the list. Within 180 more days and after public hearings, EPA will promulgate final emission standards at a level requisite to protect the public health. Thereafter, no new source of such hazardous air pollutants may be constructed without a permit from EPA or, if EPA approves a state procedure for enforcing the emission standards, from the state. The list of hazardous air pollutants "shall from time to time" be revised by the Administrator. Furthermore, the Administrator shall from time to time issue information on air pollution control techniques for hazardous air pollutants.	Research obligations on EPA for purposes of publishing the list and establishing emission standards. Personnel needed at EPA or state level for the permit issuing process and enforcement of standards. Indirect manpower requirements on private industry to insure compliance with the standards.	Mandatory for the Administrator to publish a list of hazardous air pollutants and to promulgate emission standards for each. The Administrator has some discretion in drawing up the list and in setting the standard.	The list to be composed within 90 days after the enactment of the 1970 amendments to the Clean Air Act; revisions be made from time to time. Emission standards to be proposed within 180 days after inclusion of a pollutant on the list. Promulgation of final standards follows within 180 days of the proposed standards.

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§113	This section grants the Administrator certain powers of enforcement of federal and state standards established pursuant to the Clean Air Act. In the case of a violation of an SIP, the Administrator may notify the violator, and after 30 days issue an order for compliance. If violations within a state are "so widespread" that they appear to result from the state's failure to enforce its SIP, the Administrator may notify the state, and after 30 days he may issue orders for compliance. The Administrator may also issue orders for compliance to violators of §111 or §112. Finally, the Administrator has the power to bring a civil action for relief in the event of continued violations of SIPs or compliance orders.	Personnel needed by EPA to detect violations and to process remedial actions.	Once the Administrator "finds" that a violation exists, he must ("shall") so notify the violator or, the state in the case of widespread violations. However, further remedial action (compliance orders or civil actions) are at the discretion of the Administrator.	
§114 (a)(1)	The Administrator "may require" the owner or operator of any emission source to keep records, make reports, install monitoring equipment, sample emissions, and provide such other information "as he may reasonably require."	Manpower requirements imposed on private industry to comply with record-keeping and reporting obligations.	Discretionary for the Administrator to exercise his powers of requiring record keeping, etc.	
(a)(2)	The Administrator has a right of entry to any emission source and has the right to copy records, inspect monitoring equipment, and sample emissions. These rights may be delegated to the states.	Because of many state restrictions on release of such information to the public, EPA has had to collect monitoring data and make it public.		

(c)	The records and information obtained under (a) become public information, except when they would divulge trade secrets entitled to protection.			
§101 (b) and 40 CFR §52	States must implement EPA regulations designed to prevent significant deterioration of existing air quality in relatively "clean air" areas. The regulations require states to conduct a preconstruction review of certain listed sources to determine whether their introduction into an area would exceed allowable "increment levels" for the ambient air of that area. States also have the duty to classify substate regions into one of three categories; the increment levels are different in each category. The state classification is subject to EPA review. In most areas the new sources, must use the "best available control technology" (BACT) to control emissions.	Personnel needed at the state level to conduct preconstruction review and to classify substate regions. EPA personnel needed for review of state classification of regions. Industry obligation to use BACT may create manpower requirements.	Mandatory (because of court decision) for Administrator to disapprove SIPs which did not provide for nondegradation of "clean air areas" and to issue regulations compelling states to comply with the nondegradation policy.	SIPs were disapproved in 1972. Nondegradation regulations were promulgated in final form in 1974. *Sierra Club* v. *Ruckelshaus* (1972) 2 ELR 20262. Federal District Court enjoined the Administrator from approving SIP's which allowed degradation of air quality in relatively pure air areas. (See Section III-B of this report.)
§202 (a)	The Administrator shall prescribe emission standards for motor vehicle air pollutants.	EPA staff needed, drawing on research on automotive pollution.	Mandatory for EPA to establish emission standards for CO, HC, and NO_x.	Original deadlines for the 90% reductions were 1975 for CO and HC, and 1976 for NO_x. In 1973, the EPA granted a 1-year suspension of the 1975 standards.
(b)	As originally written, the Act required the emission standards to include a 90% reduction in allowable emissions of carbon monoxide (CO) and hydrocarbons (HC) for 1975 model vehicles as compared to 1970 models, and a 90% reduction of nitrogen oxide emissions by 1976. These deadlines have been relaxed by EPA.	The emission standards may place a significant manpower demand on auto manufacturing industry to develop methods of compliance.		*International Harvester, Co.* v. *Ruckelshaus* (1973) 478 F. 2d 615 (D.C. Cir.). The Court of Appeals determined that the Administrator did not adequately justify his denial of a suspension of the 1975 deadline. Shortly thereafter, EPA granted the suspension.

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
(c)	The EPA will arrange with the National Academy of Sciences to conduct a comprehensive study of the technological feasibility of meeting the emission standards established pursuant to this section.	Continuing need for research personnel.		NAS report completed in 1975.
§206 (a) (b) (c)	The EPA may test any new motor vehicle engine in order to determine whether the vehicle or engine complies with the emission standards promulgated under §202. If compliance is found, the EPA shall issue a "certificate of conformity" to the vehicle or engine. If later tests on a sample of vehicles or engines covered by a certificate of conformity reveal that all or some of them do not comply with applicable emission standards, the Administrator may suspend or revoke the certificate. The results of the tests conducted under this section must be made available to the public in nontechnical language.	EPA personnel required for testing of motor vehicles and motor vehicle engines. There is an EPA laboratory in Ann Arbor, Michigan for this purpose.	Mandatory to test any vehicle or engine submitted by a manufacturer who applies for a certificate of conformity. Discretionary to undertake later testing in order to check for actual conformity. If nonconformity is found, suspension or revocation is discretionary. It is mandatory to make public the results of tests.	
§203	It is prohibited to offer for sale or for introduction into commerce or for importation any new motor vehicle or motor vehicle engine which is not covered by a certificate of conformity pursuant to §206.	Enforcement		
§205	Violation of §203 is subject to a civil	Enforcement		

fine of not more than $10,000. Each vehicle or engine which violates § 203 shall constitute a separate offense.

§ 207

This section deals with obligations on motor vehicle engine manufacturers to insure continued compliance with
(a) emission standards of § 202. The manufacturer must warrant that at the time of sale the motor vehicle or
(b) engine conforms to § 202 standards. Furthermore, the Administrator may establish reasonable testing procedures for determining whether motor vehicles in use actually do comply with § 202 standards. The EPA may require manufacturers to warrant continued conformity of the vehicle or engine throughout its useful life; in the event of any noncompliance with the emission standards, the manufacturer would be required to
(c) remedy the nonconformity. Moreover, if the Administrator determines that a substantial number of any category of vehicles or engines do not conform to § 202 standards, he shall require the manufacturer to submit a plan for remedying the nonconformity. In addition, the manufacturer must furnish with each new vehicle or engine written instructions for the proper functioning of the emission
(d) control system. Any cost obligations incurred as a result of remedying nonconformity with emission standards as required by this section must be borne by the manufacturer.

Personnel needed by manufacturers of motor vehicles and engines in order to comply with warranty obligations, including remedying nonconformity with emission standards.

Some EPA manpower also required to administer this section: to oversee manufacturer's compliance with warranty obligations and to undertake independent testing of vehicles and engines.

Manufacturer's warranty at the time of sale is mandatory. EPA may require warranty of continued conformity, but only if reasonable testing procedures and methods are available.

§ 207 applies to model years beginning more than 60 days after the enactment of the 1970 amendments to the Clean Air Act.

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§208	Manufacturers of motor vehicles and engines must keep such records and reports as the Administrator may reasonably require to enable him to determine the extent of the manufacturer's compliance with Part A of Title II of the Act (Motor Vehicle Emission and Fuel Standards). Any reports or information obtained under this section must be made available to the public.	Personnel required by manufacturers to comply with record-keeping obligations.	The extent of record keeping required by manufacturers is discretionary with the Administrator.	
§211 (a) (b) (c)	The Administrator may require the "registration" of any fuel or fuel additive. The sale of any fuel or fuel additive designated for registration is prohibited unless the Administrator has registered it. The Administrator may also require the manufacturer to conduct tests to determine the public health effects of the fuel or additive. The Administrator may control or prohibit the manufacture or sale of a fuel or fuel additive if its emission products "will endanger the public health or welfare."	Personnel required by fuel manufacturers and processors to comply with the registration requirement and testing provision. EPA manpower needed to administer the registration process and to obtain information on the public health effects of fuels.	Discretionary for the Administrator to require the registration of a fuel or fuel additive. It is also discretionary to require manufacturers to conduct tests, or for EPA to control the sale of a fuel or fuel additive.	D.C. Court of Appeals upheld the Administrator's decision to regulate the sale of lead-based gasoline. *Ethyl Corp.* v. *EPA* (1976) 6 ELR 20267 (D.C. Cir.)
§212	This section establishes a Low-Emission Vehicle Certification Board composed of the EPA Administrator, the Secretary of Transportation, Chairman of CEQ, Administrator of GSA, and three other persons, plus staff as needed. The function of the	EPA personnel needed for investigations pursuant to applications for vehicle certification.	It is mandatory for the Board to undertake certification investigations for any vehicle for which an application has been filed with the Board. It is mandatory for federal agencies to procure	Within 270 days of receipt of an application for certification, the Board must determine whether the vehicle is a "low-emission vehicle" and is suitable as a substitute for other vehicles presently being

	Board is to certify models or classes of motor vehicles as "low emission vehicles," i.e., vehicles whose emissions of air pollutants fall significantly below the §202 standards, and with respect to other performance characteristics, will serve as suitable substitutes for vehicles procured by the U.S. government. Such certified vehicles receive preference in procurement by fede-al agencies.		certified vehicles in lieu of other vehicles if the certified vehicles cost no more than 150% of the cost of the vehicles for which they are substitutes.	procured by the federal government.
§231	The Administrator "shall commence" a study of aircraft emissions of air pollutants in order to determine their effect on air quality and the feasibility of controlling the emissions. After commencing the study EPA shall publish a report and issue proposed emission standards for aircraft and aircraft engines. After public hearings the EPA issues final emission standards.	EPA staff needed for study of aircraft emissions and promulgation of emission standards. Indirect manpower requirements on the aircraft industry to comply with emission standards.	Mandatory to undertake the study of aircraft air pollution and to promulgate aircraft emission standards. The Administrator has some discretion in choosing which air pollutants to issue standards for: emission standards must be issued for pollutants which "in his judgment" may endanger the public health or welfare.	The study of aircraft air pollution must be commenced within 90 days of the enactment of the 1970 amendments to the Clean Air Act. Within 180 days of commencing the study, the report and proposed emission standards must be issued. Ninety days thence, final emission standards are promulgated.
§232	The emission standards promulgated under §231 are enforced by the Secretary of Transportation. Enforcement regulations issued by the Secretary are applicable in any application for any certificate authorized by the Federal Aviation Act or the Department of Transportation Act.	Department of Transportation personnel needed for enforcement of §231 aircraft emission standards.	It is mandatory for the Secretary to issue enforcement regulations, after consultation with the EPA Administrator.	

NOISE POLLUTION CONTROL
(42 USC §4901 et seq.–Noise Control Act of 1972)

Personnel Development Authorized by the Statute

There are no explicit manpower development provisions in the Noise Control Act.

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§4904(a)	The Administrator shall publish noise criteria which reflect the nature of the effects of noise on public health and welfare. (By 1973)	EPA staff needed to research and develop noise criteria and product identification reports.	Mandatory (§4904-4912)	
(b)	The Administrator shall also publish a report identifying products which are major sources of noise. (By 1974)			
(c)	The Administrator shall from time to time review and, if appropriate, revise any noise criteria or reports.			
§4905(c)	The Administrator shall publish noise emission standards for products identified in §4904(b) reports. The standards will be set at levels necessary to protect public health and welfare, and may include any appropriate testing procedures or manufacturing instructions to assure compliance with the standards. (By 1974)	EPA staff needed to research and set noise emission levels.		

(d)	The manufacturer of each such product must warrant that the product is constructed and equipped to conform to the noise emission standards.	Possible demand for industry personnel to comply with standards.	
§4906	The Administrator shall study and report on the adequacy of FAA flight and operational noise controls, the adequacy of noise emission standards on aircraft, implications of cumulative noise levels around airports, and other measures to control aircraft noise. The report was to be presented to the Congress in 1973.	EPA personnel needed for research on aircraft and airport noise.	Mandatory
§4907	The Administrator shall, for each product which emits noise capable of adversely affecting public health or welfare, require and specify the form of notice which must be given to the prospective user on the product's noise level.	EPA staff to research product noise levels.	Mandatory
§4912	Every manufacturer of products designated under §§4905 or 4907 must keep records as required by the Administrator to enable him to determine whether the manufacturer is complying with this statute.	Staff required at the manufacturing level for record keeping.	Mandatory
§4913(1)	The EPA may conduct research or finance research by contract on the effects, measurement, and control of noise.	EPA or private research personnel.	Discretionary

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
(2)	The EPA may provide technical assistance to state and local government for the development and enforcement of noise standards. This assistance may include advice on training noise-control personnel.	Personnel from state and local government, also noise-control personnel.	Discretionary	
§4914	The Administrator shall certify any product which meets the "low-noise-emission" standards as developed by EPA. Such certified products receive preferential treatment in federal government purchases or leases.	EPA staff for certification procedures.	Mandatory (§4914-4917)	
§4916	The Administrator shall publish noise emission standards for railroads, taking into account the use of the best available technology and the cost of compliance. (The Department of Transportation promulgates regulations to insure compliance with the standards thus established.) (By 1973)	EPA staff required to develop railroad noise emission standards.	Mandatory	
§4917	The Administrator shall publish noise emission standards for motor carriers engaged in interstate commerce, taking into account the use of the best available technology and the cost of compliance. (Department of Transportation promulgates regulations to insure compliance with the standards.) (By 1973)	EPA staff and industry personnel needed in the same capacities as for §4916.	Mandatory	

PESTICIDES CONTROL

(7 USC § § 135-135k – Federal Insecticide, Fungicide, and Rodenticide Act Amendments [FIFRA])
(7 USC § § 136-136y – Federal Environmental Pesticide Control Act of 1972 [FEPCA])
(16 USC § 742d-1 – Effects of the Use of Chemicals)
(21 USC § § 346, 346a – Federal Food, Drug, and Cosmetic Act of 1938)

Personnel Development Authorized by the Statute

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
7 USC § 135 Note	The Administrator shall publish regulations for the classification and registration of pesticides and reregister all pesticides registered under this law prior to the 1972 amendments.	Personnel needed to handle large number of pesticide revaluations and reregistrations.	Mandatory	Completion of reregistrations by fall of 1977.
7 USC § 136u	(a) The Administrator is authorized to enter into cooperative agreements with states (1) to delegate to states the authority to enforce this act (Federal Environmental Pesticide Control Act) through the use of state personnel or facilities, to train state personnel for enforcement of this Act, and to assist states in enforcement programs through grants-in-aid;	Training, enforcement and certification.	Discretionary	

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
	(2) to assist state agencies in developing and administering programs for training and certification of applicators. (b) The Administrator is authorized to enter into contracts with federal or state agencies for the training of certified applicators (see §136a, 136b for discussion of certified applicators).			
7 USC §135b §136a	All pesticides and economic poisons must be registered with the Administrator. Application for registration includes a statement of all claims to be made for the pesticide, and (if requested by the Administrator) a description of the test results upon which the claims are based. The Administrator will review the application for registration and approve or deny it depending on the authenticity of the claims and the environmental effects of the pesticide.	Personnel needed in pesticide industry to comply with registration requirements. Staff needed at EPA to review applications; also needed to draw up regulations for restricted use pesticides.	Mandatory (§135b-136b)	
§136a(d)	The Administrator will also classify each pesticide for general use, restricted use, or both. Restricted use applies to pesticides which, when applied without additional regulatory restrictions, may cause unreasonable adverse effects on the environment. Restricted use pesticides may be	Certified applicators needed to supervise use of restricted use pesticides.		

	applied only under the supervision of a "certified applicator" or may be subject to other restrictions as the Administrator may make by regulation.		
§136b	The Administrator shall prescribe standards for the certification of applicators; he may delegate certification power to the states.	Certification of applicators.	
7 USC §136d	If the Administrator finds that a pesticide causes unreasonable adverse environmental effects, he may cancel its registration, change its classification, or hold a hearing on the registration and classification. (Cancellation, which does not become final until exhaustion of administrative and judicial remedies, may take several years). However, the Administrator may suspend the registration immediately if necessary to prevent an imminent hazard.	EPA staff needed to handle cancellation and suspension proceedings.	Discretionary
§136e	All producers of pesticides must register their production "establishment" with the Administrator. The producer must report the types and amounts of pesticides he is currently producing or had produced or sold within the past year. The Administrator may also prescribe recordkeeping requirements for pesticide producers.	Pesticide producers must supply personnel to comply.	Mandatory

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§ 136g	Inspections of any producing or distributing establishment of pesticides may be made by officers designated by the Administrator.	Personnel needed for inspections and enforcement.	Discretionary	
§ 136k	Whenever any pesticide is distributed or sold in violation of this statute, the Administrator may issue a "stop sale" order.		Discretionary	
7 USC § 136r (a)	The Administrator "shall undertake" research by grant or contract with federal agencies, universities, etc., to carry out the purposes of this statute, including the development of biologically integrated alternatives for pest control.	Development of research personnel.	Mandatory	
§ 136r (b)	The Administrator shall undertake monitoring activities as necessary, including monitoring of the air, soil, water, plants, animals, and man.	Personnel needed for monitoring activities.	Discretionary	

16 USC §742d-1	The Administrator is authorized to undertake "comprehensive continuing studies" of the effects of insecticides, herbicides, fungicides, and pesticides upon fish and wildlife resources in order to determine safe usage levels.	Development of personnel for research activities.	Discretionary
21 USC §346, 346a	The Administrator shall prescribe regulations limiting the quantity of poisonous or deleterious substances which can be added to food. He shall also establish tolerance levels for pesticide chemicals which can be in or on raw agricultural commodities. Anyone who has registered an economic poison pursuant to FIFRA may submit a petition of a tolerance level for that substance, including reasonable grounds of support for the proposed tolerance.	EPA staff needed for research on health effects of pesticides and establish tolerance levels.	Mandatory

RADIATION CONTROL

(5 USC App. pp. 609 et seq.–Reorganization Plan No. 3 of 1970)
(33 USC § 1362(5)–Federal Water Pollution Control Act)

Personnel Development Authorized by the Statute

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
Reorganization Plan § 2(a)	There are hereby transferred to the Administrator: (6) The functions of the Atomic Energy Commission under the Atomic Energy Act of 1954, as amended, administered through its Division of Radiation Protection Standards, to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material.	EPA will need personnel to do research and to set standards, but not for enforcement. Industry will need personnel for compliance only if EPA standards are stricter than U.S. NRC standards.	Discretionary. The Administrator is authorized to set standards he deems in the public interest. The only condition is that the standards apply to the emissions from all nuclear facilities taken together, not to individual ones.	Standards for limiting levels of radioactive materials in the general environment from the uranium fuel cycle were proposed in May 1975.

	The authority transferred (42 USC 2073, 2133) is very broad, permitting the imposition of such conditions on licensees as are deemed in the public interest.			
33 USC §1362(5)	The definition of "pollutant" under the Federal Water Pollution Control Act includes "radioactive materials." This definition has been administratively interpreted to mean only those materials not regulated by the Nuclear Regulatory Commission (U.S. NRC).	The type of personnel will be the same as above (under present discretionary interpretation of OMB/EPA).	Presently determined as discretionary under OMB/EPA decision making.	Uncertain This interpretation of the statute was challenged (*Col. PIRG* v. *Train*, 507 F. 2d 743), and EPA was ordered to regulate all radioactive effluents. This means a substantial increase in EPA, state, and industrial personnel requirements.

SOLID WASTE MANAGEMENT
(42 USC §3251 et seq.–Solid Waste Disposal Act of 1965)

Personnel Development Authorized by the Statute

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§3254d	(a) The Administrator is authorized to make grants and contracts with state or interstate agencies, municipalities, educational institutions, or other organizations which are capable of carrying out the training projects authorized by this provision. (b) The grants or contracts may be used to pay partially or totally for the cost of projects designed to: (A) train persons for the management, operation, or maintenance of solid waste disposal and resource recovery equipment and facilities; or (B) to train instructors and supervisory personnel to train or supervise persons in occupations involving the design, operation, and maintenance of solid waste disposal and resource recovery equipment and facilities.	Education and training.	Discretionary	
§3253	The Administrator is authorized to make grants-in-aid to, or contract with, public or private agencies and institutions and individuals for research, training projects, surveys, and demon-	Research personnel needed in state and local agencies, educational institutions, etc.	Discretionary	

	strations for the purpose of studying the health effects of the release of solid waste into the environment, the operation of solid waste disposal systems, and the development of new methods of disposing of solid waste.		
§3253a	The Administrator shall annually report to the President and Congress on the results of research he has conducted on means of recovering materials from solid waste, changes in production practices which would reduce the amount of solid waste, the use of federal procurement to develop market demand for recovered resources, incentives to encourage the recycling of materials from solid wastes, the effect of public policies upon recycling such materials, and the necessity of imposing charges on packaging which would reflect the cost associated with nonrecycling.	Research personnel at EPA.	Mandatory
§3254a	The Administrator may make grants to state, interstate, and municipal agencies for the purpose of (1) making surveys of solid waste disposal practices, (2) developing solid waste disposal plans providing for recycling of materials from wastes, (3) developing proposals for projects pursuant to §3254b, or (4) planning programs for the removal of abandoned motor vehicle hulks.	Personnel in government agencies to carry out the research and development funded.	Discretionary

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§3254b	The Administrator is authorized to make grants to state, interstate, or municipal agencies for the demonstration of resource recovery systems or for the construction of new or improved solid waste disposal facilities.	Research and supervisory personnel at state and local agencies.	Discretionary	

WATER POLLUTION CONTROL

(33 USC §1251 et seq.–Federal Water Pollution Control Act Amendments of 1972)

Personnel Development Authorized by the Statute

Citation (cited as sections of the 1972 amendments to the FWPCA)	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§104 (b)	The Administrator is authorized to establish and maintain research fellowships.	Education and testing.	The number, value, and field of the fellowships are left to the Administrator's discretion.	Not explicit, but there is an implicit time frame for all provisions of the Act, set by the 1977 and 1983 deadlines for achievement of water quality standards. However, these dates may not be adhered to, since EPA permits actually issued have fallen behind original expected schedules.

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
(g)	(1) For the purpose of providing an adequate supply of trained personnel to operate and maintain existing and future treatment works and related activities . . . the Administrator shall finance pilot programs . . . of manpower development and training . . . Such programs . . . shall supplement, not supplant, other manpower and training programs and funds available for the purpose of this paragraph.	Development and training.	The Administrator's discretion is guided only by the admonition that he is not to permit his training program to supplant existing ones. The fields, type of training, and number of persons trained are left to the Administrator's discretion.	
	(3) The Administrator is authorized to– (A) make grants to public or private agencies and institutions and to individuals for training projects, and provide for the conduct of training by contract with public or private agencies and institutions and individuals; (B) establish and maintain research fellowships in the EPA.	Training	Discretionary	
§109	The Administrator is authorized to make grants to . . . institutions of higher education to assist them in planning projects or programs for the	Education and training.	The program, number of students and fields covered are discretionary.	

	preparation of undergraduate students to enter an occupation which involves treatment works.			
§111	The Administrator is authorized to award scholarships . . . for undergraduate study by persons who plan to enter an occupation involving the operation and maintenance of treatment works.	Education and training.	(See comment above)	

Personnel Development Implicitly Required by the Statute

§102 (a)	The Administrator shall develop comprehensive programs for preventing, reducing, or eliminating the pollution of the nation's navigable waters.	The rest of the Act is an elaboration of this section. The general implications are that EPA will need research and standard-setting personnel. The states and EPA will have enforcement responsibilities, and private industry and municipally operated waste treatment plants will require personnel for compliance.	The Administrator's discretion is guided by subsequent sections.	The first stage of water quality improvement is scheduled for 1977; the second stage for 1983. The Act includes a goal of "no discharge" by 1985.
§104 (a)	The Administrator shall establish national programs for the prevention, reduction and elimination of pollution and as part of such programs shall–	Personnel implications for research and development personnel in both public and private sectors, and for state water pollution control personnel.	Some discretion in making grants, etc., but the pollution control programs "shall" be established in accordance with the policies of the Act.	

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
	(1) conduct and promote the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, reduction, and elimination of pollution . . .			
	(5) establish, equip and maintain a water quality surveillance system . . .			
§104 (b)	The Administrator is authorized to –	(See comment above)	(See comment above)	
	(3) make grants to state and interstate water pollution control agencies, and other public or nonprofit private agencies, institutions, organizations, and individuals;			
	(4) contract with public or private agencies, institutions, organizations, and individuals;			
	(7) develop effective and practical processes, methods and prototype devices for the prevention, reduction, and elimination of water pollution.			
(c)	The Administrator shall conduct research on the harmful effects on public health or welfare caused by water pollution.	Health and other sciences research personnel.	According to Section 104(c) through (t), it is generally mandatory for the Administrator to conduct the research or	Section 104(c) through (t) suggests that an implicit time frame for the research and development tasks is fixed by the

	(d)	The Administrator shall develop and demonstrate practical means of treating municipal sewage.	Engineering development personnel.	support the development in question (note the recurring use of "shall" in the provisions). However, the Administrator has some discretion in nearly every case with respect to the scope of the inquiry, the specific topics investigated, the type of methods explored, and the amount of funding committed.	Act's water quality improvement deadlines of 1977 and 1983 (though these dates will probably be extended).
	(e)	The Administrator shall establish, equip, and maintain field laboratory research facilities.	Research staff supported on a long-term basis rather than by specific project grants.		
	(f)	The Administrator shall conduct research and technical development work, and make studies, with respect to the quality of the water of the Great Lakes.	Research and development personnel to study a variety of topics dealing with pollution in lakes.		
	(h)	The Administrator is authorized to enter into contracts with, or make grants to, public or private agencies and organizations and individuals for (a) the purpose of developing and demonstrating new and improved methods for the prevention of pollution in lakes; and (b) the construction of publicly owned research facilities for such purpose.	(See comment above)	(See comment above)	(See comment above)
§104	(m)	The Administrator shall conduct a study of the generation of waste oil.	Economic, ecological, sociological, engineering, and interdisciplinary research and development personnel.	(See comment above for §104[m]-[t])	(See comment above for §104 [m]-[t])
	(n)	The Administrator shall conduct studies of pollution effects in estuarine zones.	(See comment above for §104[n]-[t])		

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
(o)	The Administrator shall conduct research on methods of reducing the total flow of sewage, in order to reduce the costs of sewage and waste treatment services.			
(p)	The Administrator shall carry out a comprehensive study and research program to determine new and improved methods of preventing, reducing, and eliminating pollution from agriculture, including the legal, economic, and other implications from the use of such methods.			
(q)	The Administrator shall conduct a comprehensive program of research and pilot project supplementation into new and improved methods of treating pollution from sewage in rural areas.			
(r)	The Administrator is authorized to make grants to colleges and universities to conduct basic research into the structure and function of fresh water aquatic ecosystems.			
(s)	The Administrator is authorized to make grants to institutions of higher education for the purpose of conducting interdisciplinary studies on the nature of river systems.			

(t)	The Administrator shall conduct continuing comprehensive studies on the effects and methods of thermal discharges.			
§105 (a)	The Administrator is authorized to conduct in the EPA and to make grants to any state, municipality, intermunicipality, or interstate agency for the purpose of assisting in the development of– (1) new or improved methods of reducing pollutant discharge from sewers which carry storm waters; (2) any project which will demonstrate advanced waste treatment and water purification methods or joint treatment systems for municipal and industrial wastes.	Raises demands for engineering research, development, and construction personnel.	Give discretion to the Administrator over the extent of the research and development, size and type of demonstration, type of pollutant controlled, etc.	No deadline specified.
(b)	The Administrator is authorized to make grants to demonstrate advanced treatment and environmental enhancement techniques to control pollution from all sources, including new plant sources.	(See comment above for §105[b]-[d])	(See comment above for §105[b]-[c])	
(c)	The Administrator is authorized to–(1) conduct in the EPA, (2) make grants to persons, and (3) enter into contracts with persons for research and demonstration projects for prevention of pollution of any waters by industry.			

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
(d)	The Administrator shall conduct, on a priority basis, an accelerated effort to develop, refine, and achieve practical application of: waste management methods applicable to point and nonpoint sources of pollutants . . . to eliminate the discharge of pollutants.		Mandatory, but there is still discretion over the methods used, etc.	
§106 (a)	Sums are authorized to be appropriated to states to assist them in administering programs for the reduction of pollution, including enforcement of pollution controls.	Requires state enforcement personnel, either in the water pollution control agency or in the attorney general's office.	The Administrator must develop criteria for evaluating the adequacy of state programs.	
(b)	The Administrator is required to allocate the sums appropriately, on the basis of relative pollution problems in each state.			
§106 (c)	Beginning in fiscal year 1974, the Administrator shall not make any grant under this section to any state which . . . is not carrying out . . . the establishment . . . of appropriate . . . methods necessary to monitor . . . the quality of navigable waters.	(See comment above)	(See comment above)	
§107	The Administrator is authorized to conduct, make grants for . . . projects to demonstrate comprehensive approaches to the elimination or control of acid or other mine water pollution resulting from mining operations.	Engineering, biological, and other scientific research personnel.	Discretionary as to extent of research supported and the types of projects undertaken.	

§108	The Administrator is authorized to demonstrate new methods and techniques for the elimination and control of pollution within all or any part of the watersheds of the Great Lakes.	Primarily biological, ecological, and engineering research.	Discretionary. The Administrator has discretion as to the extent of the research supported, the choice of projects and methods employed.	
§113	The Administrator is authorized to carry out projects to demonstrate methods to provide for safe water in native villages in Alaska.	(See comment above)	(See comment above)	
§115	The Administrator is directed to identify the location of in-place pollutants and is authorized to make contracts for the removal of such materials from critical port and harbor areas.	Engineering research.	(See comment above)	
§201 (b)	Waste treatment plans and practices shall provide for the application of the "best practicable technology" for waste treatment before any discharge into receiving waters.	Section 201 is the most significant provision of the Act in terms of personnel requirements. Personnel will be required for the planning, construction, operation, and supervision of these publicly-operated waste-water treatment plants. EPA staff is needed for administering grants, including the development of standards of the best practicable technology, and supervision of the works for continued compliance. State and municipal personnel are needed for construction and operation of the plants.	The Administrator has some discretion in selecting the applicants for the grants, and determining the amounts of the grants, but the administration of these funds must be equitable, based on need and compliance with the conditions stated. Presidential deferrals of funds appropriated in §207 to attain goals in §§301 and 201 are governed by the Impoundment Control Act of 1974 (see Chapter 1 of this report).	Time frame is given by the requirement of secondary treatment for publicly-owned wastewater treatment plants by 1977 (§301). Implicit time frames are due to present statutory deadlines of 1977 and 1983.
(c)	To the extent practical, waste treatment management shall be on an areawide basis and provide control of treatment of all point or nonpoint sources of pollution.			
(g)(1)	The Administrator is authorized to make grants to any state, municipality, intermunicipality or interstate agency for the construction of publicly owned treatment works.			

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§201 (g)(3)	A further condition on grants for public waste treatment works is that the applicant must show that all sewer collection systems discharging into the treatment works are not subject to excessive infiltration.	(See comment above)	(See comment above)	(See comment above)
§208 (a)	For the purpose of facilitating the development of areawide waste treatment management plans– (2) the governor of each state shall identify areas which have substantial water quality control problems. The governor shall designate a representative organization capable of developing effective areawide waste treatment management plans for each designated area.	Requires a significant commitment of resources by state and substate ("areawide" planning is called for) bodies, in addition to retained consultants from the private sector.	Mandatory for the Administrator to promulgate guidelines for the identification of such areas. Mandatory for the governors of the states to designate areas and organizations. Mandatory for the organization to develop a plan for the management of waste treatment processes.	EPA regulations on the identification of such areas were to be published within 90 days of enactment of the Act; within 180 days of publication of the regulations, the governors' designations must be made. One year after the designation, the selected organization must have in operation the planning process. All regional agencies designated by their respective governors must have had their preliminary grant applications approved by EPA by July 1, 1975 to receive 100% federal funding over the two-year planning process.
(b)	Within one year after designation of the organization in (a)(2), such organization shall have in operation a continuing waste treatment management planning process consistent with Section 201 of the Act.			
	Any plan prepared under such process must include several specific components and programs including–	Planning and regulatory control.	Mandatory	Within 1 year.

	(A) identification of treatment works necessary to meet the anticipated waste treatment needs of the area over a 20-year period; (B) construction priorities for treatment works and schedules for initiation and completion of the works; (C) the establishment of a regulatory program to implement the waste treatment management requirements of Section 201, and to regulate the location and construction of any facilities which may result in discharges in the area; (D) provisions for the control of significant nonpoint source pollution; and several other components.			
§210	The Administrator shall annually make a survey to determine the efficiency of the operation and maintenance of treatment works constructed with grants under this chapter.	Administrative staff on EPA and state level needed for this annual survey.	Mandatory to conduct the survey.	Survey must be made annually.
§301 (b)(1)	There shall be achieved not later than July 1, 1977, effluent limitations for point sources, other than publicly owned treatment works, which shall require the application of the best practicable control technology as defined by the Administrator.	The setting of the effluent limitations will require significant resources on the part of EPA and retained consultants, and will draw on the research performed pursuant to earlier provisions of the Act.	It is mandatory to issue the limitations. The numerical value of the limitations is to some degree within the Administrator's discretion.	Effluent limitations must be promulgated within one year of enactment of the Act.

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Time Frame or Deadline
(b)(2)	There shall be achieved not later than July 1, 1983, effluent limitations for point sources, other than publicly owned treatment works, which require the application of the "best available technology economically achievable." In the case of publicly owned treatment works, all treatment works existing on July 1, 1977 must meet effluent limitations based upon secondary treatment as defined by the Administrator. By 1983 such works must apply the best practicable waste treatment technology as defined by the Administrator.	(See comment above)	Mandatory	By July 1, 1983.
§303 (a)	Each state shall submit water quality standards applicable to intrastate waters to the Administrator for his approval. Such standards shall be such as to protect the public health or welfare, enhance the quality of the water and serve the purposes of the Act. The standards shall consist of designated uses of the waters involved and the water quality criteria based upon such uses.	State research and administrative personnel. EPA staff for review of state standards.	Mandatory for states to submit standards.	Within 180 days after enactment of the Act.
§304 (b)	The Administrator shall publish regulations providing guidelines for effluent limitations. These regulations shall–	(See comment to §301)	(See comment to §301)	Effluent limitations must be promulgated within one year of enactment of the Act.

	(A) identify in terms of amounts, and chemical, physical and biological properties of pollutants, the degree of effluent reduction attainable through the use of the best practicable control technology currently available. (B) specify factors to be taken into account in determining control measures applicable to point sources.			
(h)	The Administrator shall promulgate guidelines for the purpose of acquiring information from owners and operators of point sources subject to any state program under Section 402 (NPDES program), including monitoring requirements, reporting requirements and enforcement provisions, and funding and manpower requirements.	Prepare guidelines.	Mandatory	(See comment above)
§305	Each state shall prepare (yearly) a report which shall include— (A) a description of the water quality; (B) an analysis of the extent to which all navigable waters of such state provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife, and also allow recreational activities in and on the water;	State personnel needed for planning and reporting.	Mandatory to prepare the report.	Annually

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
	(D) an estimate of (i) the environmental impact, (ii) the economic and social costs necessary to achieve the objectives of this chapter; (E) a description of the nature and extent of nonpoint sources of pollutants.			
§306 (b)	The Administrator shall publish a list of categories of sources, including at a minimum the 28 categories specified in this section, and for each category promulgate standards of performance for new sources within that category.	Continuing scientific and economic research required within and outside of EPA. Indirect personnel requirements for private industry to comply with the standards. Subsection (c) implies the need for state planning and enforcement personnel.	Mandatory to issue the standards.	The list must be drawn up within 90 days of the enactment of the Act. The standards must be issued within a year of this date.
(c)	Each state may submit to the Administrator for his approval a procedure for applying and enforcing standards of performance for new sources.			
§307	The Administrator shall publish a list of toxic pollutants and shall promulgate an effluent standard (or prohibition) for each such pollutant.	Research by EPA; industry personnel required for compliance.	Mandatory to promulgate the standards.	Standards must be proposed within 270 days after enactment of the Act.
§308	The Administrator shall require the owner or operator of any point source to (i) establish and maintain such records (ii) make such reports, (iii) install such monitoring equipment (as is deemed necessary).	Personnel from private industry needed for compliance.	The extent of the monitoring and reporting requirements is left to the Administrator's discretion.	

§309	The Administrator has powers of enforcement of emission limitations and of permit programs. The Administrator may, in the event of certain violations of the Act, issue an order to comply to, or bring a civil action against, the violator.	Enforcement personnel needed by EPA.	The Administrator has some discretion in acting against violations.
§311	The Administrator shall promulgate regulations for the clean-up of oil discharged into water.	Industry personnel for compliance; state personnel for inspection.	Mandatory to issue the guidelines; the content is within the Administrator's discretion.
§312	The Administrator shall promulgate federal standards of performance for marine sanitation devices.	EPA and research personnel.	Mandatory to issue standards.
§314	Each State shall prepare– (1) an identification and classification according to the eutrophic condition of all publicly owned fresh water lakes; (2) procedures to control sources of pollution of such lakes; (3) methods to restore the quality of such lakes.	State personnel needed for research and enforcement.	Mandatory for each state to submit the study.
§401	Any applicant for a federal discharge permit (see section 402) must supply to the permitting agency a certification by the state in which the discharge originates that the discharge will comply with this Act.	State administrative personnel needed to review applications for certification.	Mandatory

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§402	This section establishes a permit system (NPDES program) for the discharge of any pollutant subject to the requirements of this Act. The states may submit a program to implement the permit system; if the Administrator finds that the state program meets certain requirements listed in this section, the state will administer the permit program.	State administrative personnel needed to prepare and supervise the permit system. EPA staff needed to review the state permit program. Industry personnel required for compliance with permit requirements. EPA personnel also needed to formulate standards for approval of state permit programs.	Mandatory that a permit system be established. If the state desires to administer its own program, and has adequate authority to do so, EPA will approve a state program in lieu of an EPA administered program.	No deadline specified for submission of state programs.
§403	The Administrator shall promulgate guidelines bearing on the discharge of substances into the ocean. No permit for a discharge into the ocean may be issued except in compliance with these guidelines.	EPA personnel needed for promulgation of ocean discharge criteria.	Mandatory	Guidelines must be issued within 180 days of enactment of the Act.
§404	Permits for the discharge of dredged or fill materials into navigable waters shall be issued by the Corps of Engineers, not through the NPDES program of §402.	Army Corps of Engineers personnel to administer permit program.	Mandatory to establish the permit program.	
§405	The Administrator shall issue regulations governing the issuance of permits for the disposal of sewage sludge. Any state desiring to administer its own permit program for the disposal of sewage sludge may submit to the Administrator a proposed permit system.	EPA personnel needed to formulate regulations. State personnel needed in the event of state administration of the program.	Mandatory to issue regulations.	

DRINKING WATER QUALITY CONTROL

(42 USC § 300f et seq.–Safe Drinking Water Act of 1974)

Personnel Development Authorized by the Statute

Citation (Cited as sections of the Safe Drinking Water Act)	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§ 1442(b)(3)	The Administrator is authorized to make grants to any public agency, educational institution, and any other institution– (A) for training persons for occupations involving the public health aspects of providing safe drinking water;	Training and education.	Discretionary. The Administrator is also permitted to choose subjects, funding amount, and institutions.	Indefinite
	(B) to train inspectors and supervisory personnel to train or supervise persons in occupations involving the public health aspects of providing safe drinking water.	(See comment above)	(See comment above)	(See comment above)

Personnel Development Implicitly Required by the Statute

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§ 1412(b)(1)(g)	The administrator shall establish recommended maximum contaminant levels for each contaminant (from a list in the statute).	Research and planning personnel in the EPA to set standards enforcement and compliance for the states.	The numerical value of the Standards (which will affect compliance personnel) are left to the Administrator.	
§ 1412(c)(1)	The Administrator shall enter into appropriate arrangements with the National Academy of Sciences to conduct a study to determine the maximum contaminant levels.	Research personnel.		The results of the study are due by December 16, 1976.
§ 1413(a)	Once the Administrator has approved a state enforcement plan, the state will have primary responsibility for the enforcement of the Act.	EPA personnel to review plans for adequacy; state personnel for enforcement.	The Administrator has discretion to determine the consistency of the state plan with the Act.	
§ 1421(a)(1)	The Administrator shall publish proposed regulations for state underground injection control programs.	Research and planning personnel. EPA to establish regulations; enforcement and compliance personnel required for the states.	Proposed regulations shall be published within 180 days after the date of enactment.	
§ 1442(a)(1)	The Administrator may conduct research relating to prevention of diseases and other impairments of man resulting directly or indirectly from contaminants in water, or to the provision of a dependably safe supply of drinking water.	Medical health and engineering.	Discretionary. Type of research, topic and scope left to the Administrator.	

§ 1442(a)(4)	The Administrator shall conduct a study of the means of control of the disposal of waste which may endanger existing or potential underground water supplies.	Research and engineering personnel.	Mandatory. Results of the study shall be submitted to Congress within one year after the date of enactment.
§ 1442(a)(5)-(9)	The Administrator shall conduct studies concerning– (1) methods of underground injection which do not result in the degradation of underground drinking water; (2) methods of preventing, detecting, and dealing with surface contaminant spills which may degrade underground drinking water sources; (3) viral contamination of drinking water sources and means of control of such contamination; (4) determination of the nature, extent, sources of and means of control of contamination by chemicals or other substances suspected of being carcinogenic.	Research and engineering personnel (§ 1442[a] 1-4).	Mandatory (§ 1442[a] 1-4).
§ 1443(a)(1)	The Administrator may make grants to states to carry out public water system supervision programs.	Personnel to review applications in the EPA; enforcement personnel in the states.	Discretionary. Type of program and intensity of supervision left to the Administrator.
§ 1443(b)(1)	The Administrator may make grants to the states to carry out underground water source protection programs.	Groundwater specialists.	

Citation	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
§1444(a)	The Administrator may make grants to any person for the purpose of– (1) assisting in the development and demonstration (including construction) of any project which will demonstrate a new or improved method, approach, or technology for providing a dependably safe supply of drinking water to the public; and (2) assisting in the development and demonstration (including construction) of any project which will investigate and demonstrate health implications involved in the reclamation, recycling, and reuse of waste water for drinking and the processes and methods for the preparation of safe and acceptable drinking water.	R & D personnel and various engineering personnel (§1444[a] 1-2).	Discretionary. Very broad discretion as to the type of project, field of inquiry and scope (§1444[a] 1-2).	

OCEAN DUMPING REGULATION

(33 USC §1401 et seq.–Marine Protection, Research and Sanctuaries Act of 1972)

Personnel Development Authorized by the Statute

Citation (cited as sections of the Act)	Summary of Statute	Type of Personnel Implication	Mandatory/Discretionary	Other
Subchapter I: Regulation §102	This section authorizes the Administrator to issue permits for the dumping of pollutants at sea, upon a finding that the dumping will not unreasonably endanger human health or the environment.	The EPA will need personnel for research, to set the standards, and to administer the permit program. Industry will need personnel to apply for permits and to comply with permit conditions.	The EPA is required to set up the permit system. The criteria for permits are within the Administrator's discretion. The Administrator is required to consider at least the factors listed in the statute when reviewing an application.	Indefinite
Subchapter II: Research §201	Research duties are assigned to the Secretary of Commerce, and are outside the scope of this summary.	Research		

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APPENDIX

B Methodology and National Data Aspects

INTRODUCTION

The Panel's objectives as initially conceived were: (1) the establishment of concepts and guidelines which could be considered by the other panels in the development of statistical data for assessment of manpower in their assigned areas; and (2) the development and analysis of manpower data involving the entire spectrum of environmental protection and pollution control.

Neither the existing data nor the time available were sufficient to develop a new, unified data system which would permit a satisfactory attainment of the first objective. Rather, the Panel examined existing data including the several sets of data developed by the other panels for their specific sectors. The Panel believes that the underlying assumptions adopted by the other panels are similar enough to make possible the development of many base estimates and to some extent the presentation of selected projections of manpower requirements.

The second objective has been partially attained through use of several data systems which supplement the segmental data considered by the panels in providing overall estimates of manpower, including total employment, professional and technical, and doctoral level staff directly involved in pollution control activities. Estimates of "indirect" employment, i.e., that generated in industries other than those of primary expenditures, are difficult to deal with in sectoral approaches but which are more feasible through interindustry analysis. Unfortunately, such an analysis was not possible at this time. Selected characteristics of scientific and technical manpower currently engaged in pollution control are available as a by-product of more extensive studies covering the total populations of scientists and engineers and of doctorates and are presented later in this Panel's report.

MANPOWER ENGAGED DIRECTLY IN POLLUTION CONTROL ACTIVITIES

Pollution control activities encompass a diverse and complex occupational mix, reflecting the wide range of activities and subjects included. The scientific and technical component of this mix includes large numbers of engineers engaged in design, construction, and operations; scientists, particularly biologists and chemists, employed in research, development, and operations; technicians working in drafting, laboratory testing, and operations; and managers. There are also large numbers of craft workers, operators, clerical and service personnel, and laborers involved in research, development, design, laboratory, monitoring, construction, operations, and miscellaneous other activities.

Table B.1 shows estimates of manpower engaged in 1974 directly in the principal pollution control activities. These data compiled from various public sources, including EPA, NSF, Bureau of the Census, and Bureau of Labor Statistics (BLS), should be considered an approximation of the number of people engaged in the activity rather than a precise census count. They include some who are employed part-time in pollution control work, but exclude others who are employed by contractors and suppliers, and who are sometimes considered as indirectly employed in pollution control activities. The inclusion of such indirect employment would likely raise substantially the estimates of pollution control manpower, particularly in the industrial sector. Finally, these data do not include a substantial number of "certified" pesticide applicators, such as farmers (industrial sector) and smaller numbers of persons (other than scientists and engineers) in noise and radiation control.

TABLE B.1 Estimated Direct Employment in Pollution Control Activities,[1] Summary Data 1974

Occupation	Type of Employer: Federal	State	Local Government	Industry	Educational Institutions	Other	Total
Scientists	11,400	3,800	2,200	14,900	5,500	3,100	40,900
Engineers	8,300	5,200	5,700	64,700	1,300	8,800	94,000
Technicians	1,000	2,000	20,000	25,000	Na	Na	48,000
Skilled operators	4,000	Na	155,000	112,000	Na	Na	271,000
Unskilled, clerical, other	4,000	3,000	147,000	67,000	Na	3,000	224,000
Total	28,700	14,000	329,900	283,600	6,800	14,900	677,900

Na Includes those areas for which data were unavailable.

[1] Excludes manpower in the fields of noise and radiation control and pesticide application.

SOURCE: See text.

NOTE: This table appears in identical form as Table 4.1 in the Committee report.

The development of an aggregate estimate such as shown in Table B.1 is never an entirely satisfactory exercise. There is always the element of mixing data gathered under widely differing assumptions. Also, there is a temptation to oversimplify the real complexities of a large-scale manpower demand situation by failing to get beyond the broad perspective such an aggregation provides.

The first two lines of data in Table B.1 are based on the 1974 NSF National Survey of Scientists and Engineers. The remaining data are based on a synthesis of the material provided in the panel reports on the federal government, state and local government, and industry and the private sector. The data from the 1974 survey have certain limitations, as described later in the section on National Information on Environmental Manpower. One primary limitation is that the 1974 counts of scientists and engineers exclude post-1970 entrants to the science and engineering labor force.

The summary data reveal that by far the largest impact of the pollution control program is on local governments and the private industry sector of the economy. Federal involvement is substantial however, and includes most of EPA, research and administrative work in other agencies such as Defense and Agriculture, and the operation of a limited number of treatment facilities. State governments are involved primarily at the regulatory level, with little research or actual operational responsibility. The category of educational institutions is included in the table to indicate the size of the teaching and academic research base currently available. The "other" category includes employees of nonprofit organizations and the self-employed.

Local government employment is largely accounted for by its heavy direct involvement in the operation of wastewater collection and treatment facilities, drinking water supply activities, and solid waste management.

The total number of people—678,000—directly employed in pollution control is substantial, but represents less than 1 percent of the total U.S. labor force of 91 million persons. Thus, even if demand were to double or triple during the next decade, no serious disequilibrium in the total labor force should result, given prevailing rates of unemployment. Of these 678,000 workers, nearly 20 percent are scientists and engineers and nearly 50 percent are skilled operators or technicians. Should future spending levels rise to anywhere near those currently being projected by EPA and others, then situations of excess demand could develop in selected specialties and skill areas.

Pollution control occupations require levels and types of training that range from those required for common labor to those required for management or scientific research. In the case of solid waste management, the level of training required for a large segment of the labor force is less than completion of high school, while the level required for many positions in radiation protection is in the range of a graduate degree. Within the fields of water supply and wastewater management, training requirements range from high school graduation for operators to a college degree for the engineer–manager who supervises the operation of a system.

It appears that the most serious pollution control manpower problems are largely at the professional and technical levels. Of course difficulties are to be found at the semiskilled, unskilled, clerical, and service worker levels, but these problems usually can be solved by competent managers.

Although scientists and engineers make up less than 2 percent of the employed civilian labor force, they represent fully a fifth of those employed directly in pollution control activities. Thus, it is not sufficient to compare the expected incremental demand for total pollution control manpower with the pool of available workers to determine whether there are enough hands with which to do the job. We must also know that there will be an adequate supply of highly-trained personnel for specific activities.

INDIRECT EMPLOYMENT

The estimates of direct employment for pollution control were developed from a variety of sources. Indirect employment, or employment that is expected to result from nonlabor expenditures for pollution control, cannot be estimated with existing data and models. The Panel had hoped to prepare projections of indirect employment using the BLS model and the BLS occupation–industry matrix, but this proved to be impossible with the time, resources, and data available.

There are four major obstacles that prevent estimation of indirect employment: (1) annual estimates of future pollution control expenditures could not be projected to the satisfaction of the Panel; (2) final demand generated in various industries by pollution control spending could not be estimated adequately; (3) input-output coefficients for industries with pollution control obligations could not be adjusted to reflect changes in production technologies and purchases from other industries; and (4) the occupational coefficients reflecting changes in industrial occupational structure as a result of pollution control activities could not be estimated.

The lack of sufficient data meant that whatever estimates might be made would be unreliable. Since the Panel did not trust the data, and was unwilling to make guesses for unavailable data, even illustrative projections were not made. This is not to say that other attempts at preparing such estimates are necessarily to be discouraged. The Panel was not under any compulsion to prepare such projections and did not wish to prepare and present projections that it could not believe.

Even though the Panel did not do projections of indirect employment, it believes that such projections are important and should be developed. An understanding of the economic and employment implications of important public programs such as pollution control requires that economic models be used, and consequently these models must be expanded to accommodate the study of alternative pollution control policies. The Panel does not believe that existing models and data permit such evaluation of alternatives.

Pollution control differs from many other public programs in that it influences production technology itself, and not just patterns of final demand. If one wishes to examine the consequences of an expenditure program that shifts expenditure from defense to health, for example, it may be possible to do this simply by specifying the expected changes in final demand patterns. In many instances it will be unnecessary to modify the input–output or occupational coefficients of the model. Similarly, examining the consequences of different levels of expenditure on public water treatment facilities can be managed fairly easily in existing models, but the public sector "industry" must be modified to provide a separate "water pollution control industry" and occupational coefficients for this industry must be developed as well. Pollution control programs are economically similar to energy programs in that both the patterns of final demand and production technologies are modified by the policy. Modeling and the preparation of projections for energy planning, however, have been much more explicit in development of economic models to project costs and employment effects of energy alternatives.

The following remarks are an explanation both of why the Panel did not use the BLS model to project indirect employment for pollution control and how the BLS model might be adapted to permit future development of such projections.

UNCERTAINTY OF LEVEL AND TIMING OF EXPENDITURES

Most experts do not expect the target dates for specified levels of clean air and water to be achieved. The period of delay that will be permitted is unknown, as is the amount of expenditure that will be required. As a result, no one knows or can even guess accurately what the level of pollution control spending will be in any future year. This is not an uncommon situation in projections, but it poses a special problem in pollution control. EPA has sponsored several studies of the effect of specified water pollution control technologies on the investment and operating costs of various industries for treatment of wastewater. Thus it is conceptually possible to program the levels of treatment to be attained at specific dates in the future and to estimate how much would have to be spent in the future to achieve these objectives.

It is doubtful that such projections would be likely forecasts. Some industries are apparently delaying construction in the expectation that the treatment levels or dates will be changed. Some firms have adopted new technologies that change processes so that the end-of-pipe output of pollutants that must be treated is reduced. Thus both the timing and the level of expenditures expected may be in error. The Panel believes that the understanding of behavior and processes is insufficient to permit accurate projections of expenditures in industry. The fundamental problem is lack of adequate data on what industries are doing and planning to do. In energy planning, in contrast, projections, based on models developed by Brookhaven National Laboratory and Bechtel, Inc., have been made for the demand for energy and for various alternative sets of energy facilities required to produce specified levels of energy. The direct and indirect economic and employment effects of these alternative scenarios can be estimated by models developed by Bechtel and the Center for Advanced Computation of the University of Illinois. This is a highly complex system in which the original requirements specified do not, in general, turn out to be the requirements of the system after energy development has been programmed. Therefore a number of iterations must be run for the demand and supply models to converge. A similar problem exists in pollution control. No simple "requirements" model, like the BLS model, can incorporate all of the interactions of supply and demand.

COMPOSITION OF FINAL DEMAND

If data were available on actual expenditure plans of industry and government, aggregate investment expenditures on pollution control plant and equipment could be compiled. However, it would still be difficult to assign these expenditures in a particular year to a specific final demand category. Capital spending consists not only of plant but also of equipment, and expenditures for capital by each industry must be classified into construction and equipment-supplying industries. Such assignments have been made in various applications, but they are of questionable accuracy.

Once again, the comparison to energy planning is instructive. The Bechtel Energy Supply Planning Model includes estimates of direct employment coefficients for each of the energy facility categories and direct material requirements as well. The material requirements can be converted into industry final demand in the BLS model, so that an energy construction scenario can be readily converted to a BLS industry final demand vector.

INPUT–OUTPUT COEFFICIENTS

Not only does pollution control entail capital construction, but it involves operating and maintenance costs as well. The industries from which operating and maintenance purchases will be made cannot be estimated. It seems likely, for instance, that in many industries these purchases will be largely energy, chemicals, and direct labor. It would be expected, therefore, that the input coefficients for energy and chemicals would be increased somewhat as a result of pollution control. Data to permit such input–output coefficients are not available. The amount of change in the coefficients depends on the rate at which new facilities are actually brought into operation and therefore depends on the prior estimates of construction.

The comparison to the energy situation is again instructive. Several modes have been developed to modify input–output coefficients to reflect conservation or the higher price of energy changes in fuel mix (consistent with energy supply models) and the structure of energy producing industries themselves.

OCCUPATIONAL COEFFICIENTS

Occupational coefficients are derived from estimates of total industry production and employment and the estimated occupational employment in each industry. It is usually assumed that employment in each occupation expands or contracts proportionately with employment in the industry for different projected production scenarios. Over time, of course, the composition of an industry's employment by occupation changes. It can be expected that the occupational composition of an industry's employment will be changed by the adoption of additional pollution controls. The occupational composition of the workers engaged in pollution control operations and maintenance will differ from the composition of workers engaged in other activities. This change in occupational composition must be estimated for a specified program of pollution control. In energy planning, for instance, several attempts have been made to develop energy–industry occupational coefficients that reflect the projected sets of specific energy facilities that the industries will operate.

The Panel hopes that future efforts to study current and future impacts of pollution control programs on manpower will include specific activities to measure indirect employment.

NATIONAL INFORMATION ON ENVIRONMENTAL MANPOWER

In addition to the manpower data collected by the other panels, two national surveys were available concerning scientific and engineering personnel. These surveys, though having certain limitations (as described below), are the only comprehensive sources of data on such personnel engaged in pollution control activities. These surveys are the 1974 National Survey of Scientists and Engineers conducted by the Bureau of the Census for the National Science Foundation (called the "National Sample" by NSF)[1] and the 1975 Survey of Doctoral Scientists and Engineers conducted by the National Research Council for the National Science Foundation (called the "Comprehensive Doctorate Roster").[2] They provide selected characteristics of scientists and engineers in environmental protection and pollution control and provide a basis for estimating total science and engineering employment in these activities.

[1]Background information and data relating to this survey are provided in the following publications:

National Science Foundation. Characteristics of the National Sample of Scientists and Engineers, 1974:

Part 1 (1975) Demographic and Educational (NSF 75-333).

Part 2 (1976) Employment (NSF 76-323).

Part 3 (in press) Geographic; also see:

U.S. Bureau of the Census (1975) Current Population Reports. Selected Characteristics of Persons in the Fields of Science or Engineering: 1974. Special Studies, Series P-23, No. 53. Washington, D.C.: U.S. Government Printing Office.

[2]For background information see National Research Council (1976) Characteristics of Doctoral Scientists and Engineers in the United States, 1975. Survey of Science Resources Series. Washington, D.C.: National Science Foundation; Washington, D.C.: U.S. Government Printing Office.

SCIENTISTS AND ENGINEERS IN POLLUTION CONTROL ACTIVITIES

Information collected in connection with the NSF's 1974 National Sample identified approximately 135,000 individuals reporting professional work devoted to environmental protection and pollution control. This is about 12 percent of all persons identified in the survey as scientists and engineers. The figure is a minimum one because persons not originally included in the 1970 Population Census and a 1972 follow-up survey are omitted. Respondents in the survey were asked to indicate selected areas of critical national interest to which they devoted "a significant proportion of your professional time." Therefore, the count of 135,000 includes a number of persons spending less than full-time in pollution control activities, but also excludes other part-time involvement for those indicating another critical national area as significant. Whether these separate part-time involvements balance each other is debatable. However, the count of 135,000 is a minimum for other reasons: new entrants to the science and engineering labor force since 1970 are not included; a number of scientists and engineers did not respond to the question on areas of national interest; and a number of persons originally responding as scientists and engineers in 1970 and 1972 were excluded from the National Sample by NSF because they did not meet certain criteria. (A considerable number of engineers without degrees were excluded.)

The following tables present summary data on the 135,000 scientists and engineers involved in environmental protection or pollution control. In these tables two different measures were used to denote areas of science and engineering. One was an occupational measure, by which certain scientists or engineers could indicate actual employment in 1974; for example, as an engineer or chemist, or perhaps as an administrator, manager, or even technician (see Tables B.2 and B.3). The other measure is a classification by NSF of all persons into several "fields of identification" on the basis of training and experience (see Tables B.4 and B.5). Thus, Table B.2 shows 80,900 engineers and Tables B.4 and B.5 show some 94,000 engineers.

Similarly, in these tables, two measurements were used to indicate involvement in a sector of the economy. In Tables B.2 and B.3 the scientists and engineers are classified by response as to whether they were self-employed or employees of a private company or governmental, nonprofit, or international organization. These tables do not indicate involvement with educational institutions because the classification is by type of employee rather than by type of employer. Other data shown in

TABLE B.2 Occupation by Type of Employee for Scientists and Engineers in Pollution Control,[1] 1974

Occupation	Type of Employee[2] Private Business	Government Federal	State	Local	All Other[3]	Total
Engineers Total	54,643	7,999	5,820	5,379	7,059	80,900
Chemical	8,658	416	91	153	724	10,042
Civil	8,492	3,628	3,086	3,039	2,267	20,512
Sanitary	5,847	759	1,674	1,068	1,381	10,729
Electrical	5,460	156	133	51	445	6,245
Mechanical	13,584	999	256	527	1,188	16,554
Other	12,602	2,041	580	541	1,054	16,818
Chemists and physicists	7,659	1,823	1,195	841	1,072	12,590
Earth scientists[4]	607	1,575	865	394	713	4,154
Agricultural scientists	914	5,806	1,792	365	330	9,207
Biological scientists	771	1,267	2,066	375	992	5,471
Administrators and managers	12,880	1,009	534	214	1,709	16,346
All other occupations[5]	2,452	901	792	718	1,019	5,882
All occupations	79,926	20,380	13,064	8,286	12,894	134,550

[1] Persons reporting significant professional time devoted to these activities.
[2] Educational institutions (colleges or universities) are classified under the various categories by type of control.
[3] Includes nonprofit or international organizations, self-employed, and no reports.
[4] Includes environmental, marine, and atmospheric scientists.
[5] Includes social scientists, technicians, teachers, all other occupations, and no report.

SOURCE: 1974 National Survey of Scientists and Engineers.

TABLE B.3 Primary Work Activity by Type of Employee for Scientists and Engineers in Pollution Control,[1] 1974

Primary Work Activity	Type of Employee[2] Private Business	Government Federal	State	Local	All Other[3]	Total
R&D Total	21,754	6,072	3,248	1,069	3,003	35,146
Basic research	746	1,371	642	112	698	3,569
Applied research	3,068	1,773	1,364	341	552	7,098
Development	8,890	798	58	111	627	10,484
Management and administration of R&D	9,050	2,130	1,184	505	1,126	13,995
Other management and administration	16,514	5,484	3,091	2,329	2,768	30,186
Design	11,498	1,480	547	901	1,119	15,545
Teaching	239	232	1,934	346	1,195	3,946
Quality control	3,754	476	335	618	121	5,304
Operations	10,214	1,499	546	855	291	13,405
Consulting	6,712	1,606	797	371	3,102	12,588
All other activities[4]	9,241	3,531	2,566	1,797	1,295	18,430
All activities	79,926	20,380	13,064	8,286	12,894	134,550

[1] Persons reporting significant professional time devoted to these activities.
[2] Educational institutions (colleges or universities) are classified under various categories by type of control.
[3] Includes nonprofit or international organizations, self-employed, and no reports.
[4] Includes technical writing, all other activities, and no report.

SOURCE: 1974 National Survey of Scientists and Engineers.

TABLE B.4 Highest Degree, by Field of Science or Engineering for Scientists and Engineers in Pollution Control,[1] 1974

	Field of Science or Engineering				
Highest Degree	Engineering	Agricultural and Life Sciences	Physical Sciences	All Others[2]	Total
Doctorate	3,566	3,475	6,555	903	14,499
Master's	19,137	3,824	4,546	1,414	28,921
Bachelor's	67,933	8,657	9,708	1,390	87,688
Other degrees[3]	1,137	48	38	12	1,235
No degree	2,207				2,207
All degrees	93,980	16,004	20,847	3,719	134,550

[1] Persons reporting significant professional time devoted to these activities.
[2] Includes computer specialists, social scientists, other fields, and no report.
[3] Includes associated degrees and no report of degree.

SOURCE: 1974 National Survey of Scientists and Engineers.

Attachment B.II show employment by kind of business or industry, such as chemical, aircraft, educational institution, hospital, and so on.

In addition to these summary tables, Attachment B.II includes additional data from the National Sample Survey.

More than 60 percent of the scientists and engineers engaged in pollution control, most of them employed in private industry, reported their occupations as engineer. Chemists and other physical scientists accounted for another 9 percent, again predominantly in industry. Agricultural scientists, who represented another 7 percent, were mainly employed by the federal government, and biologists at 4 percent were employed chiefly in state government. Earth scientists[3] were reported at a modest 3 percent, mainly in the federal government. About 12 percent of the scientists and engineers were employed as managers and administrators.

These proportions may be compared to those for the more than one million scientists and engineers included in the 1974 National Sample Survey. Most of the proportions for the total population and the pollution control population of scientists and engineers were about the same with the following exceptions: less than half of the total population reported their occupation as engineer, and smaller ratios were found for agricultural and biological scientists than for those in pollution control. In the total

[3]Note that this 1975 estimate of 16,000 corresponds well to the 14,500 identified by the 1974 National Sample Survey.

TABLE B.5 Field of Study by Field of Science or Engineering for Scientists and Engineers in Pollution Control,[1] 1974

Field of study	Field of Science or Engineering: Engineering	Agricultural and Life Sciences	Physical Sciences	All Others[2]	Total
Engineering (Total)	82,813	142	765	79	83,799
Chemical	13,118	0	404	0	13,522
Civil	22,628	0	54	13	22,695
Environmental/ sanitary	542	0	0	0	542
Electrical	8,590	0	84	51	8,725
Mechanical	20,562	15	13	0	20,590
All others	17,373	127	210	15	17,725
Agricultural and life sciences	1,546	14,636	1,811	110	18,103
Chemistry and physics	2,555	43	13,534	57	16,189
Other physical sciences	1,250	104	4,171	799	6,324
Social sciences including psychology	439	186	67	2,368	3,060
All others[3]	5,772	964	652	337	7,725
All fields	94,375	16,075	21,000	3,750	135,200[4]

[1] Persons reporting significant professional time devoted to these activities.
[2] Includes computer specialists, social scientists, other fields, and no report.
[3] Includes no report.
[4] Total (135,200) exceeds others in this series owing to inclusion of 650 persons not reported by sex.

SOURCE: 1974 National Survey of Scientists and Engineers.

population of scientists and engineers larger proportions were employed in such occupations as social scientists, in health fields, and as teachers, technicians, and technologists. Attachment B.II presents a distribution of scientists and engineers in environmental protection and pollution control by field of science or engineering and by more detailed industry categories. Table B.II.3 shows that over 29,000 pollution control scientists and engineers were employed by construction/engineering firms, 15,000 were in chemical companies, 6000 in electrical, 7500 in fabricated metals and machinery, 7200 in transportation firms, nearly 4500 in public utilities, and nearly 7000 of these scientists and engineers worked for educational institutions.

Scientists and engineers in environmental protection and pollution control represented about 12 percent of all scientists and engineers in the 1974 survey population. This ratio varied considerably by occupation. Those in the pollution control group were small minorities in such occupations as mathematicians, social scientists, and administrators and managers. In several other occupations, those in pollution control represented sizable proportions of the total, for example, 28 percent of all chemical engineers, 19 percent of the chemists, 22 percent of the biological scientists, and of course practically all of the environmental and sanitary engineers.

Work activities of scientists and engineers engaged in pollution control range from basic research to operations and quality control. Table B.3 summarizes the principal work activities that were designated as being "primary" by the nearly 135,000 identifed in the National Sample enumeration.

Approximately 26 percent (35,150) report some phase of research and development design as their primary activity. Management of R&D (10 percent), development (8 percent), and applied research (5 percent) lead in that order, with basic research accounting for a little less than 4 percent. A substantial fraction of these scientists and engineers serve as managers, with 33 percent reporting this activity, including R&D and other management and administration. Design accounts for 12 percent, operations represent 10 percent, and quality control another 4 percent. The unique nature of pollution control is indicated by the 9 percent (largely in industry and self employment) reporting as consultants. Teaching is a primary activity for only 3 percent.

The proportionate distribution by work activity of the total 1974 population of scientists and engineers was again similar to that for pollution control scientists and engineers with one major exception—teaching, where 8 percent of the total was found.

Industry leads all other employee categories in each of the activities reported, with the exception of basic research and teaching. Federal government employees outnumber other types of employees in basic research, although this activity accounts for only 7 percent of all federal workers. State government leads in the teaching category because some persons on state university staffs are reported here.

In Tables B.2 and B.3, the horizontal distribution is by type of employee and not by employer. Thus, educational institutions are not shown separately but are included under state and local governments or "all other." In the total population of scientists and engineers, where data on educational institutions are separately available, 46 percent of those in basic research are employed by educational institutions, compared to 17 percent by the federal government. Similarly, in the total population 93 percent of those in teaching are employed by educational institutions, compared to under 3 percent for state and local government bodies.

Academic degree levels are one measure of professional qualifications and permit comparison among different occupational groups and employers. In Table B.4 the highest academic degrees attained for the National Sample survey population are cross-classified by broad field of science or engineering. As might be expected, bachelor's degrees dominate the distribution with 65 percent of the population; master's degrees follow with 21 percent; and doctoral degrees trail with 11 percent. Until recently, engineers tended to consider the bachelor and master degrees as meeting academic professional qualifications in the engineering field. The distribution reflects this, since the 1974 population excludes entrants after 1970. In terms of fields, physical scientists show the highest proportion of doctorates at 31 percent, followed by agricultural and life scientists at 22 percent, and engineers at 4 percent.

These ratios of pollution control scientists and engineers can be compared with similar data on the total population as indicated in the 1974 National Sample population. For all scientists and engineers combined, 17 percent reported doctoral degrees, 22 percent master's, and 58 percent baccalaureates. Thus, the pollution control group has a slightly lower level of educational attainment than the total group. The proportion with doctorates is lower in pollution control than in the total group in nearly every field of science or engineering.

Table B.5 classifies broad fields of identification according to the field of study of highest degree attained. Generally, the higher the academic degree attained, the more closely its field of study corresponds to that of the current field. The correspondence between field of identification and field of study is quite high in all these occupations. For example, 88 percent of the 94,000 identified as engineers claim their field of study to be engineering; 84 percent of the 21,000 physical scientists had physical sciences as their field of study; and 91 percent of the 16,000 agricultural and life scientists studied in those fields. While there is considerable

TABLE B.6 Type of Employer by Employment Specialty for Doctoral Scientists and Engineers in Pollution Control,[1] 1975

	Employment Speciality						
Type of Employer	Physical Sciences	Earth Sciences[2]	Engineering	Agricultural Sciences	Biological Sciences	Other	Total
Industry	2,454	937	1,898	191	410	468	6,358
Educational institutions	766	1,203	823	524	1,300	993	5,609
Federal government[4]	410	669	333	522	687	171	2,792
State government	36	201	107	49	41	89	523
Local government	30	62	88	0	48	34	262
Misc. nonprofit institutions	162	140	49	6	157	86	600
Other employers[3]	12	0	29	5	18	9	73
Total	3,870	3,212	3,327	1,297	2,661	1,850	16,217

[1] Persons reporting significant professional time devoted to these activities.
[2] Includes environmental and marine sciences.
[3] Includes social sciences, other specialties and no report.
[4] Includes U.S. military service.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

latitude within these occupational groupings (as well as the fields of study) for mismatches, the conclusion seems clear that predominantly the scientists and engineers engaged in pollution control activities carry academic credentials in their fields.

The same high degree of correlation between field of study and field of science or engineering exists for the total 1974 population of scientists and engineers. Ratios of 80 percent exist for most fields.

Engineering, however, tends to attract those academically trained in other fields, notably the physical sciences, which share a similar academic preparation. For example, of the 22,500 whose field of study was chemistry, physics, and other physical sciences, 17 percent were identified in engineering in 1974. The movement to the physical sciences from academic study in engineering appears much smaller, with less than 4 percent of persons in these fields reporting an engineering field of study.

The 1974 National Science Foundation Survey also obtained information on the geographic location of the scientists and engineers both for 1970 and 1972. The modal location in both years (in terms of residence) was the East North Central States, followed by the Middle Atlantic and Pacific States. During the two-year interval, about 6 percent of all scientists and engineers made an interregional move; 10 percent of those with doctoral degrees made such moves. Demographers indicate that both the probability and the distance of moves are positively correlated with the educational level. Migration rates of this order can have a significant impact on the geographic match or mismatch between jobs and people qualified to fill them.

DOCTORAL SCIENTISTS AND ENGINEERS IN POLLUTION CONTROL ACTIVITIES

The National Research Council (NRC) sample survey indicates that slightly over 16,000 (6 percent) of the nearly 263,000 employed scientists and engineers with doctorates reported devoting "a significant proportion of their professional time" to environmental protection or pollution control as of February 1975.[4] This is half the ratio of about 12 percent obtained in the 1974 National Sample Survey for the total population, including all degrees. As in the case of the National Survey, the count of persons involved in pollution control includes some part-time engagement in this activity, but excludes some other part-time engagement for those in other national activities. However, unlike the National Survey population, the doctorate population includes all entrants up to 1974.

As shown in Table B.6, the principal employment specialties of the

[4]See note 3 above.

TABLE B.7 Primary Work Activity by Type of Employer for Doctoral Scientists and Engineers in Pollution Control,[1] 1975

	Type of Employer							
			Government					
Primary Work Activity	Industry	Educational Institutions	Federal[2]	State	Local	Nonprofit Institutions	Other[3]	Total
R & D Total	4,120	2,810	2,275	290	110	496	15	10,116
Basic research	334	1,208	593	22	16	113	15	2,301
Applied research	1,429	1,044	811	78	43	191	0	3,596
Development	473	15	31	30	0	17	0	566
Management and administration of R & D	1,884	543	840	160	51	175	0	3,653
Other management and administration	711	132	152	126	94	33	19	1,267
Teaching	16	2,399	5	0	0	0	0	2,420
Quality control	64	13	28	12	8	0	0	125
Production	104	0	11	0	0	0	0	115
Consulting	772	25	38	28	11	19	24	917
All other activities[3]	571	230	283	67	39	52	15	1,257
Total	6,358	5,609	2,792	523	262	600	73	16,217

[1] Persons reporting significant professional time devoted to these activities.
[2] Includes U.S. military service.
[3] Includes no report.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

pollution control doctorates are in the physical sciences (24 percent), engineering (21 percent), and the earth sciences (20 percent).[5] The biological sciences account for 16 percent and agricultural sciences for another 8 percent. This distribution compares with the following for all doctoral scientists and engineers: physical sciences (19 percent), engineering (16 percent), earth sciences (5 percent), biological and agricultural sciences combined (25 percent). The main reason for the difference in distribution is that social scientists are 12 percent of all doctorates.

Another useful perspective on pollution control doctorates is the relationship between the types of their employers and their primary work activities. Table B.7 shows this relationship for the slightly more than 16,000 doctorates reporting professional time devoted to these activities.

Industry employs 39 percent of the pollution control doctorates; educational institutions (principally colleges and universities) employ 36 percent; and the federal government, 17 percent. Most of the other work for state and local governments and miscellaneous nonprofit institutions. Thirteen percent of those employed in colleges and universities identify their occupation as social scientist (included in "all other" category).

More than 30 percent of the doctorates work primarily as managers and administrators, when R&D management is combined with the "other management" category. Unlike the picture of all pollution control scientists and engineers provided by the 1974 NSF survey, the doctorate survey data show a rather strong division of labor among employment sectors. Fourteen percent of the doctorates work primarily in basic research, mainly in the four-year colleges and federal government; 22 percent work in applied research, largely in industry and the colleges; 15 percent teach; and 6 percent are in consulting (nearly all in private industry).

The distribution of all doctoral scientists and engineers differs greatly from those in environmental activities. Nearly 60 percent of all doctorates are employed by universities, compared to 25 percent by industry and only 8 percent by the federal government. Doctorates in all fields and activities are engaged to a greater degree in teaching (36 percent) and to a lesser degree as managers (20 percent) than are those in pollution control activities.

The correspondence between the number of doctorates trained in a specific field and the total number of doctorates employed in that field, as shown in Table B.8, ranges from highs of 91 percent in chemistry and the social sciences to a low of 35 percent for those employed in earth sciences.

[5] Earth sciences in the NRC Doctorate Survey include the marine and environmental sciences. As in the case of the National Sample Survey, the category of environmental sciences refers to a discipline rather than to a field of national interest such as pollution control.

TABLE B.8 Field of Doctorate by Employment Specialty for Doctoral Scientists and Engineers in Pollution Control,[1] 1975

	Employment Specialty								
Field of Doctorate	Physics	Chemistry	Earth Sciences	Engineering	Agricultural Sciences	Biological Sciences	Social Sciences	All Other	Total
Physics	325	40	367	142	10	19	22	19	944
Chemistry		3,119	562	378	34	71		213	4,377
Earth Sciences[2]	1	17	1,121	59	28	26	4	21	1,277
Engineering	106	59	268	2,619		30		91	3,173
Agricultural Sciences		44	143	14	922	218	23	12	1,376
Biological Sciences	5	142	617	50	252	2,223	6	203	3,498
Social Sciences[3]			75	34	42	39	894	77	1,161
All other fields[4]		12	59	31	9	35	29	236	411
Total	437	3,433	3,212	3,327	1,297	2,661	978	872	16,217

[1]Persons reporting significant professional time devoted to these activities.
[2]Includes environmental and marine sciences.
[3]Includes psychology.
[4]Includes mathematics, other specialties, and no report.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

Other ratios of correspondence ranged from 84 percent for those employed as biological scientists, 79 percent for engineers, 74 percent for physicists, and 71 percent for agricultural scientists. Whether the training of scientists and engineers in fields other than that of their employment is necessarily inappropriate to the performance of their jobs is a matter that must be determined separately. This matter merits further study, particularly in the case of the earth sciences, where a wide range of doctoral specialties is represented.

Correspondence between field of Ph.D. and field of employment for the *total* doctoral population differs substantially in some of the fields from that for pollution control doctorates. For example, there was an 87 percent correspondence for physicists and 61 percent for earth scientists (the latter almost double the ratio for those in pollution control activities).

A behavioral characteristic which is closely related to job mobility is that of geographic mobility or human migration. The migratory nature of Americans has been overplayed by some who correctly point out that since the Second World War, about 20 percent of our population has moved (changed residence) each year, but who ignore the converse fact that 80 percent stay put and that most movers move only a short distance, typically within a county. Still, migration patterns are sufficiently important in national and regional manpower forecasting that they need to be carefully incorporated in forecasting models.

As has been noted earlier in this report, geographic location and behavioral differences in the tendency to migrate for employment are possibly important determinants of manpower supply/demand balances. One indicator of willingness to make interregional moves is shown by the function of pollution control doctorates who remain in the region in which they received their degrees:

Region of Doctorate	Percent Employed in Same Region
New England	29.8
Middle Atlantic	39.9
East North Central	35.1
West North Central	28.7
South Atlantic	51.1
East South Central	35.9
West South Central	35.8
Mountain	39.9
Pacific	56.2
Average, all regions	39.1

On the average, fewer than 40 percent of the doctorates are found to be employed in the same region in which they received their doctoral degrees. Two regions that employ more doctorates than they train—Pacific and South Atlantic—show more than 50 percent of their awarded doctorates remained employed within the region. At the other extreme, New England and West North Central export more than 70 percent of doctorates awarded. It seems to follow that the employment market for doctorates is indeed a national one, with both training and employment opportunities well diffused among the regions.

These characteristics of training and employment make possible a high level of occupational and geographical mobility. Actual patterns of mobility in the labor force are being closely studied by social scientists, but the results of such studies remain to be incorporated systematically in manpower supply forecasting models. There is evidence that Ph.D. scientists, for example, change jobs at a rate of about 5 percent a year even 10 or more years after having received their doctorate degrees.[6] Such important behavioral characteristics must be accounted for in forecasting systems.

THE SUPPLY OF POLLUTION CONTROL MANPOWER

THE DIMENSIONS OF MANPOWER SUPPLY

In a simple, static conceptual model of the labor market, the concept of manpower supply begins with the existing stock of persons in a particular occupation or involved with a particular activity. To this stock of persons there will be additions from time to time which will tend to increase total supply. Among such sources of increased supply would be specific training programs geared to produce members of the occupations in question. For example, graduates of vocational education programs such as mechanics, or holders of certain degrees, such as accountants, constitute the specifically trained flow into their respective occupations.

In addition, almost all occupations are entered by persons who have had training courses or educational experiences in different, but often related, fields. Examples of this may be the political science graduate who

[6]McGinnis, R. and J.S. Long (1976) The Enduring Effects of Ph.D. Origin: Early Careers of Four Cohorts of Scientists. Paper presented at The International Symposium on Quantitative Methods in the History of Science, Berkeley, California. August 25-27.

enters social work, or the mechanical engineering graduate whose first job is in management. There is a great deal of this type of movement, in part because there is always a less-than-perfect match between occupations and formal education or training. The difficulty in accounting for potential movement of this type and the difficulty in predicting new entries from schools to a particular occupation become significant for manpower projection studies. The only exceptions are in fields of licensed occupations such as medicine or law.

A third source of new entries to an occupation is from other more or less related occupations. As in the case of entries from related training programs, it is difficult to predict the exact degree of occupational mobility to expect in a given situation. New fields or new occupations might tend to draw very heavily on this source until adequate specific training sources have been developed.

Other sources of new entrants to an occupation, such as immigration, are not too important in this case.

Together, the above sources provide all of the members of any occupational category. In order to fairly estimate the flow of new entrants, each source should be taken into consideration.

On the other hand, separations are always taking place from a set of occupations or activities. These separations include transfers to other occupations, retirements, deaths, and emigration. Unlike new entries, separations tend to be fairly stable and predictable and to depend in large measure on retirement and death rates.

A complete static analysis using this type of model involves estimating the stock or supply of persons at a given time, adding the potential new entries from all sources, and subtracting all likely separations. The resulting estimate of the supply of manpower at some future time can then be compared with a separately determined estimate of demand. If a severe imbalance seems likely, corrective measures can be suggested to assure a better balance between future supply and demand.

The purpose of the following presentation of supply data is to provide approximate figures regarding the flow of new entrants from training institutions to the labor market. While this clearly deals with only one of the many sources of new entrants to an activity or occupation, it is an important one when new or changing technology is involved. The actual occupational destination of these new entrants and the distribution in the existing labor force depend largely on the relative wages offered by industry and government for specialized services. In the long run the national pollution control program will have full access to a high quality labor force if, and only if, wages for environmental activities are maintained at a level equal to or exceeding that offered for general manufacturing and service activities.

POLLUTION CONTROL OCCUPATIONS

One general category of workers in pollution control includes those assigned to the specific tasks of designing and managing treatment and process facilities. This category includes a variety of engineers, specialists in environmental or sanitary engineering, scientists, treatment plant managers, sanitarians, technicians, health technologists, operators, and technical support specialists. Their background training may be multi-disciplinary in nature and quite specific to existing "end-of-pipe" treatment of waste handling and disposal technologies. While clearly this group does not include all environmental manpower, it is an important group for the efficient management of the pollution control program. It is the special expertise of this segment of the labor force that serves to set the overall control strategies and to coordinate the activities of many other professionals.

The Panel has made an effort to evaluate the supply situation for these occupations. Unfortunately, detailed and reliable data were not always available for all occupations directly related to pollution control. However, the Panel was able to assemble some data regarding environmental engineers that are illustrative of the manpower supply process. This emphasis on environmental engineers is in no way intended to minimize the importance of other pollution control professionals.

THE CASE OF ENVIRONMENTAL ENGINEERS

Environmental engineers usually have background educational skills in the applied sciences and specific skills in design, waste management, and residuals disposal. Data from the NSF National Survey cited above show that of all scientists and engineers engaged in environmental protection or pollution control, 8 percent classified themselves as sanitary or environmental engineers. Although these specifically trained pollution control engineers constitute only a small proportion of the nation's full-time environmental manpower, they are an important element in the environmental labor force. They not only provide specific expertise, but also facilitate communication among the full team of technical specialists necessary for a successful pollution control program.

According to the NSF data, slightly more than 10,700 engineers identified themselves as sanitary engineers in pollution control in 1974. Of that number, only about 542 reported their field of study as environmental or sanitary engineering. The rest apparently entered their professions following academic preparation in civil, chemical, mechanical, or other types of engineering or science disciplines (see Tables B.II.4 and B.II.5 in Attachment B.II). The 1974 survey on which this

TABLE B.9 Earned Degrees Conferred in Environmental and Sanitary Engineering

	Bachelor	Master	PhD	Number of Schools	Total
1964-65	11	130	13	25	154
1965-66	11	181	23	31	215
1966-67	17	178	28	27	223
1967-68	55	264	38	37	357
1968-69	44	197	34	35	275
1969-70	52	235	42	39	329
1970-71	54	238	49	39	341
1971-72	92	359	41	51	492
1972-73	187	527	41	50[a]	755
1973-74	182	570	59	56	811
1974-75[a]	216	467	55	60	738

[a]Unpublished data.

SOURCE: U.S. DHEW (1964-1975).

information is based used a sample selected from the 1970 Census; the total figures do not include any new entrants to science and engineering fields since 1970. It is likely that most of those receiving degrees in environmental engineering from 1970 to the present are working in the environmental field, adding about 3000 to the 1974 figure, based on the data in Table B.9 (U.S. DHEW 1964–1975).

In addition, the pattern of mobility from field of study (Table B.II.5) to occupational specialty (Table B.II.4) for older sanitary engineers suggests that some of the new environmental engineers could also have come from other academic disciplines. Indeed, the historical pattern is for 95 percent of the nation's sanitary engineers to hold degrees in fields other than sanitary engineering. This fact raises questions regarding the training of the existing stock of engineers and suggests the importance of continuing education to update the skills of these professionals.

For these reasons it is fairly certain that the data from the 1974 National Sample Survey underestimate the number of self-defined environmental engineers in this country at the present time. Based on these considerations and the data provided in Table B.9, it is estimated that the current stock of self-identified environmental engineers may reach 15,000, of whom no more than 3500 have either an undergraduate or graduate degree in environmental engineering.

The future outlook for graduate level degrees in environmental engineering programs is suggested by the enrollment data in Tables B.10 and B.11. Table B.10 shows the level of enrollment in selected

TABLE B.10 Graduate Students in Water Pollution Control Engineering[1]

Academic Year	Total Students	New M.S. Students in Fall
1971-72	2406	1271
1972-73	2424	1203
1973-74	2211	1108

[1] 108 Programs at 105 Schools

SOURCE: Association of Environmental Engineering Professors (1974).

TABLE B.11 Summary of Responses to 1975-76 Survey of Graduate Student Enrollments in Environmental Engineering and Environmental Science Programs

	Fall 1975[1]	
Program Designation	Total Graduate Students	New M.S. Students
All full-time graduate students in environmental engineering	1,340	593
Sanitary Engineering	1,001	448
Air pollution	141	59
Solid Wastes	14	4
Industrial Hygiene	5	1
Radiological Health	7	2
Environmental Control	21	13
Environmental Design and Management	18	6
Other	133	60
All full-time graduate students in environmental science	434	173
All full-time graduate students in water resources	266	108
All part-time graduate students in any of the above programs	1,091	301

[1] Data is cumulative from 106 responses out of a total of 122 programs contacted.

SOURCE: Jewell, W. J. and M. S. Switzenbaum (1976) Trends in Enrollment in Environmental Engineering and Related Areas: 1975-76 Survey. Unpublished paper.

environmental engineering programs during the 1971–1974 period. These tables also show a decline in new enrollments from the 1971 peak of 1271 to 862 full-time enrollments in 1975. However, as Table B.9 shows, both the number of institutions involved and the number of degrees granted at all levels continued to expand through 1975. The apparent growth of part-time study will tend to prevent any drastic reduction in the number of degrees granted over the next several years, particularly if there is sustained demand from employers. Finally, the striking increase in the number of bachelor-level degrees in environmental engineering (from 111 in 1965 to 216 in 1975) suggests that undergraduate programs may in the future make substantial contributions to the supply of environmental manpower.

Table B.11 shows that in addition to the 593 new full-time enrollments there were 301 new part-time candidates for the master's degree in environmental engineering and science programs. This represents 25 percent of the 1163 actual new enrollments for 1975. Also, Table B.11 indicates that 35 percent of the 3131 students enrolled in these programs were part-time. This suggests that young professionals in entry-level positions in environmental agencies were upgrading their skills through advanced-level study. Part-time study also implies that individuals and their employers are assuming the costs of training programs. Such commitments reflect both careful individual assessment of local career opportunities and a sensible mode of financing professional education.

It is difficult to assess the adequacy of the supply of environmental engineers to meet future requirements. On the one hand, the number of graduates from graduate level environmental engineering programs, about 500 in 1975, seems small for the nation's ongoing commitment to a cleaner environment. On the other hand, in the past a considerable labor market adjustment has occurred to meet actual demand. The supply of new entrants from formal training programs has been augmented by transfers from related occupations. The workings of this adjustment process have increased the stock of environmental engineers well beyond those produced by the schools.

THE CASE OF ENVIRONMENTAL TECHNICIANS

The manpower situation for technicians and operators is analogous to the situation for environmental engineers. That is, the existing supply of manpower is large and consists of those with a combination of formal education and on-the-job training. As demand expands, new entrants are attracted from other fields and more experienced workers move up to positions of greater responsibility. In the field of water and wastewater treatment, formal training programs are especially important for both

TABLE B.12 Enrollment in Vocational Education by Instructional Program and Year, 1969–1979 (Projected)

Instructional Program	Year 1969	1970	1971	1972	1973	1974	1979 (Projected)
Environmental control technology	2,559	2,035	2,956	4,634	6,603	6,031	10,000
Air pollution technology			356	1,173	763	390	2,000
Water and wastewater technology		169	802	1,483	1,298	3,837	6,000
Environmental health			2,998	1,401	1,785	2,254	5,000
Automotive mechanics and technology	130,373	135,982	181,224	235,817	283,172	315,612	515,000
Agricultural production	645,377	584,757	557,633	564,155	561,868	552,441	522,000

SOURCE: U.S. Office of Education (1972-1974).

TABLE B.13 Enrollments and Completions in Vocational Education by Instructional Program and Level for Fiscal Year 1974

	Enrollments			Total Enrollments	Completions
Instructional Program	Secondary	Post-Secondary	Other Adult		
Environmental control technology	297	3,829	1,905	6,031	1,420
Air pollution technology		122	268	390	192
Water and wastewater technology		755	3,082	3,837	2,620
Environmental health	365	1,293	596	2,254	526
Automotive mechanics and technology	181,686	49,277	84,649	315,612	77,270
Agricultural production	328,713	17,673	206,055	552,441	63,545

SOURCE: U.S. Office of Education (1974).

new and experienced workers because state certification requirements for operators have become almost universal as a quality control and public health measure.

At the technician level there are a number of formal training routes for facility operators and other skilled workers in pollution control occupations. One such route is the vocational education system operating in all parts of the United States. Another route is through community college systems, which in many localities are responsive to specialized training requirements. Tables B.12 and B.13 provide the dimensions of vocational education in pollution control training in recent years. EPA does not fund these programs nor have any significant direct involvement in their planning or oversight. For the most part, they are ongoing programs at local educational institutions and are subject to local labor market conditions and institutional policies.

Table B.12 indicates that the number of persons enrolled in environmental control technology courses of study leveled off by 1974, and the number enrolled in air pollution control programs declined rather precipitously after 1972. On the other hand, there were increases in enrollments for water and wastewater technology and environmental health programs in the same period.

Enrollment data for agricultural production and automotive mechanics and technology have been included to indicate the number of trainees in these fields who can be reached for special environmental education by the vocational education system. For example, information on new motor vehicle air pollution control devices or regarding pesticides application could quickly reach as many as half a million young workers expected to be enrolled in each of these programs by 1979.

Table B.13 indicates that little direct pollution control technology instruction is delivered at the secondary level. Most of the programs are aimed at young adults or older workers. On the other hand, a large segment of automotive and agricultural training takes place in secondary schools, suggesting that efforts to introduce special environmental training to these areas should place heavy emphasis on the high school level.

Another important source of such occupations as sanitarians, health technologists, and other operators and technicians for pollution control is the community college structure. In the field of wastewater treatment EPA has funded an extensive series of pilot programs and curriculum development projects for community colleges. These projects have provided the necessary information for rapid expansion of local operator training programs. Unfortunately, a reliable national data base indicating past or current levels of community college activity in environmental fields is not available.

OTHER OCCUPATIONS DIRECTLY RELATED TO POLLUTION CONTROL ACTIVITIES

The diverse specialists who work either alone or with the environmental engineer, treatment plant operator, or environmental program manager constitute another general category of pollution control workers.

More than 80 percent of the total of almost 135,000 scientists and engineers in pollution control activities in 1974 belonged to one of 10 broad occupational groups: civil engineers, mechanical engineers, electrical engineers, chemical engineers, sanitary (environmental) engineers, agricultural scientists, biologists, managers, chemists, and earth scientists. It is the preparation and orientation of this group of workers that is perhaps most important in terms of the technical quality of the national environmental effort.

The remaining 17 percent of the scientists and engineers came from a predictably wide variety of occupations. Of this number, a small proportion represent manpower in a series of highly specialized fields vital to the pollution control program. These fields include epidemiology, aquatic and general toxicology, health physics, limnology, and meteorology. While the numbers of persons competent in these fields and working on pollution control are not large, they are especially significant for the successful operation of the environmental program.

THE NATIONAL SUPPLY OF SCIENTIFIC AND TECHNICAL WORKERS

It is difficult, if not impossible, for a study focused on one national program, environmental pollution control, to assess the various demands which will be placed on the members of all of these general scientific and engineering occupations in the future. The continued availability of high quality manpower in science and engineering to the environmental effort is a function of the overall supply of workers in these fields, the number of competing demands from other national priorities, and the degree to which appropriate financial resources are allocated to pollution abatement. Still, the Panel considers that these issues should be addressed so as to clarify the factors involved and to emphasize the fact that questions of environmental manpower policy should not be addressed outside the broader context of overall human resource management and policy.

The National Center for Education Statistics has projected a fairly steady flow from most scientific and technical degree programs over the next decade (U.S. DHEW 1975). Tables B.14, B.15, and B.16 present, by broad category, possible graduates from bachelor's, master's, and doctoral degree programs. These data indicate that between 1974 and 1984 a total of nearly 600,000 new degrees will be granted in engineering, 281,000 in physical sciences, and 476,000 in the biological sciences. By any measure this is a sizable flow of potential new skilled workers to the job market. They join a stock of over 1 million engineers and over 600,000 scientists (Bureau of Labor Statistics' estimates) already employed in 1974.

The magnitude of the current and prospective supply is, however, only a part of the problem. An important issue facing those charged with evaluating the demand and supply of environmental manpower is not only missed, but is largely obscured, by the data presented above. That issue relates to the quality and efficiency, i.e., the long-run cost–effectiveness, of the environmental program as it is now envisioned. There is no evidence one way or the other that all positions in pollution control programs are or will be filled by persons fully qualified and prepared for their responsibilities. Expenditure levels and timing of expenditures are important when considering the total pool of manpower availability, but they are equally as important in considering the technical expertise that must be developed to maintain a viable research and development program, an experienced cadre of competent design engineers, and a viable industry capable of providing modernized hardware for new designs.

Unfortunately, society has been led to believe that if the level of expenditures and the timing can be properly coordinated, any level of

TABLE B.14 Earned Bachelor's Degrees, by Field of Study: United States, 1961-62 to 1983-84

Year (1)	Natural Sciences and Miscellaneous Fields: Total natural sciences and miscellaneous fields (2)	Mathematics and statistics (3)	Computer and information sciences (4)	Engineering (5)	Physical sciences (6)	Biological sciences (7)	Agriculture and natural resources (8)	Health professions (9)	Accounting (10)	Other business and management (11)	Education (12)	Other (13)
1961-62	265,884	14,570		36,070	15,851	16,694	6,546	12,973	11,353	40,786	95,983	15,058
1962-63	277,804	16,078		34,972	16,217	18,849	6,748	13,944	11,880	42,156	100,909	16,051
1963-64	303,377	18,624		37,014	17,457	22,454	6,947	13,421	13,675	45,523	110,559	17,703
1964-65	321,811	19,460	87	38,514	17,859	24,872	7,377	15,444	14,886	48,169	116,529	18,614
1965-66	322,508	19,977	89	37,971	17,129	26,565	7,863	15,848	14,903	48,736	115,173	18,254
1966-67	337,587	21,207	222	38,696	17,739	28,483	8,636	16,541	15,593	54,418	117,482	18,570
1967-68	375,677	23,513	459	40,541	19,380	31,429	9,215	18,170	17,922	62,670	132,087	20,291
1968-69	427,646	27,209	933	45,517	21,480	31,989	10,965	20,230	20,032	74,501	148,554	23,236
1969-70	466,440	27,442	1,544	49,678	21,439	37,031	12,382	22,141	21,183	84,871	161,904	26,825
1970-71	493,966	24,801	2,388	50,046	21,412	35,743	12,672	25,226	22,099	93,428	176,571	29,580
1971-72	521,650	23,630	3,370	50,310	20,400	37,230	13,640	28,420	24,800	97,030	190,850	31,980
1972-73	557,210	25,470	4,130	48,740	21,650	40,300	14,730	30,830	27,530	104,800	204,250	34,780
1973-74	566,810	25,800	4,610	47,180	21,400	40,840	14,710	32,610	30,250	105,110	208,530	35,770
						Projected						
1974-75	561,030	25,670	5,060	39,970	20,990	40,750	14,640	35,690	32,270	104,710	205,480	35,800
1975-76	552,320	25,190	5,350	36,180	20,080	39,960	14,110	36,640	33,750	101,380	203,960	35,720
1976-77	558,390	25,420	5,840	35,940	19,900	40,350	14,150	37,660	35,810	101,900	205,100	36,320
1977-78	568,950	25,730	6,380	40,060	19,930	40,990	14,340	38,750	36,340	103,400	206,060	36,970
1978-79	572,380	25,710	6,780	43,130	19,640	41,070	14,280	39,500	36,240	103,210	205,540	37,280
1979-80	577,950	25,890	7,320	44,840	19,670	41,540	14,450	40,180	36,670	104,570	205,120	37,700
1980-81	583,240	26,040	7,900	46,700	19,560	41,910	14,560	41,180	36,940	105,420	204,930	38,100
1881-82	582,160	25,870	8,340	48,550	19,290	41,780	14,500	41,620	36,820	105,200	202,170	38,020
1982-83	572,860	25,370	8,650	48,540	18,760	41,120	14,240	41,790	36,170	103,460	197,270	37,490
1983-84	566,470	25,010	9,050	48,720	18,380	40,660	14,070	42,020	35,730	102,330	193,380	37,120

SOURCE: U.S. DHEW (1975).

TABLE B.15 Earned Master's Degrees, by Field of Study: United States, 1961-62 to 1983-84

Year (1)	Natural Sciences and Miscellaneous Fields: Total natural sciences and miscellaneous fields (2)	Mathematics and statistics (3)	Computer and information sciences (4)	Engineering (5)	Physical sciences (6)	Biological sciences (7)	Agriculture and natural resources (8)	Health professions (9)	Accounting (10)	Other business and management (11)	Education (12)	Other (13)
1961-62	65,817	2,680		8,953	3,913	2,642	1,721	1,632	511	4,890	35,728	3,147
1962-63	69,941	3,320		9,666	4,115	2,921	1,601	2,011	499	5,439	37,276	3,093
1963-64	76,839	3,625		10,857	4,555	3,296	1,682	2,279	530	5,983	40,376	3,656
1964-65	84,253	4,196	146	12,093	4,906	3,600	1,695	2,494	617	7,073	43,323	4,110
1965-66	100,340	4,769	238	13,717	4,977	4,233	2,034	2,833	862	12,280	49,905	4,492
1966-67	111,140	5,278	449	13,986	5,405	4,996	2,119	3,436	1,024	14,086	55,155	5,206
1967-68	125,185	5,527	548	15,247	5,499	5,506	2,234	3,736	1,137	16,964	62,927	5,860
1968-69	136,331	5,713	1,012	15,372	5,895	5,743	2,496	4,065	1,333	18,279	70,231	6,192
1969-70	148,108	5,636	1,459	15,723	5,935	5,800	2,197	4,488	1,083	20,516	78,275	6,996
1970-71	165,608	5,191	1,588	16,443	6,367	5,728	2,457	5,749	1,097	25,447	88,716	6,825
1971-72	180,600	5,190	1,850	16,650	6,160	6,100	2,660	7,120	1,380	28,560	97,730	7,180
1972-73	184,520	5,210	1,900	16,420	6,080	6,190	2,670	7,450	1,390	28,840	101,080	7,290
1973-74	193,870	5,410	2,000	16,640	6,160	6,450	2,750	7,960	1,440	29,930	107,530	7,600
						Projected						
1974-75	200,230	5,510	2,080	16,800	6,210	6,610	2,810	8,360	1,470	30,840	111,750	7,790
1975-76	203,620	5,550	2,140	16,780	6,170	6,680	2,850	8,680	1,490	31,370	114,070	7,840
1976-77	208,720	5,640	2,230	16,940	6,210	6,800	2,910	9,060	1,520	32,240	117,210	7,960
1977-78	214,180	5,740	2,330	17,160	6,270	6,940	2,970	9,450	1,560	33,240	120,440	8,080
1978-79	218,900	5,820	2,420	17,350	6,300	7,040	3,040	9,830	1,590	34,050	123,270	8,190
1979-80	222,260	5,870	2,500	17,400	6,300	7,100	3,080	10,170	1,620	34,660	125,330	8,230
1980-81	224,670	5,880	2,550	17,430	6,270	7,130	3,110	10,490	1,630	35,110	126,850	8,220
1981-82	226,940	5,910	2,620	17,400	6,260	7,160	3,140	10,800	1,640	35,490	128,290	8,230
1982-83	227,280	5,890	2,670	17,300	6,190	7,130	3,140	11,020	1,640	35,680	128,480	8,140
1983-84	225,350	5,780	2,690	17,000	6,060	7,010	3,110	11,170	1,630	35,410	127,500	7,990

SOURCE: U.S. DHEW (1975).

TABLE B.16 Earned Doctoral Degrees, by Field of Study: United States, 1961-62 to 1983-84

Year (1)	Natural Sciences and Miscellaneous Fields: Total natural sciences and miscellaneous fields (2)	Mathematics and statistics (3)	Computer and information sciences (4)	Engineering (5)	Physical sciences (6)	Biological sciences (7)	Agriculture and natural resources (8)	Health professions (9)	Accounting (10)	Other business and management (11)	Education (12)	Other (13)
1961-62	8,250	396		1,216	2,122	1,338	576	148	27	205	1,867	355
1962-63	9,073	490		1,385	2,380	1,455	552	157	23	235	2,056	340
1963-64	10,190	596		1,705	2,455	1,625	668	192	21	260	2,330	338
1964-65	11,843	682	6	2,133	2,829	1,928	657	173	32	297	2,682	424
1965-66	13,047	782	19	2,315	3,045	2,097	716	251	34	368	3,034	386
1966-67	14,614	832	38	2,619	3,462	2,255	771	250	43	411	3,526	407
1967-68	16,306	947	36	2,933	3,593	2,784	800	243	33	427	4,076	434
1968-69	18,465	1,097	64	3,391	3,859	3,051	886	283	40	506	4,793	495
1969-70	21,007	1,236	107	3,691	4,312	3,289	1,004	357	56	566	5,830	559
1970-71	22,306	1,199	128	3,638	4,390	3,645	1,086	466	61	749	6,398	546
1971-72	22,780	1,130	170	3,660	4,090	3,650	970	440	50	950	7,040	730
1972-73	23,060	1,040	220	3,380	4,330	3,600	930	390	60	950	7,420	740
1973-74	22,650	1,000	270	3,320	4,040	3,350	830	470	60	1,060	7,500	750
						Projected						
1974-75	23,230	970	340	3,340	3,820	3,400	850	470	60	1,180	8,040	760
1975-76	24,230	980	410	3,330	4,040	3,580	910	510	60	1,220	8,390	800
1976-77	25,610	880	500	2,940	3,980	3,720	960	710	60	1,320	9,680	860
1977-78	26,220	890	490	2,980	4,030	3,770	960	720	70	1,330	10,100	880
1978-79	26,320	890	490	2,980	4,040	3,780	970	730	70	1,330	10,160	880
1979-80	26,960	920	500	3,060	4,140	3,870	1,000	740	70	1,370	10,400	890
1980-81	27,430	950	520	3,170	4,300	4,010	1,040	760	70	1,420	10,260	930
1981-82	27,750	960	530	3,200	4,350	4,060	1,060	780	70	1,440	10,350	950
1982-83	28,310	990	540	3,270	4,430	4,150	1,080	790	70	1,470	10,560	960
1983-84	28,960	1,010	560	3,350	4,530	4,240	1,120	810	70	1,500	10,790	980

SOURCE: U.S. DHEW (1975).

technology can be provided. It takes years to develop the speciality designer, to translate science into workable technology, and to develop a manufacturing capability with the expertise to maintain a viable product line.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSION A

Review of available manpower analyses summarized in this report leads the Panel to conclude that no major numerical imbalances between pollution control manpower demand and supply are likely to develop during the coming decade. However, this apparent balance in the environmental labor market may obscure serious deficiencies in the training of some persons already holding environmental positions or likely to be hired in the near future. The available data do not permit a definite conclusion about this issue which the Panel deems to be of substantial importance.

Significant needs for training over the next decade will be in continuing education (from short courses to degree–credit instruction), on-the-job training, workshops and seminars, extension education for adults, and other activities designed to reach those persons in positions of pollution control responsibility who need specialized and current information in order to perform effectively. Further, there is little evidence in EPA's current and immediate program plans of a coordinated effort to stimulate the development of better qualified manpower.

RECOMMENDATION A

- *Strong collaborative efforts on the part of EPA, state and local governments, industry, and educational institutions to improve the quality of workers should be given highest priority by EPA as the only organization able to provide national leadership in training and education.*

Full-time education for entry-level pollution control positions should be supported only where careful and active collaboration exists among employers and educational institutions. This collaboration, while enhancing the quality of the training delivered, could be facilitated by the use of cooperative education, summer jobs, and part-time jobs as an integral part of the training process.

The Panel recommends also that EPA undertake and/or support a series of studies concerning the performance–efficiency of scientists and engineers employed in pollution control. These studies should be done especially for those whose field of training does not match their employment field. The employment fields of earth, marine, and environmental sciences would be appropriate subjects for initial study.

CONCLUSION B

The Panel concludes that EPA's efforts in manpower assessment, planning, and forecasting are far less comprehensive and sophisticated than are needed. This deficiency, in the view of the Panel, is caused less by the general competence of the operating-level employees than by the lack of leadership at top levels of the Agency.

RECOMMENDATION B

- *The Panel recommends that an agencywide manpower and education planning unit be established and staffed with manpower and education specialists, labor economists, and others with specific competence in this field. Parts of the manpower planning and analysis function could be supported by EPA but carried out elsewhere in the Federal Government or in qualified nongovernmental organizations. This effort should be supported by a fully-qualified advisory committee including social scientists and manpower planners. This committee must possess the expertise to advise the Agency on both broad theoretical areas and technical methodology for manpower and educational planning. The establishment of a procedure to continually monitor and update the manpower projections and assumptions that are developed should be high among the priorities of this EPA planning staff. This unit should also serve as a "clearinghouse" for information on pollution control manpower and education.*

Further, the Panel recommends that EPA's leadership give serious consideration to provision of a definite, funded program for human resource planning and to support of necessary educational and training programs. These efforts should be supported at both national and local levels.

CONCLUSION C

A number of agencies could assist EPA in the area of manpower and education planning if more active cooperation were realized. These agencies include the Bureau of Labor Statistics, the National Science Foundation, and the Bureau of the Census. Similarly, EPA could realize substantial benefits by becoming more actively involved with the training organizations and educational programs already operating under the auspices of the Departments of Agriculture, Labor, and Health, Education, and Welfare.

RECOMMENDATION C

• *The Executive Branch soon ought to establish and support an interagency coordinating committee for environmental manpower and education affairs. The purpose of such a group would be to coordinate the requirements and standards of the operating agency (EPA) with the expertise, facilities, organization, and other resources of the supporting agencies (Labor, Office of Education, National Science Foundation, Agriculture, etc.). The committee could also serve as a focal point for the exchange of information on manpower and education in pollution control activities.*

Similar committees should be fostered by EPA at regional and state levels for the same purpose.

CONCLUSION D

Large-scale, comprehensive manpower models have not been developed and used by EPA. As a result, the Agency has been denied a potentially effective tool in the overall manpower planning process. One specific shortcoming of current projection models is the tendency to overlook the behavioral characteristics of the manpower system. Among the many relevant characteristics that are not taken into account are the propensity to migrate for employment purposes and the educational and occupational differences in this geographic mobility. Also, for reliable projection purposes, current models which are generally national in scope should be convertible for application to specific regions.

RECOMMENDATION D

• *The manpower planning unit described in Recommendation B would have the responsibility and the expertise to use existing models and to develop new ones for the purpose of initiating sound human resource planning for environmental protection.*

EPA should move to incorporate an effective and clearly defined manpower component into Agency economic planning models. In order to be most useful, the manpower component should be industry- and occupation-specific and should be applicable to all of the media or types of pollution covered.

This manpower modeling effort should be monitored periodically, should include collaboration with other federal agency efforts, and should use nongovernmental advice and assistance.

EPA should continue to encourage the development of state and local expertise in manpower planning for pollution control. However, the degree of emphasis to be placed on local planning should be directly related to behavioral characteristics exhibited by various elements of the labor force, such as geographic mobility.

ATTACHMENT B.I: CONCEPTUAL AND METHODOLOGICAL CONSIDERATIONS

SCOPE OF STUDIES OF ENVIROMENTAL MANPOWER

Several major dimensions are useful in delineating the scope of environmental manpower studies. The list of pollutant agents covered by governmental regulation is one dimension. This list is long and growing. For practical purposes, it could be limited to the inclusion of the presently listed set of pollutants and those scheduled for imminent addition.

Another main dimension corresponds to sectors of the national governmental–economic complex. The division between governmental and private sectors is important in understanding both pollution production and control. In terms of production, the governmental sector is relatively insensitive to the economic forces of either the micro- or macroeconomic type. For this reason, governmental manpower demand can be treated as a component of the final demand vector in an input–output analysis. Both governmental and private sectors will participate in pollution control, with a greatly increasing role to be played by state and local governments in accordance with the present national policy of administrative decentralization. It is because of these separations of roles in pollution production and control that the direct manpower estimates of the Committee were assigned to the panels on industry and private sector, state and local, and federal requirements.

A dimension crosscutting the above is that of control technology. Similar technologies are applicable to different pollutant agents and, of course, in different economic sectors. The precise mix of technologies that will be required by pollution control plants throughout the nation in the target year is a difficult matter to predict. The resources of this Panel have not permitted detailed studies of particular technologies or their usefulness, and previous studies available leave much to be desired from a manpower perspective.

THE NATURE OF DEMAND PROJECTIONS

Projections of manpower demands based largely on legislative considerations are of necessity highly conditional. Any manpower projections depend on a set of assumptions about the general performance of the national economy. Some of these assumptions are certainly subject to sizable errors over the projected period. For example, it usually is assumed that certain "optimum achievable" levels of unemployment will exist in target years; however, experience suggests that the achievement of particular specified levels is not to be taken for granted. The set of conditions assumed to hold in the general economy should be kept in mind when considering any demand figures.

General economic conditions may diverge smoothly and continuously from the assumptions of the projections. However, a different set of conditions assumed in the projections could vary in a discontinuous and important manner. Even an unforeseen legislative or intraagency policy change could be expected to have implications for the demand for certain environmental occupations far in excess of any anticipated general economic fluctuations.

The importance of policy assumptions to the accuracy of projections should not be considered a reason to discount the value of projections. The purpose of projections is to provide an early warning of possible supply and demand imbalances based on the best information now available. Less hurried and more complete preparation for handling any imbalances may be permitted by this early warning than by more accurate short-term projections at later dates. Quick adjustments of projections on the basis of policy changes can only be handled with an on-going assessment procedure such as the one proposed for EPA consideration in a later section of this report.

Several different ways to make conditional demand forecasts might be considered. One is to use expenditure projections previously prepared elsewhere as the basis for derived manpower projections. The second is to directly evaluate the manpower required to implement legislated levels of control, using engineering studies and surveys of current control operations. The panels concerned with particular sectors of the economy have found it expedient to use a mix of the two approaches in producing estimates.

SUPPLY PROJECTIONS

The difficulties of developing useful projections of manpower supply are greater than those associated with demand forecasting. The main problems concern cross-elasticities of supply and the informal nature of the qualifications required for many jobs. As a practical matter only data on formal qualifications such as educational credentials are likely to be available to manpower forecasters. The Panel has reached the conclusion that the actual qualifications required in all but professional, technical, and scientific jobs are so diffuse that supply constraints will be relatively unimportant at the manpower levels required by current implementation plans.

In the case of technical and scientific occupations, necessary job qualifications are more definite, and correspond in large part to formal educational credentials. The Panel, therefore, has examined the pool of degree holders available for scientific and technical employment in the target year under the assumption that no special programs will be initiated to increase or decrease supply. This approach permits at least a partial determination of the need for such programs.

Since many scientific and technical environmental occupations are open to persons possessing general scientific or technical credentials, it was necessary to obtain an estimate of the size of the general pool of qualified individuals. This estimate was obtained from NSF's 1974 National Survey of Scientists and Engineers. The specific distribution of credentials possessed by individuals reporting environmentally-related employment formed the basis for the transformation of occupational requirements to credential requirements.

OPERATING ASSUMPTIONS

As mentioned earlier, the lack of uniform data availability and other factors have combined to present special problems for this Panel in developing a common approach to the use of the data. In addition, there are many differences in mandated requirements for various segments of environmental control.

The Legal Panel covered in some detail the enabling legislation that directs the federal government in fulfilling these requirements. It is evident that there is little uniformity in the mandated timetables to reach the objectives of various laws.

For example, the Water Pollution Control Act, the Clean Air Act, and the Safe Drinking Water Act contain specific compliance dates that are tied to certain legislative objectives and requirements. The enabling legislation for solid waste management, noise control, radiation control, pesticides, and other pollution control efforts either is not specific in terms of the time to reach objectives or does not provide the basis for a viable operating program.

Also, the relative amount of effort committed to various environmental control programs varies substantially. To some extent these variations reflect administrative decisions and therefore are susceptible to some flexibility. However, because the major aspects of activity needed for water pollution control, air pollution control, and drinking water improvement are generally agreed upon, the amount of flexibility is limited.

Theoretically, it should be possible to use the present laws (particularly those containing timetables) to establish a data base and make reasonable projections. In this study, as in all others, there are several reasons why conclusions must be qualified and assumptions must be made despite the uncertain constraints of future events.

The Water Pollution Control Act is a good example of the special problems inherent in making manpower projections. The Act contains three fundamental dates that the Congress felt would, on a progressive and identified basis, lead to the ultimate objective of clean water in the nation's streams by 1985. The first two of these dates, July 1, 1977, and July 1, 1983, contain specific parameters of performance in the public and private sectors in order to reach the stated degrees of water quality. Both dates are tied to enforcement obligations based on these parameters. On the other hand, the ultimate goal of eliminating the discharge of pollutants into navigable waters by 1985 is not reinforced in the Act by precise performance requirements that provide for the attainment of that goal. As a result, the requirements to reach the objectives of 1977 and 1983 are reasonably well understood, but the 1985 goal is not.

In order to meet the deadlines, Congress felt that the existing subsidy program for construction of publicly-owned treatment facilities needed to be continued with increased funding. The Act contained what Congress felt were adequate amounts of supporting funds to meet the deadlines. In actual implementation of the Act, however, it soon became apparent that the estimates were grossly deficient. The deficiencies are of such magnitude that it is impractical to assume that such monies will be available within the specified deadlines or even for some time later. Lack of funds will cause many municipalities to be in violation of the compliance requirements of the Act at the time of the July 1, 1977, deadline.

Congress anticipated the need for a mid-course reassessment and in the Act created the National Commission on Water Quality to provide a study that could be used to guide Congress in making needed adjustments. That report has been submitted to Congress and will be considered in the coming months. All of this leads to the admission that some changes are expected in the Act and that these changes in some way will affect the deadline dates as related to identified quality of water in the nation's streams at any future point in time.

Similar problems have been experienced in the compliance timetables for the Clean Air Act. The Safe Drinking Water Act is too new to make intelligent guesses as to the extent of timing problems that may occur.

In considering useful approaches for making projections, the Water Pollution Control Act is again cited as an example. At one end of the scale, the most stringent case may be considered. That could be interpreted to be the 1985 goal of elimination of discharges of pollutants into navigable waters. As mentioned earlier, the detailed parameters to measure this goal are not yet developed. However, if one interpretation is that all discharges will be eliminated, i.e., all municipalities and industries will operate closed systems, then the situation would, indeed, be stringent. Because of many pragmatic factors, such as seriously reducing the volume of flow in many streams if all discharges are ceased, it is clear that some changes in the eventual interpretation of the 1985 requirements will be necessary. Therefore, the most stringent case is not a viable one.

Some kind of analysis could be made for the 1977 and the 1983 requirements, and in both instances there are varying degrees of uncertainty. One thread of generally agreed-upon understanding is that the 1977 requirements for secondary treatment for publicly-owned treatment facilities and best practicable control technology for industrial discharges are fairly well developed and substantial progress has been made toward the planning, design, and, in many instances, the construction of facilities. That, plus the uncertainties of the 1983 requirements, the 1985 goals, and the recognition that it will be several years after 1977 before 1977 requirements, as translated into concrete and steel, will be functioning, lead this Panel to the following conclusions.

It will be of most value to extend manpower estimates into the mid-1980s, but the projections must realistically be based on something less than the ultimate objectives of the enabling legislation. In the case of the Water Pollution Control Act, the most understood and best developed planning and implementation procedures are based on the 1977 requirements. Because it will be some years after 1977 before the results of the requirements can be evaluated, the mid-1980s is a reasonable target date for the projections to be meaningful. Similarities in the interpretation of legislation and implementation exist in the other areas of environmental control.

LIMITATIONS OF MANPOWER FORECASTING

Anyone who ventures seriously into the literature on manpower projections, whether in this country or in other western nations, comes away much chastened and with a greater appreciation of the efficiency of "unplanned" labor markets as an allocation device. Even a casual survey of the literature yields an impressive list of forecasting failures, particularly for occupations with extensive educational requirements. No nation has yet mastered the complex task of meshing medium-term economic predictions (themselves subject to considerable uncertainty) with the flow of individuals through the educational system (Ahamad and Blaug 1973). The available policy options in this country provide information about future labor market needs to individuals and institutions (e.g., the BLS occupational outlook forecasts) and to certain forms of pricing intervention, such as providing fellowships in areas of high demand.

The implications of these remarks for the present project are twofold: first, the supply–demand projections presented in this report must be viewed as tentative and highly likely to be proven inaccurate in retrospect; and second, the links from these projections to policy variables and hence to changes in the behavior of individuals and institutions are, at best, poorly understood. These problems are by no means unique to this project, but are a candid assessment of the current state of the art (NSB 1976, Freeman and Breneman 1974).

In spite of these difficulties with forecasting, there is a continual demand for projections as a guide to various decisions that must be made at the federal, state, local, institutional, and individual levels. Given that some of the more serious errors of early forecasts are not likely to be repeated (Breneman 1975), decisions are probably better made now with projections than without them; consequently, the demand for projections is not irrational. Uncritical use of any given forecast, however, would be unwise, and the environmental manpower projections are presented in that spirit. A few observations on the specific issues involved in our forecasts may be helpful.

DEMAND

From an economic standpoint, the difficulties with the BLS input-output modeling approach are well known. The underlying system of linear equations entails an assumption of constant returns to scale in production (i.e., in order to double output, all inputs must be doubled); the fixed-coefficient methodology entails an assumption of no substitution among inputs; and technology is assumed constant over time (or judgmental adjustments in input–output coefficients are made, a procedure clearly subject to error). In short, input–output models take a snapshot of the economy and use the measured production relationships to project future demands, abstracting from the dynamic adjustments that actually occur.

Similar remarks may be made about the industry-occupational matrix that translates activity levels in the economy into demand for individuals with specific levels and types of education. The dynamics of behavioral responses to changing labor market conditions, both at the corporate and individual levels, are not captured. Thus, substitution among people with different levels and types of education is not handled by the fixed-coefficient approach, although such adjustments continually occur within the economy.

The merit of the BLS approach, however, is that in rough terms it captures the interactions within the economy among producing sectors. Thus, it generates a consistent and feasible set of production possibilities which take into account not only the direct effects of a shift in production, but also the secondary and tertiary effects that occur in other sectors. (One of the principal reasons for the use of linear equation systems in these models, although they may not describe the economy precisely, is the need to simplify in order to find a mathematical solution.) The gains made possible by input-output models, even with the necessary simplifications, more than compensate for the problems introduced by those simplifications (Bezdek 1974).

A second and more pragmatic reason for relying on the BLS model for projections is simply that it is "the only game in town." Unless policymakers are prepared to ignore the indirect employment effects of environmental legislation (and the Panel was not willing to do so), there is no realistic alternative at this time to the BLS methodology, subject to the limitations mentioned.

SUPPLY

The analysis of supply has policy significance primarily for those jobs that require specific educational backgrounds that cannot routinely be provided on the job. As occupational requirements become more complex and demand more formal schooling, the problem of lag-time in the response of individuals and educational institutions becomes critical. If a substantial number of people must be trained in multi-year programs, and if the possibilities are limited for substitution from the existing supply of scientists, engineers, and technicians, bottlenecks can occur.

The major weaknesses in the methodology of supply projection are caused by inadequate understanding of the factors that influence career choice and subsequent field-switching. The U.S. Office of Education, for example, produces annual projections of future supplies of baccalaureate, master's, and doctoral degree holders, but these projections are little more than mechanical extrapolations of past trends and do not incorporate behavioral components. Recent trends in advanced degree enrollments and degrees awarded in physics, chemistry, and engineering suggest that a substantial behavioral response on the part of students and universities does exist; graduate enrollments have dropped by more than 30 percent in these fields from their 1960s peak, and the number of Ph.D. degrees awarded in these fields has declined steadily in recent years. These abrupt reversals in growth trends were missed by all manpower forecasters (Freeman and Breneman 1974).

Perhaps the best advice one can provide on the subject of supply projections is that highly specialized fields should be monitored continuously so that adverse trends can be offset rapidly. The stage has not yet been reached where sole reliance can be placed on projections.

MANPOWER PROJECTION METHODS[1]

Projections of future national and regional manpower needs are required for advance planning to meet future requirements. In particular, those responsible for planning and funding education and training programs require reliable information about future manpower needs early enough to provide necessary programs. Realistic projections of anticipated specialized manpower demands are particularly needed in pollution control fields.

Manpower needs in the future depend on the economic, fiscal, technological, industrial, and demographic conditions which will exist during the forecast period and manpower projections must of necessity be based on assumptions or conjectures of these future conditions. Some of these assumptions are discussed below. Few long-term manpower projections stand up when measured against later facts, nor is this always their primary purpose. As noted, manpower models such as that used by the Bureau of Labor Statistics, estimate broad categories of manpower requirements that are insufficient to evaluate the pollution control specialities required to solve relevant problems. An alternate approach is to evaluate specific functions that must be performed to meet statutory

[1]The sections on projection methods and projection problems were prepared by the Panel on Federal Aspects. Owing to the broad pertinence of the material, that panel generously agreed to its use here.

requirements and then to project, by employment category, the specialized manpower requirements to perform these functions.

PROJECTION MODELS

Manpower projection methods using computerized solution of mathematical models are available to evaluate the impact of economic, technological, and demographic factors on manpower requirements. A good example is the Manpower Projection Method used by the Bureau of Labor Statistics. These methods can provide appraisals for the conditions which are assumed for the future years. Any disparity between assumed future conditions and actual future conditions would produce a commensurate error in the manpower projections. Reliability of these manpower projection methods depends, therefore, on the selection of correct inputs from a wide range of possible assumptions about predicted national and regional trends and outlooks.

EMPLOYER SURVEYS

Other published manpower projections have been based on surveys of prospective employers regarding their future hiring plans and expected anticipated opportunities for employment. These are necessarily based on individual perceptions of economic conditions and evaluations of future trends. Analysis of these replies can provide a fair appraisal of future manpower demands in the short run during periods of relatively stable economic, fiscal, and political conditions. Projections have been wrong when these conditions change after the survey date. The reliability of results depends on these actual future conditions, which cannot be confidently forecast. Also, summations of future hiring plans include duplicative needs of individual employers.

ECONOMIC MODEL FOR PROFESSIONAL LABOR MARKET

Freeman and Breneman (1974) have developed a simple economic model for professional labor markets, with emphasis on the supply aspect, based on student career decisions, experienced personnel decisions, employer decisions, salary determinations, university responses, and government responses. Hollomon et al. (1975) report applications to national engineering enrollments and also report successful applications to other professional labor markets—law, physics, M.B.A.s, and accountants (see also Cain et al. 1973). Forecasts of the Ph.D. labor market, using

Freeman and Breneman's market adjustment model, differ sharply from other forecasts.

INTRINSIC LIMITATIONS

The following comments on probable pitfalls and assumptions underlying manpower projections are not intended as a comprehensive critique and evaluation of the manpower projection model currently used by the Bureau of Labor Statistics. Rather, they serve as an indication of the limitations on manpower projections in general, especially in relation to the accuracy of, and confidence in, future projections of pollution control manpower requirements.

First, predicting the future is at best a combination of luck, history, and perhaps an uncanny capacity to integrate into the projection model all influential variables and the prospective changes in each one. Obviously, the nature and quality of assumptions underlying the model are especially important.

Second, a manpower projection model deals primarily with the estimation of future manpower projection requirements and usually has relatively little concern for the supply side of the manpower equation. This results in emphasizing the relationship between economic factors (expenditures) and derived employment futures generated by varying the basic assumptions after available facts and data are integrated into the model. This lack of attention to the supply side is perhaps the major concern in considering pollution control manpower.

And third, manpower forecasts are necessarily based on assumptions about the "future world" in which the employment will occur. These are discussed in the sections on assumptions and examples below.

Because of these intrinsic limitations, manpower projections published by the Bureau of Labor Statistics (U.S. Department of Labor [DOL] 1969, 1971) and most other sources include: (1) warnings that results should be interpreted with caution; (2) shortcomings of techniques used; (3) the many assumptions used in the projections; and (4) the possible errors introduced by disparity between assumed and actual future conditions.

With these constraints, confidence limits cannot be quantified. Frequently, users of these projections do not heed the warnings that results should be used with caution and some do not even realize that published forecasts are based on a series of assumptions, suppositions, and surmises.

ASSUMPTIONS OF FUTURE CONDITIONS

Some of the assumptions that influence manpower projections relate to predictions of a long list of contributing, but indeterminate, factors such as:

(1) population growth, distribution, and changing composition;
(2) related growth of various industries;
(3) effects of technological change;
(4) economic, fiscal, and social factors;
(5) employment rate, GNP; and
(6) political factors.

Several of the preceding factors depend upon such things as decisions by political leaders regarding adjustments to the economy by fiscal policies, government spending levels, and tax structure.

ERRORS OF OMISSION

A critical analysis of labor market forecasting techniques and past forecasting failures is provided by Freeman and Breneman (1974). Four serious errors of omission were noted: (1) failure to consider individual responses to market conditions; (2) absence of wage-price phenomena from computations; (3) failure to evaluate the consequence of major policy variables on market outcomes; and (4) failure to take account of the interrelations and feedback processes governing the market.

AN EXAMPLE OF PITFALLS

Many assumptions of future conditions cannot be forecast with confidence and actual later facts often prove earlier assumptions wrong. One example of unfulfilled premises that led to overly-high manpower projections is the Bureau of Labor Statistics report on *Tomorrow's Manpower Needs* (U.S. DOL 1971) which used the following assumptions about the economy: (1) international climate will improve; (2) institutional framework of the American economy will not change radically; (3) economic, social, technological, and scientific trends will continue; (4) fiscal and monetary policies will achieve a satisfactory balance between low unemployment rates and relative price stability; (5) all levels of government will join efforts to meet a wide variety of domestic requirements; and (6) problems posed by air and water pollution and solid waste disposal may require an increasing amount of the nation's productive resources but will not significantly dampen our long-run potential rate of growth.

The report was careful to warn that disparity between the actual and assumed conditions would cause a corresponding discrepancy between actual manpower needs and the projections made in an earlier year. Actual developments were indeed somewhat different from optimistic 1969 conjectures. The 1969–1976 period experienced the oil embargo and greatly increased energy costs, at least a temporary recession (politically impossible to project in a government forecast), lowered governmental funding for research and development after 1969 (measured in constant dollars), and lagging funding for pollution control facilities. These and other factors produced higher unemployment rates and 1976 manpower requirements significantly lower than the 1969 projections in this sample.

PROBLEMS IN POLLUTION CONTROL MANPOWER PROJECTIONS

LACK OF SPECIFICITY

The manpower projection model used by the BLS contains occupational groupings of several major engineering categories: aeronautical, chemical, civil, electrical, industrial, mechanical, metallurgical, mining, and other technical engineers. Also present in the model as projection "output" are broad categories of natural scientists, including chemists, agricultural scientists, geologists, geophysicists, and biological scientists. There is also a large category of engineering technicians. These long-range future projections of professional, scientific, and technical manpower requirements do not help in reliably defining the proportion, nature, and specific jobs workers will be doing in the areas of research, management, and administration of pollution control efforts.

A question may be raised about whether an aggregate, macroanalytical approach is adequately detailed to project *specific* manpower requirements in a given employment area. This would seem to place greater weight on "grass roots" analysis of job content, workforce availability, and quality at the micro-occupational level. This latter approach simply asks initially about the type of work or jobs necessary to achieve a given level of pollution control at a point in time. This orientation may result in the estimation of a future manpower requirements scenario for bridging the gap between currently available pollution control manpower, its use, and future manpower needed to achieve a given pollution control objective. As noted in Appendix C, the rudiments of a manpower projection methodology for pollution control (micromanpower planning) have been initiated by the EPA Office of Water Programs.

INADEQUATE DATA BASE

The data base for pollution control manpower projections is inadequate. The complex interrelationship of federal, state, and local efforts to coordinate the funding and administration of pollution control programs virtually forces a decentralization in efforts to measure and project needed manpower. Moreover, the variation in the occupational structure of pollution control employment requires, for reliable manpower projections, detailed occupational information that is current and cumulative. It might also be noted that the current capability of manpower projection models to capture the dynamics of job mobility and unplanned shifts in occupational structure—and therefore, future employment—is limited. Generally, the composition of pollution control employment, and staffing decisions at the agency and field level, may be so much a function of budgeted (available) expenditures and shifting program priorities that long-run (5- to 10-year) manpower projections are not realistic.

ABSENCE OF OCCUPATIONAL DETAIL

It is important to stress the absence of occupational detail inherent in most, if not all, manpower projection models. The BLS model, for example, uses an occupational classification system that is based more on socioeconomic status of the work force rather than on actual work performed (job content). Therefore, it is obvious that this model can tell little about the education, training, and compensation for jobs required in the future. Many manpower projection specialists have underscored the need for occupational data to be reformulated, collected, and classified in a manner more accurately reflecting job requirements, skills, responsibilities, educational requirements, and vocational training. Other researchers suggest the need for greater emphasis on "more analytical investigations of market phenomena—supply and demand elasticities, changes in salaries for workers of a given quality, and various forms of supply behavior such as retirement, occupational job mobility, and career choices" (Cain et al. 1973:84). This methodology is discussed briefly above in the section, "Economic Model for Professional Labor Market."

UNCONFIRMED ASSUMPTIONS

As discussed above, some of the economic assumptions underlying most projection models tend not to be realistic—for example, the full employment assumption of 3 or 4 percent unemployed during the 1970s. As a matter of fact, recent employment rates are lower than the BLS projections for most occupations since unemployment has been over 5 percent during the early 1970s. Also, the extended recession of 1974–1976 and the apparent low-level, long-range economic activity for the rest of the decade suggest a substantial gap between projected pollution control employment and the actual jobs available and funded in the area of pollution control. This particular economic assumption is made even more unrealistic by the recent cutbacks in state and local employment due to budget-revenue squeezes.

ALTERNATIVE PROJECTIONS

The reliability of any manpower projection can be evaluated only at the end of a forecast period. Meanwhile, the confidence limit placed on any projection is an indeterminate. One approach would be to make a series of projections, each based on a different set of inputs, regarding future assumed contributing factors. Published projections would give "high," "middle," and "low" estimates, together with the sets of assumptions used. These alternative projections would show the indeterminate nature of the method to those using the forecasts. Moreover, assumptions could be continually matched against actual conditions as they develop during the forecast period.

ATTACHMENT B.II: STATISTICAL TABLES FROM 1974 NATIONAL SAMPLE SURVEY OF SCIENTISTS AND ENGINEERS AND 1975 SURVEY OF DOCTORAL SCIENTISTS AND ENGINEERS

Tables Compiled from the 1974 National Survey of Scientists and Engineers

Tables Compiled from the 1975 Survey of Doctoral Scientists and Engineers

TABLE B.II.1 Field of Science or Engineering by Sex, Age, and Highest Degree for Scientists and Engineers in Pollution Control,[1] 1974

	Field of Science or Engineering							
	Computer Specialists	Engineers	Mathematicians	Life Scientists	Physical Scientists	Environmental Scientists	Social Scientists	Total
Sex								
Male	490	93,767	602	15,260	15,618	4,231	2,333	132,301
Female	15	213	45	744	782	216	234	2,249
Age								
under 25	0	145	0	11	11	0	0	167
25-29	51	8,299	98	1,971	1,436	427	263	12,545
30-34	162	13,950	141	2,662	2,702	613	557	20,787
35-39	154	14,729	111	2,851	2,483	689	401	21,418
40-44	61	13,112	163	2,412	2,409	891	432	19,480
45-49	51	15,623	42	2,291	2,639	411	294	21,351
50-54	13	12,703	51	1,531	2,010	780	348	17,436
55-59	0	8,515	26	1,285	1,576	440	85	11,927
60-64	13	4,145	15	606	743	171	187	5,880
65 and over	0	2,759	0	384	391	25	0	3,559
MEDIAN	(2)	(3)	(2)	(3)	(3)	(3)	(3)	

Highest Degree Obtained								
Doctorate	41	3,566	139	3,475	5,029	1,526	723	14,499
Master's	227	19,137	298	3,824	3,227	1,319	889	28,921
Bachelor's	237	67,933	198	8,657	8,119	1,589	955	87,688
Associate's	0	925	0	0	0	0	0	925
Other degree	0	212	12	48	25	13	0	310
No degree	0	2,207	0	0	0	0	0	2,207
Total	505	93,980	647	16,004	16,400	4,447	2,567	134,550

[1] Persons reporting significant professional time devoted to these activities.
[2] Median age 35-39
[3] Median age 40-44

SOURCE: 1974 National Survey of Scientists and Engineers.

TABLE B.II.2 Field of Science or Engineering by Type of Employer for Scientists and Engineers in Pollution Control,[1] 1974

Type of Employer	Field of Science or Engineering							
	Computer Specialists	Engineers	Mathematicians	Life Scientists	Physical Scientists	Environmental Scientists	Social Scientists	Total
Educational institution	26	1,322	89	2,879	1,112	711	693	6,832
Federal government	45	8,301	119	7,217	1,943	1,599	479	19,703
State government	13	5,241	12	2,522	627	465	136	9,016
Local government	35	5,657	26	764	890	377	149	7,898
Other government	33	1,657	0	36	200	36	0	1,962
Nonprofit	53	1,215	52	291	587	195	50	2,443
Industry or business	300	64,650	336	1,867	10,402	738	942	79,235
Self employed	0	5,106	0	239	499	297	118	6,259
Military or no report	0	367	13	41	37	0	0	458
Not employed	0	464	0	148	103	29	29	744
Total	505	93,980	647	16,004	16,400	4,447	2,567	134,550

[1] Persons reporting significant professional time devoted to these activities.

SOURCE: 1974 National Survey of Scientists and Engineers.

TABLE B.II.3 Field of Science or Engineering by Kind of Business for Scientists and Engineers in Pollution Control,[1] 1974

	Field of Science or Engineering							
Kind of Business	Computer Specialists	Engineers	Mathematicians	Life Scientists	Physical Scientists	Environmental Scientists	Social Scientists	Total
Chemicals	33	10,060	35	135	5,165	23	0	15,451
Electrical	208	5,203	107	14	356	0	116	6,004
Fabricated metal	16	6,993	13	0	452	13	12	7,499
Transportation	33	6,645	50	12	398	24	52	7,214
Ordnance	0	1,300	0	0	172	0	0	1,472
Petroleum	0	2,564	0	12	494	104	0	3,174
Primary metals	0	3,228	12	0	413	0	0	3,653
Other industry	0	4,736	25	189	1,304	30	105	6,389
Colleges	13	1,176	89	2,565	1,027	626	642	6,138
Junior colleges	0	0	0	143	12	85	25	265
Medical education	0	0	0	14	140	0	13	167
Other education	13	146	0	257	0	0	13	429
Health services	0	155	0	140	229	12	43	579
Construction/engineering	13	28,153	0	77	250	449	125	29,067
Mining and petroleum	0	1,067	0	23	50	274	107	1,521
Public utilities	17	4,041	25	57	289	49	13	4,491
Government	53	8,535	64	2,248	1,353	789	520	13,562
All other	106	9,978	227	10,118	4,296	1,969	781	27,475
Total	505	93,980	647	16,004	16,400	4,447	2,567	134,550

[1]Persons reporting significant professional time devoted to these activities.

SOURCE: 1974 National Survey of Scientists and Engineers.

TABLE B.II.4 Occupation by Type of Employee for Scientists and Engineers in Pollution Control,[1] 1974

Occupation	Type of Employer: Private Company	Nonprofit Institution	Federal Government	State Government	Local Government	Self-Employed	Other	Total
Engineers (Total)	54,643	1,354	7,999	5,820	5,379	4,421	1,284	80,900
Agricultural	92	0	296	275	128	88	0	879
Chemical	8,658	183	416	91	153	305	236	10,042
Civil	8,492	265	3,628	3,086	3,039	1,821	181	20,512
Electrical	5,460	89	156	133	51	293	63	6,245
Industrial	2,629	0	332	43	16	107	16	3,143
Mechanical	13,584	173	999	256	527	625	390	16,554
Metal	1,745	24	201	0	0	24	0	1,994
Mining	884	0	93	55	12	66	38	1,148
Nuclear	374	0	152	12	0	0	0	538
Sanitary	5,847	348	759	1,674	1,068	913	120	10,729
Other	6,878	272	967	195	385	179	240	9,116
Computer specialists	394	0	71	45	74	13	33	630

Mathematics and statistics	280	110	166	130	163	0	0	849
Chemists	7,139	469	1,206	1,007	694	211	136	10,862
Other physical scientists	520	190	617	188	147	52	14	1,728
Atmospheric scientists	38	153	421	60	39	105	0	816
Earth scientists	484	158	950	643	277	168	36	2,716
Ocean scientists	85	93	204	162	78	0	0	622
Agricultural scientists	914	186	5,806	1,792	365	108	36	9,207
Biological scientists	771	875	1,267	2,066	375	117	0	5,471
Medical scientists	36	0	12	14	121	0	0	183
Social scientists	152	275	429	465	199	63	0	1,583
Health occupations	0	0	0	12	0	0	0	12
Technicians	419	87	26	24	47	0	30	633
Teachers	0	55	0	77	103	0	0	235
Managers	12,880	494	1,009	534	214	876	339	16,346
All others	1,171	72	197	25	11	202	79	1,757
Total	79,926	4,571	20,380	13,064	8,286	6,336	1,987	134,550

[1]Persons reporting significant professional time devoted to these activities.

SOURCE: 1974 National Survey of Scientists and Engineers.

TABLE B.II.5 Field of Study by Field of Science or Engineering for Scientists and Engineers in Pollution Control,[1] 1974

	Field of Science or Engineering							
Field of Study	Computer Specialists	Engineers	Mathematicians	Life Scientists	Physical Scientists	Environmental Scientists	Social Scientists	Total
Agricultural sciences	0	124	0	1,351	50	147	0	1,672
Biological and life sciences	0	986	17	5,738	1,142	303	0	8,186
Food, fish, and forestry	18	436	0	7,547	88	81	75	8,245
Education	0	632	12	336	213	35	52	1,280
Aerospace engineering	15	1,697	0	0	0	26	0	1,738
Agricultural engineering	0	1,418	0	85	24	0	0	1,527
Architectural engineering	0	777	0	0	0	0	0	777
Chemical engineering	0	13,118	0	0	390	14	0	13,522
Civil engineering	13	22,628	0	0	23	31	0	22,695
Electrical engineering	51	8,590	0	0	12	72	0	8,725
Engineering sciences	0	1,132	0	0	24	0	0	1,156
Engineering technology	0	558	0	0	0	0	0	558
Environmental engineering	0	542	0	0	0	0	0	542
General engineering	0	1,329	0	0	0	0	0	1,329
Industrial engineering	0	3,253	0	0	0	0	0	3,253
Mechanical engineering	0	20,562	0	15	0	13	0	20,590
Metallurgical and material engineering	0	2,012	0	0	64	13	0	2,089
Mining engineering	0	846	0	0	0	0	0	846

Marine engineering	0	288	0	0	0	0	0	288
Nuclear engineering	0	12	0	0	0	0	0	12
Operations research engineering	0	12	0	0	0	0	0	12
Petroleum engineering	0	467	0	0	0	0	0	467
Other engineering	0	3,572	0	42	12	47	0	3,673
Health sciences	17	399	27	267	37	37	0	784
Mathematics, statistics	121	495	533	0	88	50	20	1,307
Computer science	53	140	0	0	25	0	0	218
Other physical sciences	0	247	0	68	467	1,095	0	1,877
Chemistry	0	1,651	12	43	12,071	36	0	13,813
Geography	0	34	0	13	91	126	72	336
Physics	45	904	0	0	1,260	167	0	2,376
Geology and geophysics	0	334	0	23	74	2,155	0	2,586
Psychology	0	13	0	14	24	0	401	452
Social sciences	52	426	17	172	43	0	1,898	2,608
Arts and humanities	105	3,197	17	280	134	0	50	3,783
All others[2]	15	1,544	12	81	171	25	30	1,878
Total	505	94,375	647	16,075	16,527	4,473	2,598	135,200[3]

[1] Persons reporting significatnt professional time devoted to these activities.
[2] Includes no report.
[3] Total (135,200) exceeds others in this series (134,550) owing to inclusion of 650 persons not reported by sex.

SOURCE: 1974 National Survey of Scientists and Engineers.

TABLE B.II.6 Primary and Secondary Work Activity by Type of Employee for Scientists and Engineers in Pollution Control[1] 1974

	Type of Employer							
Primary Work Activity	Private Company	Nonprofit Institution	Federal Government	State Government	Local Government	Self-Employed	Other	Total
Research and Development								
Total	24,202	1,356	5,422	2,611	1,465	1,093	547	36,696
Basic research	746	616	1,371	642	112	68	14	3,569
Applied research	3,068	513	1,773	1,364	341	26	13	7,098
Development	8,890	157	798	58	111	119	351	10,484
Design	11,498	70	1,480	547	901	880	169	15,545
Management and								
Administration Total	25,564	1,243	7,614	4,275	2,834	1,796	855	44,181
R&D management	9,050	626	2,130	1,184	505	334	166	13,995
Other management	16,514	617	5,484	3,091	2,329	1,462	689	30,186
Teaching	239	1,195	232	1,934	346	0	0	3,946
Quality Control	3,754	48	476	335	618	0	73	5,304
Operations	10,214	63	1,499	546	855	153	75	13,405
Other Production	163	0	0	79	36	13	0	291
Consulting	6,712	308	1,606	797	371	2,613	181	12,588
Report Writing	1,637	55	1,145	830	562	139	28	4,396
Other & No Report	7,441	303	2,386	1,657	1,199	529	228	13,743

Secondary Work Activity								
Research and Development								
Total	24,009	1,564	4,372	2,623	1,427	1,106	373	35,474
Basic research	888	613	652	1,101	274	0	0	3,528
Applied research	3,003	555	1,693	995	288	234	12	6,780
Development	10,050	223	915	121	279	220	214	12,022
Design	10,068	173	1,112	406	586	652	147	13,144
Management and								
Administration Total	10,740	675	2,770	1,670	1,257	1,167	161	18,440
R&D management	3,057	400	761	626	357	294	13	5,508
Other management	7,683	275	2,009	1,044	900	873	148	12,932
Teaching	740	369	486	1,261	198	34	25	3,113
Quality Control	4,455	49	521	544	336	215	48	6,168
Operations	10,410	390	2,045	644	1,322	610	392	15,813
Other Production	57	17	46	37.	0	0	0	157
Consulting	8,583	120	2,544	1,069	852	1,432	255	14,855
Report Writing	7,880	859	3,772	2,374	1,373	572	334	17,164
Other & No Report	13,052	528	3,824	2,842	1,521	1,200	399	23,366
Total	79,926	4,571	20,380	13,064	8,286	6,336	1,987	134,550

[1] Persons reporting significant professional time devoted to these activities.

SOURCE: 1974 National Survey of Scientists and Engineers.

TABLE B.II.7 Mobility of Scientists and Engineers in Pollution Control,[1] 1972-1974

1972 Residence	1974 Residence: New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Atlantic	West South Atlantic	Mountain	Pacific	Out of United States, No Report	Total
Those Having a Bachelor's Degree or Less											
New England	5,636	50	26	0	0	0	14	24	11	0	5,761
Middle Atlantic	73	13,739	136	23	333	45	37	147	113	60	14,706
East North Central	12	197	19,081	288	106	207	37	176	49	13	20,166
West North Central	12	53	116	6,501	97	0	27	62	37	0	6,905
South Atlantic	53	98	62	37	11,728	204	181	0	118	49	12,530
East South Atlantic	0	37	49	0	63	4,110	0	12	63	0	4,334
West South Atlantic	0	12	52	102	69	101	8,503	64	47	38	8,988
Mountain	0	16	68	12	77	51	35	3,528	109	25	3,921
Pacific	0	0	24	0	12	0	134	342	13,655	33	14,200
Out of United States, No report	0	12	0	0	12	0	0	0	35	14	73
Total	5,786	14,214	19,614	6,963	12,497	4,718	8,968	4,355	14,237	232	91,584
Those Having a Master's Degree											
New England	2,307	0	0	12	0	0	0	0	0	0	2,319
Middle Atlantic	27	5,046	13	0	145	0	59	11	0	0	5,301
East North Central	30	98	5,134	91	102	80	36	66	144	49	5,830
West North Central	0	0	12	1,384	0	0	13	0	37	13	1,459
South Atlantic	12	284	101	0	3,376	86	60	23	48	0	3,990
East South Atlantic	0	0	0	0	48	1,122	37	0	0	0	1,207
West South Atlantic	0	0	14	14	0	47	2,278	0	0	0	2,353
Mountain	0	0	0	0	62	0	0	1,602	32	14	1,710
Pacific	0	0	35	0	83	0	27	49	4,643	0	4,837
Out of United States, No report	0	0	0	15	0	0	0	0	0	17	32

Total	2,376	5,428	5,309	1,516	3,816	1,335	2,510	1,751	4,904	93	29,038
Those Having a Doctoral Degree											
New England	1,172	18	0	0	0	0	0	0	0	0	1,190
Middle Atlantic	47	2,312	40	0	198	0	0	0	12	58	2,667
East North Central	72	61	2,189	0	78	0	13	0	11	43	2,467
West North Central	0	0	58	752	61	0	78	0	35	16	1,000
South Atlantic	70	0	12	0	2,579	39	0	12	73	0	2,785
East South Atlantic	0	0	0	13	38	552	11	12	0	0	626
West South Atlantic	0	0	0	0	90	0	826	13	0	0	929
Mountain	0	0	0	0	45	0	0	898	0	52	995
Pacific	0	0	0	0	0	0	24	17	1,780	23	1,844
Out of United States, No report	0	0	0	0	0	0	0	0	14	61	75
Total	1,361	2,391	2,299	765	3,089	591	952	952	1,925	253	14,578
All Degree Levels											
New England	9,115	68	26	12	0	0	14	24	11	0	9,270
Middle Atlantic	147	21,097	189	23	676	45	96	158	125	118	22,674
East North Central	114	356	26,404	379	286	287	86	242	204	105	28,463
West North Central	12	53	186	8,637	158	0	118	62	109	29	9,364
South Atlantic	135	382	175	37	17,683	329	241	35	239	49	19,305
East South Atlantic	0	37	49	13	149	5,784	48	24	63	0	6,167
West South Atlantic	0	12	66	116	159	148	11,607	77	47	38	12,270
Mountain	0	16	68	12	184	51	35	6,208	141	91	6,626
Pacific	0	0	59	0	95	0	185	408	20,078	56	20,881
Out of United States, No report	0	12	0	15	12	0	0	0	49	92	180
Total	9,523	22,033	27,222	9,244	19,402	6,644	12,430	7,058	21,066	578	135,200[2]

[1] Persons reporting significant professional time devoted to these activities.

[2] Total (135,200) exceeds others in this series (134,550) owing to inclusion of 650 persons not reported by sex.

SOURCE: 1974 National Survey of Scientists and Engineers.

TABLE B.II.8 1975 Employment Specialty by Sex and Age for Doctoral Scientists and Engineers in Pollution Control,[1] 1975

	Employment Specialty											
	Mathe-matics	Physics	Chemistry	Earth Science	Engi-neering Science	Agricul-tural Science	Medical Science	Biologi-cal Science	Social Science	Other	No Report	Total
Sex												
Male	141	434	3,326	3,082	3,303	1,290	279	2,424	915	314	84	15,592
Female	8	3	107	130	24	7	24	237	63	13	9	625
Age												
25-29	18	13	163	127	118	12	18	95	51			615
30-34	34	147	722	746	805	325	39	611	237	38	20	3,724
35-39	49	93	718	759	850	284	56	546	198	55	14	3,622
40-44	8	68	468	528	665	256	67	488	183	65	33	2,829
45-49	14	58	430	424	299	116	46	372	122	41	5	1,927
50-54	23	7	470	344	221	126	39	258	71	52		1,611
55-59	3	21	247	113	191	114	5	190	30	26	7	947
60-64		17	161	123	156	46	11	78	64	33		689
65 and over		13	54	48	21	18	22	23	22	17	14	252
No report					1							1
Total	149	437	3,433	3,212	3,327	1,297	303	2,661	978	327	93	16,217

[1] Persons reporting significant professional time devoted to these activities.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

TABLE B.II.9 Type of Employer by Employment Specialty for Doctoral Scientists and Engineers in Pollution Control,[1] 1975

	Employment Specialty											
Type of Employer	Mathematics	Physics	Chemistry	Earth Science	Engineering Science	Agricultural Science	Medical Science	Biological Science	Social Science	Other	No Report	Total
Business or industry	46	147	2,307	937	1,898	191	74	410	121	175	52	6,358
Two-year college			6	3	11	5		54	18		6	103
Medical school		5	34	32			69	88				228
Four-year college	77	179	532	1,167	812	519	45	1,155	693	73	12	5,264
Elementary or secondary school			10	1				3				14
Hospital or clinic							1	8	2			11
U.S. military			10	10	73		12	11			6	122
U.S. government	13	89	311	659	260	522	50	676	50	35	5	2,670
State government			36	201	107	49	30	41	34	14	11	523
Local government		5	25	62	88		12	48	22			262
International agency					29	5					1	35
Nonprofit organization	13	12	150	140	49	6	10	157	38	25		600
No report			12					10		5		27
Total	149	437	3,433	3,212	3,327	1,297	303	2,661	978	327	93	16,217

[1] Persons reporting significant professional time devoted to these activities.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

TABLE B.II.10 Primary Work Activity in 1975 by Employment Specialty for Doctoral Scientists and Engineers in Pollution Control[1]

Primary Work Activity	Employment Specialty: Mathematics	Physics	Chemistry	Earth Science	Engineering Science	Agricultural Science	Medical Science	Biological Science	Social Science	Other	No Report	Total
Management or Administration of R&D	4	34	942	552	629	234	76	340	140	70	9	3,030
Management or Administration of other than R&D	2	13	176	301	475	50	28	89	45	73	15	1,267
Management or Administration of both	8	8	104	166	116	54	23	75	38	27	4	623
Basic research	20	85	526	585	156	184	61	603	65	11	5	2,301
Applied research	50	135	993	659	632	486	39	501	92		9	3,596
Development		30	155	56	297			11	12	5		566
Design					86							86
Teaching	51	57	240	436	349	88	38	638	480	37	6	2,420
Technical writing		1	12	66	61	16		62	24		11	253
Production		6	37	8	55						9	115
Consulting	11	44	52	247	288	53	7	160	32	10	13	917
Professional services			9	11	52	37	18	8	11	19		165
Quality control			69		20	11	2	23				125
Sales			46		10	5		8				69
Other	3	5	45	83	75	41		19	16	75		362
No report		19	27	42	26	38	11	124	23		12	322
Total	149	437	3,433	3,212	3,327	1,297	303	2,661	978	327	93	16,217

[1] Persons reporting significant professional time devoted to these activities.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

TABLE B.II.11 Primary Work Activity by Type of Employer for Doctoral Scientists and Engineers in Pollution Control,[1] 1975

Primary Work Activity	Type of Employer: Business or Industry	Two-Year College	Medical School	Four-Year College	Elem/ Secondary School	Hospital or Clinic	U.S. Military	U.S. Government	State Government	Local Government	International Agency	Nonprofit Organization	No Report	Total
Management or Administration of R&D	1,574	17	16	411			49	686	114	35		128		3,030
Management or Administration of other than R&D	711	12	13	107		3	11	141	126	94	11	33	5	1,267
Management or Administration of both	310		5	94			17	88	46	16		47		623
Basic research	334	2	86	1,120		5	10	583	22	16		113	10	2,301
Applied research	1,429		56	988			22	789	78	43		191		3,596
Development	473			15				31	30			17		566
Design	85							1						86
Teaching	16	68	42	2,276	13			5						2,420
Technical writing	80			35			2	81	21	17		17		253
Production	104						11							115
Consulting	772			25		1		38	28	11	23	19		917
Professional services	114			33		2		6	10					165
Quality control	64			13				28	12	8				125
Sales	65							4						69
Other	168			2				114	34	22		10	12	362
No report	59	4	10	145	1			75	2		1	25		322
Total	6,358	103	228	5,264	14	11	122	2,670	523	262	35	600	27	16,217

[1] Persons reporting significant professional time devoted to these activities.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

TABLE B.II.12 Geographic Mobility from Region of Doctoral Institution to Region of 1975 Employment for Doctoral Scientists and Engineers in Pollution Control,[1] 1975

Location of Doctoral Institution	Location of 1975 Employment: New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Atlantic	West South Atlantic	Mountain	Pacific	Other, No Report	Total
New England	411	376	43	17	261	14	52	36	151	19	1,380
Middle Atlantic	294	1,169	301	80	559	33	99	172	166	57	2,930
East North Central	162	509	1,211	200	667	168	156	100	249	29	3,451
West North Central	23	211	229	430	204	30	66	92	172	39	1,496
South Atlantic	106	199	170	46	990	172	115	41	91	9	1,939
East South Central	12	30		8	159	141	25		2	16	393
West South Central	23	47	100	70	145	79	296	28	36	2	826
Mountain	23	39	78	78	76	45	67	378	163	1	948
Pacific	125	111	145	49	317	11	43	177	1,265	8	2,251
Other	72	152	65	34	95	10	26	19	119	11	603
Total	1,251	2,843	2,342	1,012	3,473	703	945	1,043	2,414	191	16,217

[1] Persons reporting significant professional time devoted to these activities.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

TABLE B.II.13 Field of Doctorate by 1975 Employment Specialty for Doctoral Scientists and Engineers in Pollution Control,[1] 1975

Field of Doctorate	Employment Specialty: Mathematics	Physics	Chemistry	Earth Science	Engineering Science	Agricultural Science	Medical Science	Biological Science	Social Science	Other	No Report	Total
Mathematics	70			5	14		9	10	2			110
Physics	13	325	40	367	142	10		19	22	6		944
Chemistry			3,119	562	378	34	14	71		162	37	4,377
Earth science		1	17	1,121	59	28		26	4	4	21	1,277
Engineering	34	106	59	268	2,619		13	30		34	10	3,173
Agricultural science			44	143	14	922		218	23	12		1,376
Medical science			10	41	7	6	148	21				233
Biological science	7	5	142	617	50	252	109	2,223	6	56	31	3,498
Social science	20			75	34	42	10	39	894	185	17	1,161
Other	5		2	13	4	3		4	27			62
No report					6							6
Total	149	437	3,433	3,212	3,327	1,297	303	2,661	978	327	93	16,217

[1] Persons reporting significant professional time devoted to these activities.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

TABLE B.II.14 Age and Years of Professional Experience by Type of Employer for Doctoral Scientists and Engineers in Pollution Control,[1] 1975

	Type of Employer													
	Business or Industry	Two-Year College	Medical School	Four-Year College	Elem/ Secondary School	Hospital or Clinic	U.S. Military	U.S. Government	State Government	Local Government	International Agency	Nonprofit Organization	No Report	Total
Age														
25-29	256	4	29	210		2		73	19	6		16		615
30-34	1,525	11	41	1,237	10		38	529	121	48		164		3,724
35-39	1,410	18	33	1,217			28	588	81	103	11	123	10	3,622
40-44	943	52	39	1,023	3	1	26	500	132	26	12	72		2,829
45-49	731	1	27	589			17	396	58	32		71	5	1,927
50-54	682	3	15	426		8	8	309	63	3	6	88		1,611
55-59	373	5	10	329			3	149	35	5	5	33		947
60-64	327	9	7	173				114	6	29		24		689
65 and over	110		27	60	1		2	12	8	10	1	9	12	252
No report	1													1
Median age	39.46		40.91	39.37				40.95	41.03	38.24		39.38		39.76
Years of Professional Experience														
0-1 year	36			72				5		8		1		122
2-4 years	756	18	70	680		2	38	215	75	23		114		1,991
5-9 years	1,630	10	41	1,364	10		6	698	157	78		114	10	4,118
10-15 years	1,288	47	36	1,380		1	11	653	102	79	23	123		3,743
16-20 years	817	4	28	580	3		43	401	99	27	5	54		2,061
More than 20 years	1,710	18	48	1,116	1	3	24	688	88	47	7	194	17	3,961
No report	121	6	5	72		5		10	2					221
Total	6,358	103	228	5,264	14	11	122	2,670	523	262	35	600	27	16,217

[1] Persons reporting significant professional time devoted to these activities.

SOURCE: 1975 Survey of Doctoral Scientists and Engineers.

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APPENDIX C Federal Aspects

INTRODUCTION

The effects of environmental pollution on public health are of fundamental concern to the nation. Where the environment has been seriously degraded, or in occupations that are discovered to be hazardous to health, increases in "environmental diseases," such as emphysema, certain types of cancer, and lead poisoning, are directly attributable to pollutants.

To provide medical treatment on a national basis for these types of diseases, Congress has supported health care programs and promoted the establishment of health agencies. This is a laudable objective.

However, provision of health care will not resolve the basic problems of achieving acceptable standards for a safe water supply, pure air, and uncontaminated food products to support life.

In addition, public health is affected by the presence of solid wastes, or toxic materials, in the environment as well as by the presence of radiation, noise, and other pollutants. The major role of the EPA is to study, resolve, and regulate the problems of all pollutants: noise, toxic materials, radiation, solid wastes, air contaminants, sewage, and other forms of wastes.

If a safe environment is to be maintained, provision must be made for monitoring and treating all of society's polluting effluents resulting from population increase and industrial technology. An adequate supply of manpower is essential for the successful prevention of environmental degradation. A large variety of specialists is required to meet current and future needs in controlling the quality of the environment, such as: environmental engineers, environmental health specialists, design engineers, environmental sanitarians, technicians, agriculturalists, entomologists, biologists, ecologists, economists, administrators, chemical engineers, mechanical engineers, civil engineers, air and water pollution technologists, radiological health physicists, noise-control technologists, toxicologists, chemists, geologists, virologists, environmental lawyers, and other specialists in pollution control.

Based on reports it received, the Panel believes that adequate manpower in some of these specialties is often lacking. Had it not been for earlier traineeships, scholarships, and project grants from the United States Public Health Service (PHS) and from EPA, there would be a shortage of environmental manpower today. The federal government has the right and responsibility to assure that adequate manpower, funds, and equipment are available to monitor and control environmental pollution at national, state, and local levels in order to protect the health of its citizens. Furthermore, it should help assure that adequate manpower can be available to solve future environmental problems, such as new sources of energy, the need for more food, and the necessity for recycling solid wastes.

EPA has primary responsibility for protecting the environment. Although medical care for environmentally produced health problems is imperative, and an adequate supply of environmental specialists is necessary to ensure the public's health in any health care system, the first priority must be concentration on the abatement, or removal, of dangerous pollutants in the environment. The United States cannot afford the health and economic costs created by rampant pollution.

ANALYTICAL REQUIREMENTS FOR MANPOWER STUDIES

Insight on environmental issues may be provided by examining the problems to be resolved, identifying the skills needed to provide solutions, and determining the quantitative and qualitative adequacy of the manpower supply to achieve the desired results.

Had such an analysis accompanied the passage of the Water Pollution Control Act and similar environmental legislation, a more realistic timetable might have resulted and realization of the stated goals would have been accomplished more rapidly. In the absence of such analyses and planning, manpower needs are frequently considered in terms of the manpower pool available, rather than in terms of the goals to be accomplished. If manpower is qualitatively or quantitatively inadequate, persons with dubious or inadequate qualifications may be employed in available positions. Once established in these positions, their removal may be difficult when appropriately trained personnel become available. Also, their retraining needs are difficult to identify because removal from one position and training for another often involve serious difficulties. Retention of unqualified personnel, especially in areas involving public health, might be unwarranted. Such individuals would continue to be ineffective and dangerous consequences might result.

OBJECTIVES AND METHODOLOGY

An assessment of the current and future demands by the federal government for environmental manpower is presented in this report, with special emphasis placed on EPA as the principal federal agency responsible for pollution abatement and control.

A detailed profile of EPA's current work force is provided in terms of educational background, occupation, grade level, and function. Although these data do provide some interesting and valuable insights into the Agency, its priorities, and its methods of operation, the evaluation should not be considered as a study primarily of the Agency's management and policies.

Projections of future levels of activity are always difficult to make for discretionary governmental programs, and the environmental area is no exception. In sections of this report, projections of future government funding and employment levels are presented and discussed. In general, these projections are based on the assumption of decreasing direct federal involvement and financing of pollution control programs.

A particular concern of the Panel is that adequate studies of the impact of all federal expenditures or legislative programs on national resources, especially manpower supplies, be made an integral part of planning for any new national endeavor. For example, staffing implications created by federal environmental laws will be greatest on local governments and private sectors of the economy. Comparable effects will not be felt in federal agencies.

On the other hand, because federal decisions are both far-reaching and long-lasting in their effects, the organization and characteristics of the Agency that guides these decisions are appropriate subjects for environmental manpower study. It is most important to keep in mind that major public policies represent the workings of a political process that attempts to resolve many conflicting interests and that, in so doing, may develop apparent inconsistencies. As a result, general opinion may attribute inconsistent or ineffectual operations of programs entirely to personnel within the Agency. This view is erroneous because administrators and personnel in the Agency are obligated to operate within legislative limitations established by Congress and by judicial decisions.

FEDERAL EMPLOYMENT PATTERNS FOR POLLUTION CONTROL PROGRAMS

The federal government is the dominating influence in establishing the scope and character of the nation's environmental pollution control programs, and has the legal responsibility to ensure that pollution is controlled throughout the country. The federal government also determines its own manpower requirements. The federal role in environmental matters is primarily one of instigating, coordinating, financing, monitoring, and also regulating national policies. Therefore, direct federal employment requirements should be relatively modest. On the other hand, the bulk of the manpower requirements generated by pollution control programs are in design and construction of treatment plants and other equipment, in operation and maintenance staffs for public, private, and industrial waste disposal facilities, and in industrial plants producing supplies and equipment for the systems.

MANPOWER FUNCTIONS IN FEDERAL AGENCIES

Generally, federal agencies fund two types of functions incident to pollution control for which federal employees are required. The first category includes the instigation, coordination, and control of programs that are actually performed by nonfederal employees, such as those in state or municipal organizations or industrial concerns. These activities include reviewing local and regional programs, evaluating funding requests, arranging demonstration projects, training personnel, conducting research and development, providing surveillance and technical services, undertaking manpower studies, identifying toxic substances, and similar duties. Most of these functions are assigned to EPA. Some specialized duties are assigned to other agencies; for example, the Coast Guard is responsible for assessment of penalties for illegal discharge of oil.

The second category of functions requiring federal environmental employees involves the operation and maintenance of pollution control systems on federal installations. In this category are the water and wastewater treatment systems operated by the military, similar systems in recreational areas operated by the Forest and Park Services, and air pollution control devices at Tennessee Valley Authority installations. These treatment plants are similar to municipal or industrial systems and require manpower with equivalent skills for their operation and maintenance.

TABLE C.1 Federal Expenditures for Pollution Control and Abatement Activities by Function, FY 1975 (Actual), FY 1976 and FY 1977 (Estimated)

	Expenditures					
	FY 1975		FY 1976		FY 1977[1]	
Function	Actual	Percent	Estimated	Percent	Estimated	Percent
			(dollars in millions)			
Financial aid to state, interstate, and local governments	$2,189.0	61.3	$2,718.6	60.9	$4,143.7	71.2
Research, development, and demonstration	569.6	16.0	740.5	16.6	743.0	12.8
Establishment of standards and enforcement	368.8	10.3	404.7	9.0	377.5	6.5
Reduced pollution from federal facilities	334.2	9.4	475.0	10.6	441.8	7.6
Manpower development	14.7	0.4	14.3	0.3	8.6	0.1
Other	94.5	2.6	114.1	2.6	108.5	1.9
Total	$3,570.8	100.0	$4,467.2	100.0	$5,823.1	100.0

[1] The amounts do not include the July/September 1976 interim quarter adjustment to the new October/September fiscal year 1977.

SOURCE: U.S. OMB (1976).

BUDGET ALLOCATIONS FOR POLLUTION CONTROL

The federal government's annual budget presentation includes a series of "Special Analyses" that classify federal appropriations functionally, rather than by the agency to which funds are allocated. Table C.1 summarizes actual and estimated federal outlays for pollution control and abatement activities by function, as reported in Special Analysis Q of the U.S. Budget for FY 1977.

Of the $5.8 billion to be expended in FY 1977, an estimated $4.1 billion is scheduled for transfer to state, interstate, and local governments, principally in the form of EPA grants for construction of waste water treatment facilities ($3.9 billion) in accordance with provisions in the Water Pollution Control Act. The balance of $1.7 billion is primarily for operation of direct federal programs of R&D, establishment of standards and enforcement, and reduction of pollution from federal facilities. EPA administers nearly 50 percent of the allocation for pollution control, but other agencies with a substantial share of funds include the Department of Defense, the Energy Research and Development Administration, and the Department of Agriculture. Note that projected funds in FY 1977 for manpower development decrease substantially from 0.3 percent in FY 1976 to only 0.1 percent of the total projected expenditure for pollution control and abatement activities in FY 1977. By any standard of comparison this is an exceedingly small fraction of the total pollution control budget allocated for manpower development. In addition, the amount of funds projected for manpower is cut by 40 percent in FY 1977 from FY 1976.

Table C.2 shows the federal outlays after transfers to other governmental organizations, mostly as construction grants. It will be noted that

TABLE C.2 Net Direct Outlay for Federal Pollution Control and Abatement Activities and Total Transfers to Other Governmental Organizations, FY 1973-1975 (Actual) and FY 1976-1977 (Estimated)

Fiscal Years	Transfers to Other Governmental Organizations	Net Direct Outlay	Total
		(dollars in millions)	
1973	$ 908	$1,017	$1,925
1974	1,867	1,107	2,974
1975	2,189	1,382	3,571
1976 (estimated)	2,719	1,748	4,467
1977 (estimated)	4,144	1,679	5,823

SOURCE: U.S. OMB (1974, 1975, 1976).

although transfer funds increase by about $2 billion from 1975 to the 1977 budget estimate, net direct federal funds decline from 1976 to 1977.

EPA SUPPORT FOR MANPOWER DEVELOPMENT AND TRAINING ACTIVITIES

Data on program support for manpower and training activities for a sequence of years will be reviewed to discern trends. These can then be compared with the needs for manpower required to solve the pollution problems facing the nation.

Table C.3 provides data on EPA's manpower and training activities for FY 1973 through FY 1977 by program activity. The projected decline in support for manpower activities is precipitous, in many cases reduced to zero for various program activities. The wisdom of eliminating support for manpower development is questioned, as drastic reductions predictably retard progress in reaching environmental goals.

In Table 3.6 of the Committee report, the number of personnel trained with support from different offices of EPA is given for FY 1973 through FY 1977. Again, the data for FY 1977 are projections.

A breakdown of EPA's support for training activities in FY 1976 is given in Table C.4. The total of approximately $14.9 million is comparable to the estimated $14.3 million shown in Table C.1 for manpower development. The difference between the two figures is not great and is accounted for by variations in reporting procedures by the sources.

EPA OPERATING FUNDS AND MANPOWER ESTIMATES

EPA funds account for approximately 35 percent of the total direct federal budget authority for pollution control and abatement activities (U.S. Budget 1976). The distribution of the EPA budget is shown in Table C.5.

Most of these activities involve a large professional and technical staff. Although the categories are too broad to permit analysis by the usual procedures employed for computation of manpower factors, a generalization can be made that no substantial increase in federal environmental manpower is expected. The FY 1977 budget estimates for end-of-year staff positions in EPA are 9550, which are equivalent to the staffing levels in FY 1976.

Estimates of probable funding levels for EPA's operating programs through 1980, provided by the Office of Management and Budget, indicate no increase and probably some decline.[1] On this basis, there is unlikely to be any substantial increase in the Agency's overall staff, although the numbers of people in specific categories may be expected to fluctuate.

EXPENDITURES FOR POLLUTION ABATEMENT IN OTHER FEDERAL AGENCIES

Approximately 12 federal agencies, in addition to EPA, project expenditures for pollution control and abatement activities in FY 1977. The estimates for these agencies are given in Table C.6.

Most of these funds will be applied to reduction of pollution in federal facilities, such as installation of new equipment, process changes, fuel switching, and similar projects, and for research, development, and demonstration projects concerning energy, agriculture and agricultural products, and transportation.

FEDERAL MANPOWER REQUIRED TO IMPLEMENT LEGISLATION ON ENVIRONMENTAL CONTROL

The federal government not only has the legal responsibility, but also has an obligation to set an example for control of pollution in the nation. In monitoring pollution throughout the nation, the federal government must supervise itself, because it is the owner and operator of numerous installations and residential complexes that may become significant sources of pollution. The Departments of Defense and Interior, and the Tennessee Valley Authority own most of these federal facilities.

EMPLOYMENT PROFILE IN EPA

General Classifications of Personnel

EPA currently employs about 10,000 full-time permanent employees, almost all of whom are classified as white-collar. This figure represents

[1]Unpublished correspondence between the Office of Management and Budget and the Committee.

TABLE C.3 EPA Funding and Staff for Manpower Development and Training Programs

	Thousands of Dollars				
Program Activity	FY 1973	FY 1974	FY 1975	FY 1976	FY 1977 (Estimated)
Office of Education and Manpower Planning/ Office of Federal Activities					
Staff (positions)	14	20[a]	18	17	8
Manpower planning projects	$ 40	$1,000[b]	$ 210[c]	$ 450[c]	$450[c]
Office of Water Program Operations					
Staff		42	35	29	29
Training grants[1]	$6,533	$4,092	$1,600	$1,000	0
Fellowships[1]	$ 17	$ 215	$ 270	$ 344	0
Demonstration grants[1]				$ 195	0
Operator training grants[2]	$1,879	$1,875	$1,910	$1,100	$1,100
Undergraduate training grants[3]				$ 331	0
Manpower planning projects[4]	$ 343	$ 191	$ 318	0	0
State training centers[5]	($250 thousand through construction grant funds)				
Office of Water Supply					
Fellowships[6]				$ 435	0
Office of Air Quality Planning and Standards/ Air Pollution Training Institute					
Staff	31	36	33	26	6[d]
Training grants and fellowships[7]	$2,180	$2,000	$1,200	$1,200	0
Inspection/maintenance[7]				$ 90	0

Office of Pesticide Programs					
Staff				5	5
Applicator training & state certification[8]				$10,200	$5,200
Office of Solid Waste Management Programs					
Training Grants[9]	$ 365	$ 202	0	0	0
Direct training[9]	$ 74	0	0	0	0
Manpower planning[9]	$ 50	0	0	0	0
Office of Radiation Programs					
Training grants[10]	$ 758	$ 121	$ 41	0	0
Direct training[10]	$ 26	$ 35	0	0	0
Office of Noise Abatement Control[11]	0	0	0	0	0
Regional manpower offices[2]					
Staff	38	34	30	32	27
Regional manpower offices				$1,000	$1,000

[1] Water Pollution Control Act, § 104(g)(3)(a).
[2] Water Pollution Control Act, § 104(g)(1).
[3] Water Pollution Control Act, § 109(a).
[4] Water Pollution Control Act, § 104(g)(2).
[5] Water Pollution Control Act, § 109(b).
[6] Safe Drinking Water Act, § 1442(b)(3).
[7] Clean Air Act, § 103(b).
[8] Federal Insecticide, Fungicide, and Rodenticide Act.
[9] Solid Waste Disposal Act.
[10] Reorganization Plan No. 3 of 1970.
[11] Noise Control Act.

[a] Salaries for 5 positions paid by the U.S. Department of Labor.
[b] Evenly distributed among 10 regional offices.
[c] For contracts and grants.
[d] Reflects use of contract personnel.

SOURCE: Table developed by the U.S. EPA for internal review.

TABLE C.4 EPA Support for Training Activities, by Office and Training Activity, FY 1976

Office and Training Activity	Funds: Subtotals	Funds: Totals
	(thousands of dollars)	
Office of Water Program Operations		
Training grants	$ 1,000	
Fellowships	344	
Demonstration grants	195	
Operator training grants	1,100	
Undergraduate training grants	331	
		$ 2,970
Office of Water Supply		
Fellowships	435	
		435
Office of Air Quality Planning & Standards		
Training grants & fellowships	1,200	
Inspection/maintenance	90	
		1,290
Office of Pesticide Programs		
Applicator training & state certification	10,200[a]	
		10,200[a]
Total Funds		$14,895

[a]Approximately $5 million was transferred to the Agricultural Extension Service for training, the remainder being allocated to designated state agencies for both training and certification.

SOURCE: Table developed by the U.S. EPA for internal review.

about half of 1 percent of the total federal civilian white-collar labor force of 1.9 million.[2]

Table C.7 is derived from data in the Central Personnel Data File of the Civil Service Commission and presents the broad occupational distributions of EPA employees. For purposes of comparison, data are also presented for the government as a whole and for the former Atomic

[2]Civil Service Commission, Central Personnel Data File, Table E, dated October 1974. Not published.

TABLE C.5 Operating Budget of the Environmental Protection Agency for FY 1977

Function	Dollars (in millions)	Percent
Abatement and control	$329.6	45.9
Enforcement	56.6	7.9
Research and development	242.7	33.8
All other	89.3	12.4
Total	$718.2	100.0

Not including Construction Grants Program or supplemental appropriations.

SOURCE: U.S. EPA (1976).

Energy Commission (AEC), from which were formed the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (U.S. NRC).

The former AEC was selected for comparison with EPA because of similarity in focus on scientific matters and equivalent size. The figures given are for 1974, but are the most recent available through the Civil Service data file. However, EPA has experienced very little change in the level or pattern of employment since that time.

Table C.7 provides data on broad categories of employees of the EPA,

TABLE C.6 Planned Expenditures for Pollution Abatement by Federal Agencies Other Than EPA, FY 1977

Agency	Funds (dollars in millions)
Department of Defense	$ 436.0
Energy Research and Development Administration	224.9
Department of Agriculture	195.3
Department of Transportation	92.8
Housing and Urban Development	83.6
National Aeronautics and Space Administration	85.0
Department of Interior	52.8
Department of Commerce	53.0
All Other	99.7
Total	$1,323.1

SOURCE: U.S. OMB (1976).

TABLE C.7 Occupational Distribution of Full-Time, White-Collar Employees in the Environmental Protection Agency (EPA), the Atomic Energy Commission (AEC), and All Federal Agencies, 31 October 1974

Occupational Category	Number of Employees					
	EPA		AEC		All Federal Agencies[1]	
	Number	Percent	Number	Percent	Number	Percent
Administrative and clerical	3,690	40.8	3,543	45.5	633,890	43.5
Biological, physical and mathematical sciences	2,425	26.8	748	9.6	99,306	6.8
Engineering and architecture	1,676	18.5	1,672	21.5	146,490	10.0
Legal and kindred occupations	221	2.4	202	2.6	57,044	3.9
Other	1,024	11.3	1,627	20.9	521,982	35.8
Total	9,036	100.0	7,792	100.0	1,458,712	100.0

[1] This computation excludes 498,540 white-collar postal employees. It also excludes employees of the Central Intelligence Agency, National Security Agency, Board of Governors of the Federal Reserve, and foreign nationals overseas. Errors in addition are caused by rounding.

SOURCE: U.S. Civil Service Commission, Central Personnel Data File, Table E, dated October 1974. Not published.

AEC, and total federal employment. The statistics show that EPA had proportionally fewer administrative personnel (41 percent) than the AEC (46 percent) or the government as a whole (44 percent). Also, about 20 percent of both EPA and AEC employees were engineers, which is double the percentage for all federal agencies. About 2.5 percent were in legal and associated occupations in both AEC and EPA, which is lower than the government average of 3.9 percent. A significant difference was in the category of biological, physical, and mathematical scientists, who contributed to 27 percent of EPA's labor force, in contrast to only 10 percent of AEC's personnel and 7 percent of the federal labor force as a whole.

In Table C.8, a more detailed breakdown of current EPA employment as of March 13, 1976, is given. Table C.8 indicates that, after administrative personnel, engineers, physical scientists, and biological scientists form the largest employment categories in EPA.

TABLE C.8 Distribution of All Full-Time, White-Collar EPA Employees, by Occupation and Grade Level, March 1976

	Number of Employees by Grade Level (GS)[2]				Total	
Occupational Category[1]	1-5	6-11	12-15	16-18	Number	Percent
General administrative, clerical, and office services	1,911	1,303	644	19	3,877	37.7
Engineering	188	674	1,008	6	1,876	18.3
Physical sciences	208	540	814	81	1,643	16.0
Biological sciences	170	329	397	5	901	8.8
Accounting and budget	62	150	176	3	391	3.8
Legal	9	78	177	5	269	2.6
Information and arts	33	116	87	1	237	2.3
Personnel management	36	81	79	1	197	1.9
Business and industry	35	75	69	1	180	1.8
Social sciences	8	52	96	0	156	1.5
Mathematics and statistics	14	42	82	7	145	1.4
Medical	3	59	43	2	107	1.0
Other	70	137	89	2	298	2.9
Total number	2,747	3,636	3,761	133	10,277	–
Total percent	26.7	35.4	36.6	1.3	–	100.0

[1] See Table 3.2 for the professional occupational distribution of engineering and scientific categories.

[2] Effective October 1, 1976, the basic annual salary structure for federal civilian employees is as follows:

Grades (GS)	1-5	\$ 5,810-12,093	12-15	\$20,442-43,923*
	6-11	10,370-22,177	16-18	39,629-54,410*

*The rate of basic pay for grades 15-18 is presently limited to \$47,500. Until March 1, 1977 the basic pay for these grades was limited to \$39,600.

SOURCE: Derived from unpublished data provided by the Personnel Management Division of the U.S. EPA (1976).

NOTE: This table appears in identical form as Table 3.1 of the Committee report.

Scientists and Engineers

It is interesting to note in Table C.8 the predominance of physical science occupations (chemists, and so on) in the highest echelons of the Agency and the fact that all scientists, including mathematicians and biologists, represent 65 percent of the "supergrade" (GS 16-18) employees of EPA. Administrators (14 percent) and lawyers (4 percent) have relatively little representation at this top career level of the Agency.

At the middle level of the career service the scientists again dominate with 1211, or 32 percent, of the positions. However, at this level engineers are also well represented with 1008 or 27 percent. Altogether, at this middle level scientists and engineers make up about 60 percent of the Agency's entire work force.

The general impression given by the data in Table C.8 is that EPA has a large proportion of scientists and engineers in its middle and top levels of management. On the other hand, the Agency has relatively few professionals in such categories as management, law, social science, and medicine.

Table C.9 provides a more detailed breakdown of EPA's scientific and engineering personnel, by specific field, based on data of March 13, 1976.

Table 3.3 in the Committee report provides the educational distribution of 5905 full-time EPA employees having a college degree by major discipline. Table 3.5 provides the same information only for those employees in EPA's Office of Research and Development. Not surprisingly, the data in Table 3.3 show that engineering and scientific disciplines predominate (62 percent), comprising about two-thirds of the degrees held by staff members within the Agency as a whole. An important feature of Table 3.5 is that it reflects the strong emphasis in the Office of Research and Development on physical sciences and engineering expertise. There are relatively few employees with academic preparation in the medical, agricultural, and social sciences disciplines.

The most significant fact illuminated by these data is the high level of educational achievement among EPA personnel, in general, and among research and development personnel in particular. These statistics on educational background strongly suggest that EPA has the basic reservoir of talent and skill needed to study and understand the scientific and engineering aspects of environmental pollution. Table 3.4 of the Committee report shows the distribution by academic discipline of all EPA employees with engineering and science degrees, and Table C.10 shows this distribution in EPA's Office of Research and Development. A close examination of the detailed fields of study indicates that specialties

TABLE C.9 Scientists and Engineers in EPA on 13 March 1976

Occupational Category[1]	Number of Personnel: Subgroup	Major Group
Engineering		
Engineers		
Sanitary	607	
General	501	
Chemical	190	
Mechanical	135	
Civil	78	
Other	61	
Total		*1,572*
Physical Sciences		
Scientists		
General	640	
Chemistry	604	
Physics	28	
Health physics	25	
Oceanography	20	
Hydrology	19	
Geology	13	
Meteorology	6	
Total		*1,355*
Biological Sciences		
Scientists		
General	476	
Microbiology	94	
Entomology	30	
Pharmacology	21	
Other	85	
Total		*706*

[1]Technicians and trainees included in the totals in Table 3.1 are omitted from this tabulation.

SOURCE: Derived from unpublished data provided by the Personnel Management Division of the U.S. Environmental Protection Agency (1976).

are widely distributed in science and engineering and that relevant academic fields, such as sanitary engineering, are especially well represented by employees with advanced degrees.

National Science Foundation (NSF) data support the statistical evidence of the predominance of staff in EPA with advanced degrees

TABLE C.10 Detailed Educational Distribution of Full-Time EPA Employees in the Office of Research and Development with Degrees in Engineering, Biological and Physical Sciences, 28 February 1976

Academic Discipline		Number of Employees by Highest Degree BA/BS	MA/MS	PhD/D	Total Number	Percent
Engineering						
Environmental and sanitary		10	55	14	79	32.1
Chemical		41	13	21	75	30.5
Electrical		15	6	1	22	8.9
Mechanical		10	8	3	21	8.5
Civil		10	6	1	17	6.9
Other engineering disciplines		17	11	4	32	13.0
Total	number	103	99	44	246	–
	percent	41.9%	40.2%	17.9%	–	100.0%
Biological Sciences						
General biology		45	15	6	66	21.8
Microbiology		18	13	21	52	17.2
General zoology		12	9	7	28	9.2
Biochemistry		5	3	20	28	9.2
Ecology		5	5	15	25	8.3
Marine biology		6	5	10	21	6.9
Entomology		1	3	3	7	2.3
Other biological sciences		16	27	33	76	25.1
Total	number	108	80	115	303	–
	percent	35.6%	26.4%	38.0%	–	100.0%
Physical Sciences						
General chemistry		124	13	9	146	40.9
Organic chemistry		6	16	23	45	12.6
Analytical chemistry		23	9	10	42	11.8
Physical chemistry		2	4	34	40	11.2
General physics		12	4	7	23	6.4
Geology		7	6	1	14	3.9
Oceanography		3	5	3	11	3.1
Meteorology		1	3	1	5	1.4
Other physical sciences		8	5	18	31	8.7
Total	number	186	65	106	357	–
	percent	52.1%	18.2%	29.7%	–	100.0%[1]

[1] Error in addition caused by rounding.

SOURCE: Derived from unpublished data provided by the Personnel Management Division of the U.S. EPA (1976).

TABLE C.11 Degree Levels of Federal Scientists and Engineers at Major Agencies, January 1974

	Percent				
Agency	Ph.D.	Master's	Professional	Bachelor's	No Degree
All Agencies	9.1	19.8	1.4	62.6	7.1
Environmental Protection Agency	13.6	44.9	.9	39.6	1.0
Department of Health, Education, and Welfare	14.4	25.0	13.1	38.8	8.7
Atomic Energy Commission	13.0	30.4	.4	52.0	4.2
Department of Commerce	14.6	21.9	.5	50.5	12.5
National Aeronautics & Space Admin.	7.7	23.0	.6	67.1	1.6
Department of Agriculture	11.0	15.9	.6	68.9	3.6
Department of Defense	5.6	19.5	.8	66.3	7.8
Department of Interior	7.6	17.2	.8	69.1	5.8
Department of Transportation	3.1	16.7	.7	63.1	16.4
All Other Agencies	21.1	20.6	1.8	43.3	13.1

SOURCE: Unpublished National Science Foundation data.

NOTE: Totals may not equal 100.0 percent due to rounding.

(NSF 1976), as compared with other major federal agencies. Table C.11 shows percentages of scientists and engineers with college degrees in principal federal agencies. The statistics, though differing in some respects from the educational data in previous tables, present a consistent pattern and place EPA well ahead of other federal agencies, and the government as a whole, in terms of employed scientists and engineers with advanced degrees.

Attorneys

EPA is not only a regulatory agency, but it also has the authority of enforcement to prosecute violators who fail to meet prescribed standards. Approximately 1600 employees are assigned at present to the enforcement office, about 16 percent of the Agency's personnel (U.S. EPA 1974).

TABLE C.12 EPA Legal and Kindred-Group Employees, September 1975

Classification	Number
Attorneys	206
Administrative law judges	6
Court clerks	1
Legal assistants	16
Subtotal	229
Legal clerical personnel	47
Total	276

SOURCE: Derived from unpublished data provided by the Personnel Management Division of the U.S. EPA (1976).

Of the attorneys on the legal staff, 127 (55 percent) are assigned to regional offices.[3] Table C.12 indicates the distribution of legal personnel in the EPA (Civil Service Series 900).

It is difficult to judge whether the number of legal personnel is adequate to meet the Agency's needs. EPA is selective of the cases it wishes to prosecute, presumably beginning with the worst offenders, and proceeding to less serious cases as time allows. The Agency cannot predict its work load, because it is subject to lawsuits from concerned public and environmental groups on the one hand, and industrial interests on the other. Furthermore, a substantial portion of the legal personnel required by the Agency is provided by the Department of Justice. Also, a great deal depends on the qualifications and abilities of the government's attorneys, although this is a subject beyond the scope of this Panel to assess.

The use of attorneys in nonlegal roles in EPA has frequently been questioned. This subject is difficult to analyze, but relevant data are available for possible clarification. Table C.13 shows the occupational distribution of EPA employees with law degrees. Although not all those with law degrees are represented, some conclusions may be drawn from these figures.

The data from this table indicate that the majority of employees with law degrees are in legal positions (72.3 percent). Other individuals with law degrees hold positions of a secretarial and clerical nature (4.1

[3]Based on data provided by the Personnel Management Division of the U.S. Environmental Protection Agency, dated September 27, 1975.

TABLE C.13 EPA Employees with Law Degrees, by Occupational Category,[a] October 1975

Occupation	Number	Percent
Legal and kindred positions (CSS 900)	197	67.2
Other legal positions	15	5.1
General administrative (301)	37	12.6
Secretarial and clerical (GS Grades 3-5)	12	4.1
Miscellaneous	32	10.9
Total	293	100.0[b]

[a]Educational data currently available for most, but not all, EPA employees.
[b]Figures do not total 100.0 percent because of rounding.

SOURCE: Derived from unpublished data provided by the Personnel Management Division of the U.S. EPA (1976).

percent). The 32 individuals classified as "miscellaneous" are in 18 occupational categories and are mostly at middle grade levels. The remaining 37 persons are classified as "general administrative" personnel.

Nearly half of the lawyers in general administrative positions are in upper and upper-middle level management (grades GS–15 and above), where they make up only 3 percent of some 575 Agency employees at these levels. In the highest management positions, however, 6 of 17 posts are filled by lawyers. Both the Administrator and Deputy Administrator are lawyers, as are two of the five Assistant Administrators and two of the Regional Administrators.[4] Among these top-level positions, the only one requiring a lawyer is that of the Assistant Administrator for Enforcement.

Consultants and Advisory Boards

Data on the distribution of consultants and advisors by occupational and organizational category within EPA are provided in Table C.14. It should be noted that this table shows consultant employment on a particular date and that the figures could vary considerably over a period of time.

Personnel Allocation by Budgetary Categories

EPA's personnel is also organized and allocated according to broad categories for fulfillment of the Agency's legislated goals. For budgetary purposes there are four main functions by which the Agency is work is

[4]Based on data provided by the Personnel Management Division of the Environmental Protection Agency, dated October 25, 1975.

TABLE C.14 Distribution of Consultants, Experts, and Advisory Board Members by Occupational Categories and EPA Organization, 14 February 1976

Occupational Category	Office of the Administrator	Planning and Management	Enforcement	Air and Waste Management	Water and Hazardous Materials	Research and Development	Regional Offices	Total
Social sciences	1	1		11	2	2		17
Management	3	5		7	4	4	1	24
Biological sciences	3		14		17	29	1	64
Medical	3		3	2	5	13		26
Engineering	1			14	35	12	1	63
Legal	3		2		6			11
Physical sciences	1		4	22	8	30	1	66
Mathematics			2	1	3	2		8
Other	1			4	4		2	11
Total	16	6	25	61	84	92	6	290

SOURCE: Derived from unpublished data provided by the Personnel Management Division of the U.S. EPA (1976).

TABLE C.15 End-of-Year Employment in EPA by Budget Category, FY 1973-1977

	Number of Positions[1]					
					1977	
Budget Category	1973	1974	1975	1976	Estimate	Percent
Abatement and control	3,179	3,671	3,703	4,232	4,230	44.3
Enforcement	1,322	1,557	1,662	1,568	1,604	16.8
Research and development	1,825	1,902	1,810	1,811	1,801	18.9
Agency and regional management	1,698	1,859	1,773	1,822	1,798	18.8
Other	246	214	212	117	117	1.2
Total End-of-Year[2] Employment	8,270	9,203	9,160	9,550	9,550	100.0

[1] The total number of EPA employees is constantly changing. This accounts for the slight differences in total EPA employment shown in several tables of this report.
[2] End-of-Year Employment represents permanent positions.

SOURCE: U.S. EPA (1974, 1976).

characterized. The end-of-year employment in those broad categories for the past four years (FY 1973–1977) is presented in Table C.15. In a very crude way these figures indicate the emphasis that the Agency has placed on the broad aspects of its programs.

The heaviest commitment of manpower is in the area of abatement and control (44.3 percent in FY 1977). The abatement and control category includes programs providing for "development and implementation of environmental standards, monitoring and surveillance of pollution, pollution control planning, financial and technical assistance to state and local pollution control agencies, assistance to other federal agencies to minimize adverse impact of their activities on the environment, and training of personnel engaged in pollution control activities" (U.S. EPA 1974). In each of the next largest categories, research and development and agency and regional management, EPA committed 19 percent of its personnel, followed by nearly 17 percent in enforcement in FY 1977.

It is possible, however, to determine from budget data the EPA manpower commitment to the different categories of pollution abatement control. Table 4.2 of the Committee report presents employment figures by pollution control programs, as well as by the budgetary categories shown in Table C.15. Table 4.2 indicates the priority placed by EPA on water quality programs. In fact, if a proportional percentage of the management and support personnel are included, about 45 percent of the Agency's employees are working primarily on the implementation of the Water Pollution Control Act. Other interesting features of EPA's personnel allocations include the relatively large number of research staff (261) who work in a number of areas (interdisciplinary designations) and the small number of people (21) assigned to do research on solid waste programs.

The profile of EPA's manpower described by these classifications may change somewhat as the data are revised with current information. However, the main patterns are unlikely to change in any substantial way. The Agency has a fairly stable number of employees, about half of whom are classified in technical or scientific positions. The data indicate that EPA's scientific and engineering staffs are at least as well trained as others in government, with nearly 60 percent holding master's or doctoral degrees (Table C.11). At least in terms of personnel allocations, the Agency emphasis has been on abatement and control, rather than on R&D or enforcement. In R&D, EPA has been involved primarily with the implementation of water quality legislation, followed by a secondary interest in air pollution control. Emphasis on manpower development is low and seems destined to diminish further in the immediate future (Tables C.1, C.3, and C.4).

EMPLOYMENT IN OTHER FEDERAL AGENCIES

The federal government is a potential polluter as well as an important force in determining issues, such as land use, that profoundly affect pollution production and environmental quality. In this section, the Panel concentrates on the role of the federal government as the owner of potential pollution-generating facilities.

According to a General Services Administration (GSA) survey of property owned by the United States throughout the world in 1973, the federal government's ownership of property in the United States amounts to 21,000 installations, including 400,000 buildings located on these properties, costing $32 billion (U.S. GSA 1974). Included in these costs are $7 billion for housing, $2.7 billion for industrial buildings, and $4.1 billion for such institutions as schools and prisons. In addition, the government expended about $40 billion for facilities other than buildings, of which $8 billion provide for utility systems. In addition, the federal government pays $0.5 billion annually to lease buildings and facilities (U.S. GSA 1975).

Although most of these facilities have either minimal pollution problems, or are included within municipal water supply and wastewater systems, many are served by separate treatment facilities. These facilities are not only required to meet federal standards, but Executive Orders 11507 and 11752 specify that they be "exemplary in the abatement and control of water pollution" (U.S. Congress, House 1972). EPA reported that in 1972 there were approximately 9,320 federal wastewater treatment plants in operation, most of them under 1000 gallons per day capacity (see Table C.16).

In 1971, EPA surveyed other federal agencies to determine the number and occupational level of personnel who devoted 25 percent or more of their time to water pollution control activities. The results of that survey, together with EPA's projection to 1976, are presented in Table C.17. The number of federal employees, other than those in EPA, who were engaged in water quality activities was 12,500, and the FY 1976 estimate for such employees was 15,800. Similar data were presented in a 1976 EPA manpower planning document.[5]

In contrast to these results, the Civil Service Commission (CSC) listed a total of 900 wastewater treatment plant operators employed by the entire federal government in 1972 (U.S. CSC 1974). One explanation for the difference between the CSC and EPA figures is that EPA included workers whose involvement with water quality operations was part-time or seasonal, whereas CSC counted only those whose occupational classifications were in maintenance and operations of sewage disposal and water treatment plants. Table C.18 presents the 1972 Civil Service data, which indicate that slightly more operators were in water supply occupations than were working in wastewater treatment. This is consistent with the findings for state and local government personnel. Also apparent from Table C.18 is the fact that about nine out of ten workers in each category were employed by the Department of Defense.

Again in 1975, EPA surveyed other federal agencies to determine their current and required manpower needs for water quality activities (Kauffman 1975). This study included only those plants with an average flow of not less than 10,000 gallons per day, or requiring at least 20 man-hours per week to operate and maintain, and covered a total of 1467 water supply plants and 1286 wastewater treatment plants. The employment figures are given in Tables C.19 and C.20.

The estimate of a current federal water supply and wastewater treatment work force of about 5000 seems reasonable. The EPA report projects a 1977 requirement, based on each agency's estimate of its needs, for water supply personnel of 3038 and wastewater treatment personnel of 3212.

Requirements for federal personnel in air pollution control are more difficult to determine. The Office of Federal Activities in EPA prepared

[5] U.S. Environmental Protection Agency (1976) 1976 Preview on Manpower Development and Training. Washington, D.C.: U.S. Environmental Protection Agency. (Unpublished)

TABLE C.16 Number of Federal Waste Treatment Facilities by Type, Function, and Capacity, 1972

Capacity (gallons per day)	Number of Facilities											
	Industrial			Sanitary			Combined			Total		
	P[1]	PS[2]	T[3]	P	PS	T	P	PS	T	P	PS	T
1,000,000 or more	16	60	0	15	113	0	0	0	0	31	173	0
100,000 to 999,999	9	50	0	52	316	5	1	3	0	62	369	5
10,000 to 99,999	3	13	0	99	623	61	0	6	0	102	642	61
1,000 to 9,999	1	4	0	801	1,228	101	0	0	0	802	1,232	101
999 and under	20	2	0	3,411	2,298	8	1	0	0	3,432	2,300	8
Total										4,429	4,716	175
Grand total											9,320	

[1] P=Primary treatment only.
[2] PS=Primary and secondary treatment.
[3] T=Tertiary treatment.

SOURCE: U.S. Congress, House (1972).

TABLE C.17 Non-EPA Federal Employees Engaged in Water Quality Activities, FY 1971 and Estimated FY 1976

	Number of Employees			
Occupational Category	FY 1971		FY 1976 (estimated)	
Professional				
Engineer	2,300		3,200	
Scientist	2,300		2,700	
Subtotal		4,600		5,900
Operator		4,200		5,600
Technician		1,800		2,000
Other				
Maintenance	800		900	
Related blue-collar workers	–		–	
Administrative	1,100		1,400	
Subtotal		1,900		2,300
Total		12,500		15,800

SOURCE: U.S. Congress, House (1972).

TABLE C.18 Federal Blue-Collar Employment in Sewage and Water Treatment Occupations, 31 October 1972

	Number of Employees	
Agency	Operation and Maintenance of Sewage Disposal Plants	Operation of Water Treatment Plants
Army	258	335
Navy	307	295
Air Force	256	355
Department of Interior	17	25
Other Agencies	62	63
Total	900	1,073

SOURCE: U.S. CSC (1974).

TABLE C.19 Federal Employees in Water Supply Plants by Agency and Occupation, 1974

	Number of Employees				
Agency	Management/ Supervision	Operation/ Maintenance	Laboratory	Distribution/ Pumping	Total
Forest Service	3	108	2	0	113
Army	50	300	9	0	359
Army Corps of Engineers	53	296	10	67	426
Navy/Marine Corps	46	249	11	17	323
Air Force	69	561	9	32	671
Bureau of Indian Affairs	73	100	0	10	183
National Park Service	55	115	2	19	191
Tennessee Valley Authority	5	52	5	0	62
Others	40	113	19	1	173
Total	394	1,894	67	146	2,501

SOURCE: Kauffman (1975).

TABLE C.20 Federal Employees in Wastewater Treatment Plants, by Agency and Occupation, 1974

	Number of Employees				
Agency	Management/ Supervision	Operation/ Maintenance	Laboratory	Collection/ Pumping	Total
Forest Service	8	95	1	0	104
Army	53	411	24	0	488
Army Corps of Engineers	23	142	2	3	170
Navy/Marine Corps	56	318	11	2	387
Air Force	100	693	28	47	868
Bureau of Indian Affairs	14	41	2	8	65
National Park Service	38	107	4	11	160
Coast Guard	8	56	2	16	82
Others	27	102	12	0	141
Total	327	1,965	86	87	2,465

SOURCE: Kauffman (1975).

TABLE C.21 Projected Capital Costs at Federal Installations for Air Pollution Control, by Agency for FY 1976 and 1977

Agency	Projected Capital Costs FY 1976	FY 1977
	(dollars in millions)	
Department of Defense	\$141.8	\$ 53.7
Energy Research and Development Administration	0.2	14.7
Department of Agriculture	3.0	0.1
Tennessee Valley Authority	38.1	71.9
Department of Transportation	0.8	–
General Services Administration	–	0.5
Department of the Interior	–	0.2
Total	\$183.9	\$141.1

SOURCE: U.S. EPA (1974, 1975) Pollution Abatement Needs at Federal Installations, Fiscal Years 1976, 1977. A Report to the U.S. Office of Management and Budget by the Office of Federal Activities of U.S. EPA. Washington, D.C.: U.S. Environmental Protection Agency. (Confidential)

the figures in Table C.21 as estimates of future hardware costs to federal agencies in FY 1977 to meet pollution control standards.[6,7] Not surprisingly, the Department of Defense and the Tennessee Valley Authority (TVA) are the agencies most affected by air pollution control requirements.

Figures in Table C.21 do not indicate the current inventory of air pollution control equipment in federal establishments. TVA and the military have, in some cases, already moved to meet state and national standards. TVA, alone, may spend a total of \$350 million on its particulate emission program from 1958 through 1977 (Hudson and Greco 1974). It is difficult to relate manpower estimates to these spending patterns. The operation and maintenance tasks in current technologies,

[6] U.S. Environmental Protection Agency (1974) Pollution Abatement Needs at Federal Installations, Fiscal Year 1976. A Report to the U.S. Office of Management and Budget by the Office of Federal Activities of U.S. Environmental Protection Agency. Washington, D.C.: U.S. Environmental Protection Agency. (Confidential)

[7] U.S. Environmental Protection Agency (1975) Pollution Abatement Needs at Federal Installations, Fiscal Year 1977. A Report to the U.S. Office of Management and Budget by the Office of Federal Activities of U.S. Environmental Protection Agency. Washington, D.C.: U.S. Environmental Protection Agency. (Confidential)

for example, are primarily capital intensive and not demanding of large numbers of workers in the federal sector. Therefore, the recent EPA estimate of 6500 federal workers in air pollution control may be excessive.[8]

To summarize, the federal employment of environmental manpower outside of EPA is not great, probably totaling less than 10,000. However, the number is significant because the federal government should serve—both legally and morally—as a model for other government agencies and industries for control and abatement of pollution.

PROJECTIONS OF FEDERAL EXPENDITURES AND MANPOWER NEEDS FOR POLLUTION ABATEMENT

Direct federal spending for pollution abatement and control falls into three main categories. First, in terms of dollars to be expended, is the Construction Grants Program authorized by the Water Pollution Control Act, and presently funded at $18 billion. This program is intended to provide 75 percent of the capital investment needed by local governments to construct or improve wastewater treatment facilities to conform to federal effluent standards.

Second, the federal government empowers the EPA to conduct and direct relevant research and development, to provide technical assistance and support to other governmental agencies and industries, and to enforce existing environmental regulations. EPA's responsibilities include abatement and control programs in the areas of water pollution, water supply, air pollution, noise, pesticides, solid wastes, and radiation. The Agency is funded at slightly more than $700 million for FY 1977, not including the Construction Grants Program or supplemental appropriations (see Table C.5).

Third, the federal establishment itself generates some pollution by the operation of its own facilities. Control of this pollution at federal installations will require initial capital investments and continuing

[8]See note 5 above.

TABLE C.22 Capital Costs of Pollution Abatement and Control Programs for Federal Installations, by Type of Pollution FY 1974-1977 (Estimated)

Type of Pollution	Capital Costs FY 1974	FY 1975	FY 1976	FY 1977 (Estimated)
	(millions of dollars)			
Water	$237.8	$256.4	$373.9	$324.0
Air	93.5	153.8	177.0	142.4
Noise	1.9	1.8	24.0	10.6
Solid Waste	–	–	–	4.7
Pesticides	–	–	–	0.1
Total	$333.2	$412.0	$574.9	$481.8

SOURCE: U.S. EPA (1974, 1975) Pollution Abatement Needs at Federal Installations, Fiscal Years 1976, 1977. A Report to the U.S. Office of Management and Budget by the Office of Federal Activities of U.S. EPA. Washington, D.C.: U.S. Environmental Protection Agency. (Confidential)

operation and maintenance costs to conform to federal standards. Also, other agencies besides EPA conduct research and development on programs for pollution control. These control programs may equal or exceed the direct operational expenditures of EPA in any given year.

Table C.22 shows the estimated cost of new capital investments that will be needed at federal facilities through FY 1977. Unless there is an abrupt change in current governmental policy, such expenditures will probably continue to decline after 1977 as the required equipment is placed in service. In contrast, operation and maintenance of this equipment will continue for the foreseeable future.

Table C.23 summarizes the estimated federal expenditures for pollution control in the next decade. According to these figures, overall level of spending is expected to increase from approximately $3.5 billion annually in FY 1975 to a high of almost $7 billion in FY 1978, with the Construction Grants Program at its height. However, following 1978 the best estimate is that federal spending in this area will fall to a $1.5 billion annual "maintenance" level.

Assumptions for these projections are based on analysis of the three categories of expenditures listed in the overall figures. First, it is apparent that most of the variability in spending is caused by the construction grants program. This is a one-time program with a specified time frame. Although some debate continues on the required amount that needs to be

TABLE C.23 Estimated Expenditures of Federal Pollution Abatement and Control Programs, FY 1975 through 1985

Program	FY 1975	FY 1976	FY 1977	FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
	(billions of dollars)										
Construction Grants Program[1]	$2.299	$2.400	$4.100	$5.200	$5.000	$3.160	$2.000	$1.500	$1.000	$ .500	$ .000
EPA operating programs[1]	.637	.785	.764	.707	.656	.636	.690	.700	.710	.720	.730
Other federal agency abatement and control expenditures[2]	.635	1.282	.959	1.000	.900	.800	.700	.600	.500	.600	.700
Total federal pollution control and abatement activities[3]	$3.571	$4.467	$5.823	$6.907	$6.556	$4.596	$3.390	$2.800	$2.210	$1.820	$1.430

[1] FY 1975 to FY 1980 based on unpublished U.S. OMB data; 1981 to 1985 estimates by Committee for Study of Environmental Manpower (CSEM).
[2] FY 1975 to FY 1977 derived from U.S. OMB (1976) and unpublished U.S. OMB data; FY 1978 to FY 1985 estimates by CSEM.
[3] FY 1975 to FY 1977 based on U.S. OMB (1976); FY 1978 to FY 1985 estimates by CSEM.

invested, the flow of federal dollars for this purpose is likely to stop completely by 1985, and probably before, if current governmental policies prevail. Another feature of the construction grants program is that it will have very little, if any, impact upon the federal government's need for additional personnel. The main employment effects will be felt in the construction and environmental control equipment industries, and for operation of the plants.

The overall EPA operating budget can be expected to remain relatively stable throughout the next 10 years. Although OMB projects a slight decrease in Agency funding through 1980, it is unlikely that any major shifts will occur soon in the composition, funding patterns, or personnel of the Agency. As new priorities and concerns arise, EPA's management will have to shift resources away from established programs to newer ones to meet current demands. An example of this has been the shift of resources away from air and water pollution programs to water supply programs over the past year. Passage of a toxic substances law would cause a similar internal shift in expenditures. In terms of manpower, the implication is that there will be very little change in the composition or size of the EPA labor force in the next decade.

Finally, the category of "other federal agency abatement and control expenditures" rises unsteadily and then declines after 1978 until 1983 as the construction phase of work on federal installations is completed, and normal operation and maintenance begin. Again, the employment impact of capital investment is on the construction and equipment industries, not on the federal establishment. However, increased federal employment of operations personnel is likely. As estimated by EPA, the number of new personnel for water-related activities will be about 1200 (Kauffman 1975), with proportionately fewer employees required for air quality operations. Therefore, it seems reasonable to project an incremental demand for 2,000 to 2,500 new federal workers in pollution control operations through 1985.

The pattern emerges of environmental funding being channeled through a federal establishment which will itself expand very little. Most of the federal pollution control dollars are channeled to state and local agencies, where they are used to buy capital goods and services. However, under present policy the funding of training grants is terminating. The federal agencies themselves will grow slightly where new operations are necessary, although very little, if any, increase is anticipated in regulatory or enforcement functions. In the absence of any major policy changes EPA, in particular, can be expected to maintain its present size and funding level through the next decade.

TABLE C.24 Number of Positions and Funds Authorized for EPA's Water Quality Programs by Appropriation, FY 1973 through FY 1977 (Estimated)

	Number of Positions and Funds									
	FY 1973		FY 1974		FY 1975		FY 1976		FY 1977	
Funding Category	Number	Funds	Number	Funds	Number	Funds	Number	Funds	Number	Funds
	(dollars in thousands)									
Research and development	653	$ 47,319	635	$ 43,359	588	$ 46,373	552	$ 40,387	548	$ 42,168
Abatement control	1,515	78,892	1,691	106,572	1,664	111,191	1,830	148,846	1,816	115,172
Contract authority	–	50,000	–	100,000	–	150,000	–	–	–	–
Enforcement	1,047	19,298	957	23,401	890	24,065	738	19,946	764	21,241
Total	3,215	$195,509	3,283	$273,332	3,142	$331,629	3,120	$209,179	3,128	$178,583[a]

[a]Error in addition caused by rounding.

SOURCE: Data based on U.S. EPA budget summaries.

MANAGERIAL RESPONSIBILITIES FOR STAFFING IN EPA

Special personnel concerns of management were examined in this study to ascertain if major problems exist, specifically, those in connection with authorizations and funding for positions, and with recruitment, retention, use, and competence of employees. In this analysis EPA was used as a study model because its comprehensive legislative base and clear-cut mission, totally within the field of environment, made it more amenable to objective analysis than parts of other large federal agencies concerned to a lesser degree with environmental matters.

In reviewing managerial responsibilities for staffing in EPA, the period FY 1973 through FY 1977 was selected as a base for analysis. During this period, the various environmental programs were consolidated within EPA and organization was begun for their operation. Furthermore, in 1973 action was initiated to implement the Water Pollution Control Act, which authorized the largest program in EPA. EPA's environmental manpower experiences are compared in this section with other federal agencies in order to evaluate comparative federal environmental manpower experiences in the specific areas of funding availability and the recruitment, retention, and use of manpower.

AUTHORIZATION OF FUNDS

The water quality programs of EPA demonstrate the growth and development of pollution control activity under the authority of the Water Pollution Control Act, as shown in Table C.24 for FY 1973 through 1977.

According to these figures, funds for EPA's water quality programs in the four listed categories increased approximately 70 percent between FY 1973 and FY 1975, while at the same time the number of positions decreased slightly in the same period. Changes in EPA's personnel numbers are not correlated with the amount of contract authority shown on Table C.24 (of $50 million in FY 1973 and $150 million in FY 1975), as these funds have little or no effect on direct federal employment. For all EPA programs, excluding construction grants, Table C.25 shows a 22

TABLE C.25 Number of Positions and Funds Authorized for All EPA Programs (Excluding Construction Grants) by Appropriation, Fiscal Years 1973 through Estimated 1977

	Number of Positions and Funds									
	FY 1973		FY 1974		FY 1975		FY 1976		FY 1977	
Funding Category	Number	Funds	Number	Funds	Number	Funds	Number	Funds	Number	Funds
	(dollars in thousands)									
Research and development	1,961	$176,870	1,848	$152,642	1,834	$166,674	1,689	$149,232	1,678	$159,422
Abatement control	3,479	215,638	3,682	248,714	3,750	271,363	4,236	326,191	4,230	329,574
Enforcement	1,488	32,020	1,550	45,812	1,683	50,747	1,567	42,038	1,568	52,743
Total	6,928	$424,528	7,080	$447,168	7,267	$488,784	7,492	$517,461	7,476	$541,739

SOURCE: Data based on U.S. EPA budget summaries.

percent increase in funds, and an increase of 8 percent in personnel, between FY 1973 and FY 1976.

Figures are not readily available on the breakdown of EPA's professional personnel by occupational categories drawn within pollution control programs. The conclusion may be drawn that because of the Agency's relationship to public works and industry, the water quality programs would require a large percentage of engineers. For example, review of plans, specifications, and field inspections of construction projects by the regional offices requires mainly engineers, whereas the pesticides program relies predominantly on scientists and laboratory technicians as specialists for management of these respective responsibilities.

RECRUITMENT POLICIES

EPA and, so far as is known, other federal agencies involved in environmental matters have not established a formal program for recruitment. Furthermore, there is no evidence that active recruitment procedures are necessary. Public concern about the degradation of the environment, together with challenging work, and a highly competitive pay scale compared to that of most industry and state and local governmental employees, evidently have attracted people in adequate numbers to the Agency. In professional and scientific categories, job opportunities seem to be communicated informally to interested applicants in sufficient numbers to fill available positions, with the exception of certain health specialists, such as virologists. Specific efforts to obtain trained personnel in these specialties have been only partially successful. The value of organized recruiting efforts for obtaining personnel with knowledge in these specific subjects is undetermined. However, some method is needed to ensure that adequate numbers of trained personnel in all specialties are available to the Agency to meet its commitments.

RETENTION RATES

Data are not readily available for critical analysis of the retention rate of EPA's employees. As a general observation, some qualified individuals have transferred to other federal agencies from occupational categories not directly related to the environment. Others have left to join private industry, to enter academic institutions as teachers, or to engage in research. There is some apprehension that qualified employees, although not in large numbers, have left the Agency. No explanations are available on the causes for their departure, which may be attributed to normal job changes or possibly to changes in emphasis from the environment to other programs such as energy. These are speculative observations, but, on the whole, the retention rate does not appear to deviate greatly from that of any recently-formed agency of the federal government.

USE OF MANPOWER FOR RESEARCH AND DEVELOPMENT

EPA's use of its environmental manpower can be improved. For example, it needs to expose its employees to advancing scientific developments. Discussions with personnel, both inside and outside of EPA, indicate the failure to define clear objectives in the Agency's research and development activities. Although considerable money flows into R&D at the Agency level, incentive appears to be lacking in pursuit of developing and learning new technologies, and those employees who demonstrate enthusiasm for various R&D projects dissipate their efforts in too many directions. Uncoordinated efforts in achieving objectives may result from indecisive managerial leadership, lack of knowledge, or both. Possibly, management is failing to define clear objectives under budgetary and personnel constraints within the Agency. For example, it seems that R&D expenditures for improvement of water quality, amounting annually to $40 to $50 million for the past several years, should have achieved more significant results. The Panel recognizes that changes in such factors as research emphasis, program responsibilities, and supervisory personnel may have caused unavoidable problems. The fact remains that such difficulties need to be studied and resolved.

STAFFING IN OTHER FEDERAL AGENCIES

In other federal agencies delegated with some responsibilities for environmental control, difficulties arise in defining job classifications and funding for environmental projects. In part, this is because many employees engage in diverse activities that may involve responsibilities on environmental matters only as a subsidiary duty. For example, the Farmers Home Administration in the Department of Agriculture has a primary responsibility for agricultural rather than environmental problems, although the two are intimately related. Manpower devoted entirely to environmental concerns in similar agencies has not increased substantially in recent years, nor is it expected to do so in the immediate future. No concentrated effort is evident for recruiting or retaining environmental personnel in these agencies.

Greater effort should be made in training operators for water quality and waste treatment plants at federal installations than has been expended so far. Other training programs should be initiated periodically for air pollution control techniques, solid waste management, and occupational health hazards, but opportunities for training in these specialized fields are not sufficiently available.

RECOMMENDATIONS FOR IMPROVEMENT

In public meetings held by this Panel and by the Committee for Study of Environmental Manpower, the need was expressed by witnesses and interested members of the public for EPA on-the-job training that concentrates on fundamentals: (1) identification of problems; (2) collaboration by specialists in providing all available knowledge and insight into those problems; and (3) communication of that accumulated knowledge to the authorities who write the laws and regulations. The traditional academic doctorate programs do not develop capabilities for holistic evaluation of all information from a variety of sources and communication of the comprehensive knowledge to individuals who establish policies and write laws. For the most part, these qualifications for leadership are acquired by experience.

Individuals without strong professional training in at least one academic field may have difficulty in directing others in the proper approach to solving problems. The "generalist" with second- or third-rate training in a variety of disciplines usually has not proven useful in a leadership role. Only a few well-qualified people are needed for the entire country. Since they might develop from any discipline, certification would be extremely difficult. However, as they will be comparatively conspicuous, they may be judged by performance records. Leaders capable of dealing with interdisciplinary problems are needed in both corporate and governmental organizations.

TRAINING REQUIREMENTS

Although there are shortages of trained personnel, salaries have not increased sufficiently to attract qualified individuals for the available positions, nor have students responded in their choices of academic subjects to meet requirements for job potentials in environmental careers. As a consequence, the supply of qualified individuals has not been keeping pace with the demand.

In the past, training grants were offered to students to encourage their interest in environmental subjects. However, these funds have been severely curtailed, or have become virtually unavailable, because of economic pressures on the former funding agencies. It was expected that, in part, research grants would replace training grants, but funding for research has declined during an inflationary period, with a consequent reduction of money available for training. At a time when requirements for trained technicians are increasing, federal financial support for training has declined substantially. Also, support is diminishing for summer jobs and cooperative study programs, which are important in supplying training for college students interested in environmental subjects.

Witnesses at public hearings have testified that EPA and other federal agencies, as well as legislators at both national and state levels, regard environmental and related educational programs as momentary financial commitments that can be turned on and off like water faucets. Not only is substantial lead-time necessary to develop the facilities and faculty for a substantial environmental program in academic institutions, but once operation of this program has substantially declined, academic faculty is almost certain to devote its attention to other interests, and the facilities developed for study of environmental matters are replaced by other parts of the educational institution. Thus, the "on–off" approach to training funds may achieve an institutional response in terms of accepting funds, but an inadequate response in pursuit of research for which the funds were intended.

The education and experience of college professors who teach subjects in the environmental field should be given as rigorous an examination as is now given for traditional disciplines. With the recently increased student interest in environmental subjects, broad, general courses on the environment have emerged. These may be taught by persons who lack specific knowledge in a given scientific field related to the environment. Students in these courses are given a broad survey of environmental knowledge, but the courses often fail to provide the specific background needed to contribute significantly to effective monitoring or solving of environmental pollution.

Universities and colleges should emphasize disciplines for analyzing problems as a primary goal in their training. Unfortunately, too few faculty members teaching general environmental courses have had practical experience in either research or in the field.

With the current reduction of financial support for higher education, the expectations are slight that substantive new programs (except the generalized ones previously noted) will emerge in academic institutions to provide adequately trained manpower in environmental subjects unless there is an external stimulus in the form of training grants, or similar support from other sources of revenue. If all public programs were dependent on uncertain supplies of trained manpower to staff them, there would be a public outcry. The shortage of trained individuals to meet problems that are of importance for preservation of a life-sustaining environment indicates that the public does not perceive the imminent dangers of failure to correct the current shortages of properly trained specialists.

EPA's training programs for industry have been too limited for evaluation, but those offered were judged by industry as worthwhile, and their curtailment regretted.

ADVISORY COMMITTEES

The abolishment, or gradual dissolution, of federal environmental advisory committees, including one on manpower, has contributed to the problem of meeting environmental manpower needs and the establishment of program quality control. As a result, one of the most important safeguards for maintaining standards of both personnel and programs has been eliminated. The abolishment of advisory committees may contribute to disregard of manpower requirements in environmental legislation. Lack of foresight in planning technological changes to meet future requirements also contributes to inefficient operation and preparation of programs for development of an adequate supply of manpower to meet future emergencies.

LEGISLATORS AND ENFORCEMENT PERSONNEL

Legislators who write the laws, and the officials who enforce them, ideally should have some experience or background knowledge of environmental subjects. As a minimum requirement, advisors with experience should be consulted at the time legislation is being drafted. For example, legislators proposing bills on coliform standards should have themselves, or rely on scientific advice for, knowledge of the subject before establishing rules and regulations governing standards and regulatory procedures.

Analytical Procedures

Many techniques may be adopted for assessment of environmental problems, but most of these are not subjected to thorough technical or scientific evaluation, comparable to analysis of structural steel, for example, by an organization like the American Society for Testing and Materials (ASTM). EPA has two alternatives for environmental research: the Agency may conduct its own studies internally, for which manpower must be available, or it may place responsibility for evaluation upon outside organizations. In the latter instance, EPA needs to allocate manpower for liaison with committees of ASTM, which survey methods on environmental studies. The collaboration requires not only attendance at meetings by participating members of the two groups, but close cooperation with laboratory technicians in the field.

The standards recommended by EPA for development of technical specialists, and methods for analysis, have not received adequate attention. For example, EPA has recently emphasized continuous flow, or "flow-through", bioassay tests. However, adequately trained aquatic toxicologists are not in sufficient supply to implement this recommendation in the near future (i.e., three to five years), nor is it likely that specialists in the subject will become available unless a major training program is initiated. This example is not extreme compared to many other methods that require sophisticated training (e.g., analyses of biological community structure). However, the example illustrates the effect that technological requirements may have on planning for future manpower. It is also worth noting that training appropriate manpower is impossible without adequate facilities.

Environmental manpower projections must consider also the specific jobs to be accomplished if certain environmental goals are to be realized. The manpower training programs should be geared to realistic objectives in meeting those goals.

RECOMMENDATIONS FOR EVALUATING FUTURE MANPOWER REQUIREMENTS

LEGISLATIVE OBJECTIVES

With the passage of recent federal legislation, such as the Federal Water Pollution Control Act, the Safe Drinking Water Act, the Clean Air Amendments, and others, the federal government has decreed that certain environmental goals must be met. The Water Pollution Control Act, for example, specifies dates when specific environmental objectives must be achieved, and establishes procedures that ensure compliance. Although the law does not precisely delineate levels of authority, it specifies that the primary responsibility for pollution abatement remains with state governments. The EPA Administrator has responsibility for implementation of the law and for management of the construction grants program. Step-by-step procedures are necessary for localities to request financial assistance for various waste treatment projects, including surveys of requirements, facility planning (step 1), plans and specifications (step 2), construction (step 3) and, finally, operation and maintenance (NCWQ 1975b).

The consensus among several authorities concerning progress in achieving the environmental goals of the Water Pollution Control Act is that the 1985 goal of zero discharge of pollutants may not be reached, nor, in fact, be feasible, environmentally desirable, or necessary. Some are more blunt and declare that the goals cannot be met on schedule, even with reasonable expenditure of funds.

The intent of these comments is not to quarrel with the laudable objectives of the Water Pollution Control Act, or of any other environmental legislation, but only to examine environmental manpower needs to achieve the statutory requirements of all environmental laws and the rules and regulations promulgated for their enforcement. Particular attention should be given to the apparent absence of projections of manpower needs in the process of drafting and evaluating proposed environmental legislation.

Laws concerning the environment tend, by their very nature, to be directed toward the goals to be achieved rather than the process for their attainment. Costs of facilities are estimated, and frequently are underestimated. For example, in the Water Pollution Control Act a federal expenditure of $18 billion was projected at the time the law was enacted. Estimates based on recent surveys and studies demonstrate that this figure was far too low (NCWQ 1975a).

A shortcoming in the process of developing environmental legislation is failure to develop realistic evaluations of manpower requirements for achieving goals on schedule. Statutory requirements for pollution control cannot be met unless sufficient supplies of trained manpower are available for such tasks as assuring that compliance requirements are being met. Also, programs must be initiated to train a supply of manpower to design and build advanced systems, where required, and to operate and maintain them. A contractor's study on the institutional constraints on environmental legislation concludes: "An efficient and effective program of operations and maintenance is essential to achieving the objectives of the construction program. Without efficient operation and maintenance, many of the dollars spent in construction will be wasted" (NCWQ 1975b). The same report further advises that:

As treatment technologies become more complex, manpower requirements and associated costs increase. This increase is manifest in both the number of persons necessary to administer and operate plants as well as the amount and sophistication of training required. Many localities, which are receiving federal grant funds or have made application for funds, have had limited levels of treatment in the past. Therefore, a need exists to increase personnel to handle new treatment requirements. In most instances, the local government salary structure does not support the recruiting of highly trained personnel. In some municipalities, on the other hand, the waste treatment department is not supported by taxes and changes to salary structures are easily accomplished. In Dallas the water supply and waste treatment departments are solely supported by revenues from user charges and sale of water. In other cities, such as Baltimore, the Department of Public Works is subject to municipal civil service ratings and operators have traditionally been low on the civil service scale. Consequently, salaries for operators are considered too low in some places to provide the level of expertise required for sophisticated treatment technology.

These manpower factors should be taken into account when proposed legislation is considered by Congress, and not after the fact in reports by studies of progress long after a law has been passed. During the debate and hearings on proposed legislation by Congress, a careful and detailed assessment should be made of the amount and kinds of manpower required if all the installations to be built are to function correctly and efficiently. A "manpower impact analysis" should be made prior to the passage of legislation, which would evaluate both the kinds of jobs and specialties of personnel necessary for accomplishment of goals.

TRAINING

The level of government that should assume the responsibility for training environmental manpower is a subject on which there are many diverse opinions. At one time, training programs in the environmental area were significant in numbers and largely because of these training programs the current nucleus of environmentally trained scientists became available. Similarly, the training programs for operation and maintenance personnel in the past have been most useful in improving the standards for operation of waste treatment plants. The Panel has grave concern about the future, however, as these programs have been severely curtailed and there is no evidence that alternative programs are being developed currently by the states to fulfill these training needs. Pay scales for persons working in environmental areas often have been low, and therefore provide little incentive for young people to pursue careers in environmental occupations. Industry is an exception where pay scales can be adjusted to attract personnel to meet job priorities, but environmental personnel working for the government, particularly state and local governments, often are underpaid in relation to their educational qualifications.

Recognizing this difficulty with salaries, the Panel believes that one way to help assure that this nation has an adequate and continuous supply of adequately trained environmental manpower is for the federal government to assume a leadership role in providing stipends and other incentives to encourage education and training of personnel to work in environmental areas. Also, salaries paid to environmental pollution control workers by state and local governments must be made competitive. It is folly to assume that the environmental legislation of recent years will be fulfilled without greater attention to long-range planning which will assure that the necessary environmental manpower is available to perform the tasks necessary to achieve environmental objectives and that salaries are adequate. In fact, to concentrate on providing support for waste treatment facilities, for instance, as important as this is, without giving similar attention to the environmental manpower question, is not a prudent use of taxpayers' funds.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSION 1

Past training programs supported by EPA have been most helpful in providing trained environmental manpower, but the Panel views with concern the lack of funding and planning for their continuation. It is not realistic to assume that training of needed environmental manpower will occur without incentive and financial support instigated by the federal government.

RECOMMENDATION 1

• *The federal government should provide more encouragement for professional people to enter occupations in the environmental field. EPA, especially, should assume leadership for the responsibility in providing the supply of required manpower.*

CONCLUSION 2

No consistent view of future environmental manpower needs or policy to assure that future needs are met appears to exist within EPA. Also, no plan emerges for a concerted effort to deal with future environmental manpower shortages.

RECOMMENDATION 2

- *EPA should develop and implement a policy for manpower development and regular evaluation of its policies in achieving its manpower goals. Specific attention should be given to an analysis of the kinds of specialization required to solve specific environmental problems, and to the development of training programs to ensure a continuing supply of trained personnel for these purposes.*

CONCLUSION 3

Elimination of financial support for manpower training is detrimental to achievement of EPA's environmental aims. The cost of poorly designed and operated treatment facilities is greater than is usually anticipated. The Panel recognizes the need for a continuing supply of trained staff to operate and maintain existing and future sophisticated waste treatment plants. Evidence indicates that many plants are operating far below expected efficiency and capacity because adequately trained operations personnel is not available.

RECOMMENDATION 3

- *Immediate steps should be taken to eliminate this defect by providing incentives to ensure that the necessary trained personnel are available. The federal government has a responsibility also to assume leadership in providing incentives and financial support for training and attracting qualified specialists for these positions.*

CONCLUSION 4

Congress has recognized the importance of environmental quality and has enacted laws for improving environmental quality. However, it has done this without adequate consideration of the manpower required to achieve desired environmental goals.

RECOMMENDATION 4

• *Manpower requirements should be considered in drafting legislation on establishment of environmental standards and regulatory procedures and throughout the entire legislative process. This should prompt all agencies charged with administering statutory provisions to be responsive to manpower needs on a continuing basis. A thorough analysis of manpower requirements should be included in debates on proposed environmental legislation by Congress.*

CONCLUSION 5

In practice, a disparity exists between legislation authorizing action to protect the environment and subsequent appropriations for financing these activities. Laudable environmental goals in Congressional enactments may not be achieved because of technological difficulties or financial strictures.

RECOMMENDATION 5

• *EPA should carefully determine the reasons for failure to achieve environmental objectives and identify obstructions to progress, whether they are technical complications, manpower policies, lack of funds, or other deficiencies. EPA should strengthen its communication with Congress concerning the technological and manpower considerations for effecting its environmental pollution control programs.*

CONCLUSION 6

Manpower activities in EPA are relegated to a low priority.

RECOMMENDATION 6

• *Program managers with the responsibility for manpower should be at sufficently high grade levels in the administrative structure of EPA, or a chief administrator should be appointed for planning and evaluating manpower to meet current and future needs.*

CONCLUSION 7

Although the Panel has not analyzed the management of EPA in detail, the general view is that delays in reaching decisions may create a morale problem. An observed excessive turnover of individuals in specific job assignments may also affect efficiency adversely. EPA personnel are highly trained and a special effort should be made to use their capabilities and maintain continuity in assignments.

RECOMMENDATION 7

- *To improve managerial functions, program administrators should be given the maximum authority required to accelerate action on EPA's programs. EPA regulations need to be drafted based on technical realities with the technical input and legal input in proper balance. The technical personnel in EPA should make greater input in developing rules and regulations.*

ATTACHMENT

Correspondence between the Committee and the Environmental Protection Agency regarding a proposed analysis of federal manpower needs under the Water Pollution Control Act and the Safe Drinking Water Act.

NATIONAL RESEARCH COUNCIL
COMMISSION ON HUMAN RESOURCES
[illegible] Constitution Avenue Washington, D C [illegible]

COMMITTEE FOR STUDY OF
ENVIRONMENTAL MANPOWER

October 20, 1975

Dr. Russell Train, Director
Environmental Protection Agency
Waterside Mall
401 M Street, S.W.
Washington, D. C. 20024

Attention: Kerringan Clough, Special
Assistant to Administrator Train

Dear Dr. Train:

I am writing on behalf of the Committee on Environmental Manpower of the National Academy of Sciences, and wish to request additional data comparable to the information now available in selected areas.

We have learned that a study has been underway within the Environmental Protection Agency to assess the state environmental manpower needs to satisfy the requirements of the Safe Drinking Water Act (PL 93-523) and the Federal Water Pollution Control Act (PL 92-500). We have been provided drafts of Reports 1 and 2 from this EPA study on state agency manpower needs for the implementation of the Safe Drinking Water Act. These reports are entitled, "Estimate of State Water Supply Agency Manpower Needs", and "Manpower Planning Criteria Manual for State Water Agencies". Also, we understand that the corresponding reports from the manpower studies for PL 92-500 will be available soon.

We commend EPA for making these studies undertaken at the direction of Assistant Administrator James L. Agee. We are particularly pleased to see the methodology used whereby the manpower needs are determined based on jobs that must be done if the provisions of these environmental enactments are to be satisfied. It is good that these analyses are made on the basis of the problems which must be solved if the provisions of the Acts are to be satisfied as opposed to relating future manpower needs only to funds that are anticipated to be available.

The Panel on Federal Environmental Manpower, operating under the Committee, has inquired whether a similar study might be done to assess the federal manpower needs to fully meet the requirements of PL 92-500 and PL 93-523. We, therefore, respectfully request that the same kind of study be made by EPA of federal manpower needs as has been made for the state agency manpower needs. It would appear that these estimates could best be based on the assumption that the states will assume all functions appropriate under the provisions of the Acts. The EIA documentation of federal manpower estimates would complement these excellent studies already near completion for the state agency manpower needs.

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Dr. Russell Train
October 20, 1975
Page 2

We will certainly be appreciative if these studies can be undertaken by EPA in the near future. We are convinced that the studies suggested could be of major assistance to EPA in their immediate and long range planning and programming. The Civil Service Commission's survey of EPA headquarters implied such a manpower analysis need according to the memorandum of Assistant Administrator Alvin L. Alm, dated February 6, 1975, on the CSC evaluation of EPA headquarters.

The NAS Committee on Environmental Manpower is committed to providing assistance to meaningful assessments of future environmental manpower needs. We believe the studies EPA has underway related to state agency manpower needs for wastewater and drinking water will be of great value. We hope the companion studies requested for federal manpower can be made. Similar studies related to air pollution, solid wastes, and pesticides are urgently needed and we suggest that the team developing the water pollution and drinking water manpower studies might undertake these studies for the state agency and federal manpower needs using the methodology they have developed. If they do so, it will be of inestimable value to our Committee in our work, and we believe of value to EPA in its short range as well as long range manpower planning.

We will be appreciative of any help EPA can give on these requests.

Sincerely,

Earnest F. Gloyna
Committee Chairman

EFG:pkr

cc: Charles Malone
William Kelley
Stanton Ware
Panel Chairmen

December 8, 1975

Dear Mr. Gloyna:

Mr. Train asked me to respond for him to your letter of October 20. As you may know, we received your letter last week which explains the delay in this response.

You, on behalf of your Committee, recommended to the Agency that it undertake a study to assess the Federal manpower needs to meet the requirements of P.L. 92-500 and P. L. 92-523. I have requested Dr. George Pratt, Director of the Education and Manpower Planning Staff, to get in touch with you to further discuss your request. Dr. Pratt will recommend to me the proper course of action that, in his opinion, would be most appropriate.

Thank you for your letter and your very kind words about the state manpower needs studies.

Sincerely yours,

Kerrigan G. Clough
Special Assistant

Mr. Earnest F. Gloyna
Committee Chairman
Committee for Study of Environmental Manpower
National Research Council
2101 Constitution Ave., N.W.
Washington, D.C. 20418

NATIONAL RESEARCH COUNCIL

COMMISSION ON HUMAN RESOURCES

2101 Constitution Avenue Washington, D.C. 20418

COMMITTEE FOR STUDY OF
ENVIRONMENTAL MANPOWER

December 15, 1975

Mr. Kerrigan G. Clough
Special Assistant to the Administrator
Environmental Protection Agency
1214 West Tower, Waterside Mall
401 M Street, S.W.
Washington, DC 20460

Dear Mr. Clough:

This is in response to your letter of December 8 concerning my letter of October 20 to Administrator Train which apparently reached you only when Dr. Ware discovered that the original had not been delivered. It is regrettable that this happened. Our initial objective in sending the letter was to seek assistance for the Committee through the performance of an analysis of Federal environmental manpower along the lines of the reports issued in August and November of this year on state water supply agency and water pollution control agency manpower needs respectively.

A study of this type would be beneficial to EPA as well as to the Committee in the fulfillment of its responsibilities. Timing is important, however. In order to be most useful such a study should be done soon. The data upon which it would be based should be readily available so that a report could be completed with a minimum of effort and without delay.

We will appreciate your early consideration of this request. If any questions arise as to the Committee's needs in this respect, please contact Dr. Ware. Our study is going forward well and we hope to continue the excellent and cooperative working relationships which have been enjoyed with your staff since the beginning of this project.

Sincerely yours,

Earnest F. Gloyna
Chairman

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

March 22 1976

OFFICE OF THE ADMINISTRATOR

Dear Dr. Gloyna:

The Agency has considered your recommendation that we conduct a study of Federal manpower needs to meet the requirements of P.L. 92-500 and P.L. 93-523. After careful and lengthy review we advise you that it will not be possible to undertake the study this fiscal year. We agree that such a study would be valuable to the Agency, and for this reason, it will be introduced into the planning process for studies during FY 1977.

As a practical matter a considerable amount of Agency resources would have to be reprogrammed to gather, validate, and analyze the data. We have calculated that to do the study adequately it would require the participation of every division in headquarters and every regional office and that the manpower expenditure would be 212 to 307 total man-weeks.

With the tight budget and personnel ceilings that EPA must operate under this year -- and with the concomitant need for us to carry out the functions assigned to the Agency by the statutes -- we do not feel that it is possible to divert personnel at this time.

I realize that the information that the study could have developed would have been useful to your Committee. I do hope you understand and can appreciate our present situation. Perhaps the Committee could suggest to us methods for manpower needs assessments which produce accurate results with minimum investments of manpower.

Sincerely yours,

Kerrigan G. Clough
Special Assistant

Dr. Earnest F. Gloyna
Committee Chairman
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APPENDIX D

State and Local Aspects

INTRODUCTION

The National Environmental Policy Act of 1969 created a broad framework for restoring and maintaining environmental quality through improved agency decision making. Subsequent pollution control legislation prescribed goals and a time schedule whereby the nation's water, air, and general environment are to be rehabilitated and maintained at high quality, with major responsibilities vested in EPA.[1] This report was prepared as source material for the Committee for the Study of Environmental Manpower in its analysis. Therefore, this panel did not dwell on the provisions of the legislation except to state goals and time schedules for implementation by state and local governments.

In the case of *water*, the goal is to have navigable waters clean enough for "the protection and propagation of fish, shellfish, and wildlife and . . . for recreation in and on the water" by July 1, 1983. Elimination of pollutant discharges into navigable waters is an objective to be achieved by 1985. With respect to *drinking water*, the Safe Drinking Water Act of 1974 required EPA to publish proposed interim primary drinking water regulations by June 1975, to take effect 18 months after promulgation. Secondary drinking water regulations were to be promulgated by December 1975.

Goals for *air* include the establishment of national primary and secondary ambient air quality standards to protect public health and welfare. Plans were to be developed and implemented for establishment of primary and secondary air quality standards by 1972 and the attainment of these standards in all air quality control regions by 1975.

[1]National Environmental Policy Act of 1969 (42 USC 4321 et seq. 1971; PL 91-190); Federal Water Pollution Control Act Amendments of 1972 (PL 92-500); Clean Air Amendments of 1970 (PL 91-604); Safe Drinking Water Act of 1974 (PL 93-523); Resource Recovery Act of 1970 (42 USCA Chapter 39); Noise Control Act of 1972 (PL 92-574); the Federal Environmental Pesticide Control Act of 1972 (92-516); and Reorganization Plan No. 3 of 1970, which established EPA as an independent agency in the executive branch and assigned to it various programs and responsibilities related to protection of the nation's environment.

Hazardous pollutants and fuel additives detrimental to the public health and welfare were to be identified and control requirements specified. The Clean Air Amendments of 1970 require most new sources in all areas—polluted or unpolluted—to apply "best available control technology," and that statutory standards of automobile emissions of hydrocarbons, carbon monoxide, and nitrogen oxides be accomplished. The statutory standards require that emissions of carbon monoxide and hydrocarbons from automobiles made in the 1975 model year be reduced 90 percent from 1970 standards, that emission of nitrogen oxides be reduced 90 percent by 1976 from average emission levels in 1971, and that emission levels be reduced by stages in the meantime. The dates for compliance have been extended by Congress to 1977 and 1978. In addition, the Supreme Court in 1973 let stand a decision of the Federal District Court in the District of Columbia that EPA is required by law to prevent "significant deterioration" of ambient air quality in relatively unpolluted areas.

The Federal Environmental Pesticide Control Act of 1972 requires EPA to register all *pesticides* sold in the United States. EPA is authorized not to register a pesticide if it will not perform its intended function "without unreasonable adverse effects on the environment." Registration must be either for "general use" or "restricted use," and a pesticide approved for restricted use must be applied by a certified applicator. States were given until October 1975 to submit plans for the certification of applicators and EPA was given until October 1976 to approve state plans. Applicators were to be certified by October 1976.

Under the Solid Waste Disposal Act of 1965, EPA is required to recommend guidelines for *solid waste* recovery, collection, separation, and disposal. However, no target dates or mandatory authority are included in the law.

The Noise Control Act of 1972 gave EPA the responsibility to control certain sources of *noise*. To carry out this responsibility, EPA was to publish criteria based on the identifiable effects of noise on public health and welfare, and to promulgate revised regulations by October 1974 for construction equipment; transportation equipment except aircraft, motors, and engines; and electrical and electronic equipment. The Act also required EPA, in consultation with the Department of Transportation, to publish regulations governing the noise emissions of interstate railroads and road vehicles engaged in interstate commerce, with appropriate consideration to be given to the cost of complying with the regulations.

With respect to *radiation* control, responsibility is divided between EPA and the Nuclear Regulatory Commission. The Commission is to issue uranium fuel cycle standards and to develop, implement, and enforce standards for individual nuclear facilities. In May 1975, EPA proposed standards for limiting the total quantity of radioactive materials entering the general environment from the whole uranium fuel cycle.

OBJECTIVES AND METHODOLOGY

The purpose of this report is to provide information about current levels of environmental pollution control employment by state and local governments, to project future personnel requirements for selected categories of environmental programs, and to identify and assess environmental personnel supply factors. Data and projections are presented for these categories of environmental activities: water supply; wastewater treatment; solid waste management; and air pollution control.

ASSUMPTIONS IN THIS REPORT

Projections are made on the assumption that the time schedules established in legislation will be met, even though in some cases it is clear that funding is not available to permit state and local governments to accomplish the goals set for specified time schedules. However, data are not available with which to estimate alternative time schedules, and it is imperative that the State and Local Panel of the Committee for Study of Environmental Manpower present information and analyses consistent with analyses of other Committee panels, which presumably are subject to the same data limitations. The unadjusted results of the entire study will, therefore, be biased on the high side in the early years of the projections. It may be possible to make adjustments of the estimates when the situation is clarified as a result of appropriations to accomplish legislative goals for protection of the environment.

METHODOLOGY IN THIS REPORT

The estimates of current employment and future needs in this report are based on numerous sources of information. There have been many studies that estimate current and future personnel demand in the pollution control field. While not in total agreement, these studies do permit reasonable estimates to be made of the existing labor force. Appropriate methodological comments and notations accompany these data as they appear in the text.

MANPOWER FOR WASTEWATER TREATMENT

LOCAL PERSONNEL NEEDS IN WASTEWATER TREATMENT

The treatment and distribution of water supplies to consumers involve somewhat similar technologies and management procedures as those needed to collect and treat used, polluted water from consumers. While significant differences do exist, the systems are parallel in many respects within a given community, and the treated wastewater of one locality often contributes to the water supply source of another locality.

Because of these similarities and interdependencies, the management and personnel of distribution and collection systems are sometimes shared or interrelated in a community. Even when this is not the case, the inherent similarities of the two systems might be expected to produce fairly common patterns of manpower use, at least in production stages. On the other hand, water distribution involves detailed metering and accounting tasks that are not directly associated with wastewater collection systems and one might therefore expect to encounter larger support and clerical staffs in water supply activities.

The findings of the numerous research projects presented in this report generally confirm these expectations. While considerable disagreement still exists as to the size of the work force that is required, there are adequate data to make possible a set of "consensus" figures on the size of the currently employed work force. The situation is considerably less clear for the projection of future manpower needs.

An estimated 21,011 wastewater treatment plants in the United States in 1974 served a population of approximately 154,950,000, or 72 percent of the total population of 214,000,000 (National Commission on Water Quality [NCWQ] 1975). A breakdown of plants by type of treatment in 1974 is shown below:

Primary Treatment	3,032
Secondary Treatment	16,987
Tertiary Treatment	992
Total	21,011

Based on plant inventory data from EPA and data from the Water Pollution Control Federation (WPCF), estimates of total wastewater

TABLE D.1 Wastewater Works Employees in 1974, by Size of Population Served

Population Size Group $\times 10^3$	Population Served by Group $\times 10^6$	Employees per 10,000 Population	Employees in Group
< 10	26.18	5.14	13,457
10 - 25	16.58	3.76	6,234
25 - 100	30.99	2.80	8,677
> 100	81.20	1.53	12,424
Total	154.95		40,792

SOURCE: Burke (1976).

treatment plant employees for 1974 have been calculated (Burke 1976) and are presented in Table D.1.

Burke also distributed this total of wastewater treatment plant employees by educational level, using proportions in a 1969 WPCF survey. These data indicate the following distribution by training level (Burke 1976):

College graduate	4,089
Technical (but not college graduate)	23,000
Little or no training	13,703
Total	40,792

It should be noted that these figures exclude workers in sewer collection systems. Training of these workers has been conducted on a more informal basis than that for other workers and with variable emphasis, depending on the local agency.

After the WPCF study cited above was completed, the U.S. Bureau of the Census released results of a sample survey of public employment which indicates that 86,047 people were employed in October 1974 for all local wastewater collection and treatment functions (Table D.2). As the

TABLE D.2 Local Government Employment for Sewerage Functions October 1974

All Employees	Full-time Employees	Full-time Equivalent Employment
86,047	76,000	78,032

SOURCE: U.S. Bureau of the Census (1975).

TABLE D.3 Water Quality Employment by Local Governments: 1971 Fiscal Year Inventory and 1976 Fiscal Year Projected Requirements

Occupational Category	Wastewater Treatment		Sewage Collection		Design and Administration		Total	
	1971	1976	1971	1976	1971	1976	1971	1976
Professional								
Engineer	1,400	1,800	1,600	2,000	600	800	3,600	4,600
Scientist	200	300	200	300	300	400	700	1,000
Subtotal	1,600	2,100	1,800	2,300	900	1,200	4,300	5,600
Operator	29,700	38,600	–	–	–	–	29,700	38,600
Technician	3,200	4,200	–	–	800	1,000	4,000	5,200
Other								
Maintenance	2,100	2,700	1,200	1,600	–	–	3,300	4,300
Related blue collar	9,200	12,000	25,700	33,400	–	–	34,900	45,400
Administrative	400	500	–	–	100	200	500	700
Subtotal	11,700	15,200	26,900	35,000	100	200	38,700	50,400
Total	46,200	60,100	28,700	37,300	1,800	2,400	76,700	99,800

SOURCE: U.S. Congress, House (1972).

TABLE D.4 Estimated 1974 Local Employment in Water Quality Activities

Occupational Category	Wastewater Treatment	Sewage Collection	Design & Administration	Total
Professional	1,900	2,100	1,080	5,080
Operator	35,040	–	–	35,040
Technician	3,800	–	920	4,720
Other	13,800	31,760	160	45,720
Total	54,540	33,860	2,160	90,560

SOURCE: Panel estimates based on Table D.3.

treatment of domestic and pretreated industrial wastewater in the United States is almost exclusively within the domain of local governments, this figure should be an inclusive one.

In a 1969 survey, WPCF found that treatment plant employees accounted for 47.3 percent of total wastewater utility personnel. By this standard, about 40,700 of such jobs in local governments in 1974 would have been in the operation and maintenance of wastewater treatment facilities. The nearness of the WPCF (40,792) and Census (40,700) figures is noteworthy.

Official EPA estimates of local wastewater personnel stocks and requirements, which were first presented in a 1972 report to Congress and reconfirmed in a 1976 Congressional report, are shown in Table D.3. The estimates are based on an inventory of wastewater facilities from the Storage and Retrieval for Water Quality Data (STORET) system and average staffing patterns from engineering studies.

An extrapolation of the data in Table D.3 to estimate 1974 personnel needs yields the information shown in Table D.4. This shows an estimated 54,540 wastewater treatment plant employees in 1974, compared to Burke's estimate of 40,792 for personnel needed in this area and to 46,819 derived by taking 60 percent (the proportion of all water quality workers in treatment plants, as shown in Table D.4) of the full-time equivalent employment for sewerage functions, shown in Table D.2.

A significantly higher estimate of current municipal wastewater treatment plant employment has been made by EPA and is shown in Table D.5. These data are based on the informed estimates of EPA regional personnel rather than on a survey or other direct data collection efforts. It is possible that the data are biased on the high side to underscore EPA concern with adequate manpower to comply with the Federal Water Pollution Control Act.

TABLE D.5 EPA Estimates of Municipal Wastewater Treatment Plant Personnel Needs

Occupational Category	Current Manpower 1974	Manpower Projections 1977
Operators	45,884	54,607
Supervisors	11,537	13,460
Maintenance	9,731	12,538
Total	67,152	80,605

SOURCE: U.S. EPA (1975) 1976 Preview on Manpower Development and Training. Washington, DC: U.S. Environmental Protection Agency. Unpublished report.

TABLE D.6 Comparison of Estimates of 1974 Wastewater Treatment Plant Employment

	Derived from EPA Data		Derived from WPCF Data	
Occupational Category	All Employees (Number)	(Percent)	All Employees (Number)	(Percent)
Professional/College Graduate	1,900	3.5	4,089	10.0
Operator-Technician/ Technical	38,840	71.2	23,000	56.4
Other/No Training	13,800	25.3	13,703	33.6
Total	54,540	100.0	40,792	100.0

SOURCE: Adapted from Tables D.1 and D.4.

Table D.6 compares the Panel's adaptation of EPA estimates with the Burke distribution of WPCF data (Burke 1976).

Finally, Table D.7 summarizes what this Panel considers to be fair estimates of the size of the labor force now employed by local governments to collect and treat wastewater. The figures are derived from the data presented earlier in this report and are intended to provide the basis for a discussion about the value of studies in the area. They also are helpful for making projections of future demand and training requirements. It should be noted, however, that data are not available with which to make precise and reliable quantitative estimates of future personnel demands in wastewater treatment plants. A number of factors

TABLE D.7 Estimates of the Magnitude of Local Government Employment for Wastewater Collection and Treatment

Category	1974 Estimates	1985 Projections
Total Wastewater Utility System Employment	85,000	127,500
Total Treatment Plant Employment	45,000	67,500
Professional	3,500	5,250
Operator/Technician	28,000	42,000
Unskilled	13,500	20,250

SOURCE: Panel estimate based on U.S. Bureau of the Census (1975) and Burke (1976).

might affect the demand, including changes in the number or size of treatment plants or a shift in the complexity of the treatment required, such as from secondary to tertiary treatment. In these cases, there would be increased demand in the operator and professional categories. Also, a change in monitoring or testing requirements would lead to changes in the demand for laboratory personnel.

For purposes of illustration, Table D.7 shows an across-the-board increase of 50 percent in employment for wastewater treatment by 1985. To some extent, this is based on the fact that 1974 operating expenditures by local governments for water quality control were about $1.5 billion (U.S. Bureau of the Census 1976) and this is based on an EPA estimate of incremental operation and maintenance costs to local governments of $2 billion a year by 1985 to implement the Water Pollution Control Act (U.S. EPA 1976), an increase of about 35 percent. It is considered reasonable to assume a major increase in employment in this area.

Another approach to projecting personnel requirements relies on the type of analysis cited at the beginning of this section. According to the NCWQ (1975), Table D.8 provides a likely projection of the population to be served by sewerage systems in 1990.

With an estimated U.S. population of 234 million in 1985, and with about 82 percent expected to be served by sewers, the population with this service would be approximately 192 million. Using the methods employed in Table D.1, the projected wastewater treatment employees in 1985 are shown in Table D.9. These 50,728 workers made up 47.3 percent of all wastewater personnel.

In addition to those employed in wastewater treatment, 56,519 persons would be needed by wastewater collection systems for a total employment of 107,247. However, the total employment is an underestimate in the sense that it fails to take account of more advanced treatment and

TABLE D.8 Projection of United States Population Served by Publicly-Owned Sewerage Systems

Year	Total Population	Population Served by Sewers	Percent Served by Sewers
	(population in millions)		
1970	203.2	143.3	70.5
1990 (Estimated)	256.0	210.2	82.1

SOURCE: NCWQ (1975).

TABLE D.9 Projected Number of Wastewater Treatment Employees in 1985 by Size of Population Served

Population Size Group x 10^3	Population Served by Group x 10^6	Employees Per 10,000 Population	Employees in Group
$\leq$ 10	32.63	5.14	16,771
10 – 25	21.11	3.76	7,939
25 – 100	38.39	2.80	10,748
> 100	99.80	1.53	15,270
Total	191.93	–	50,728

SOURCE: Panel estimate.

better staffing patterns than existed before the main impact of the Water Pollution Control Act. Therefore, it is safe to assume that the actual 1985 demand will fall somewhere above this estimate and perhaps closer to the 127,500 estimate in Table D.7. A third estimate is based on NCWQ data for 1973 and projections for 1990, as shown in Table D.10 (NCWQ 1975).

Assuming that the changeover time is reasonably constant and continuous, there would be about 74,000 wastewater treatment employees and 76,000 collection employees by 1985, totaling an employment of about 150,000 persons. This figure, higher than the preceding estimates, probably represents the upper limit of likely employment in the wastewater field by 1985.

STATE PERSONNEL NEEDS IN WASTEWATER TREATMENT

Under the Water Pollution Control Act, the primary responsibility for monitoring and enforcing water quality standards lies with state agencies.

TABLE D.10 Manpower Requirements for Operation and Maintenance of Publicly-Owned Treatment Works

	Thousands of Man-Years/Year	
Year	Wastewater Treatment	Wastewater Collection
1973	47,000	60,000
1990	85,000	82,000

SOURCE: NCWQ (1975).

TABLE D.11 EPA Data on State Water Pollution Agency Personnel

Estimated Employment 1971	3,600
Projected Employment 1976	8,300

SOURCE: Adapted from U.S. Congress, House (1972). See also Table 4.4 of the Committee report.

These agencies are also responsible for planning and coordination for their jurisdictions. Because of these responsibilities, state agency manpower will consist chiefly of highly trained professionals and technicians.

Using information from state applications for program grants, EPA was able to determine the occupational composition and number of state agency personnel in 1971. This information is presented in Table D.11 along with projections made in 1972 of future staffing requirements (U.S. Congress, House 1972). Assuming equal annual increments in employment, the total figure for 1974 would be 6400, a number consistent with the most recent data available, and 8300 in 1976.

A useful study completed by EPA in November 1975 estimates that the states will require about 7300 people to meet their statutory obligations (U.S. EPA 1975b). Table D.12 summarizes the results of the EPA study, which provides the most reliable estimates that are available. Currently, employment by state agencies is about 1000 less than these requirements. However, the crucial thing about state agency personnel is not the number of persons, but the high skill levels needed. Thus, the real issues regarding the state work force involve qualitative rather than quantitative factors and relate to the effectiveness rather than simply to the size of the agencies.

A summary of estimated state and local agency employees required in 1975 and 1985 for operation of wastewater systems is shown in Table D.13.

TABLE D.12 EPA Estimates of Personnel Needs in State Water Pollution Control Agencies to Meet the Requirements of the Water Pollution Control Act

Function	Full-Time or Shared[a]	Professional				Technical			Other	Total
		Engineers	Scientists	Interdisciplinary	Other	Engineering	Laboratory	Other	Clerical	
Oil and hazardous	FT			185				136	73	394
materials	S									
Planning, training, and	FT	118		79					138	335
operator certification	S			115						115
Municipal wastewater	FT			88	28	229			74	414
treatment plant O&M[b]	S			2					4	6
Municipal wastewater	FT	484		83	183			39	208	1002
treatment construction	S									
Monitoring and data	FT	123	445	546	325		131	228	347	2145
support	S			38	5					43
State water quality	FT	202	108	45	182				122	659
management planning	S									

Areawide waste treatment	FT	31		73	14				21	139
management planning	S	8		5	3				25	41
Administration and	FT				416			33	110	559
support	S				109			15	28	152
Enforcement	FT	211	82	361	144			39	264	1101
	S			6	1					7
Laboratory quality	FT		281	14					14	309
assurance	S		17	41					41	99
Research & development	FT			10				2	9	21
	S			45				7	46	98
Total	FT	1169	916	1484	1292	229	131	477	1380	7078
	S	8	17	252	118	0	0	22	144	561
Total FT & S		1177	933	1736	1410	229	131	499	1524	7639
Estimated work years[a]		1173	925	1610	1351	299	131	488	1452	7359[c]

[a] FT=Full-time positions
S=Shared positions
Shared positions counted as ½.

[b] Operation & Maintenance.

[c] Total affected by rounding.

SOURCE: U.S. EPA (1975b).

TABLE D.13 Summary of Estimated Personnel Needed for Wastewater Systems

	1975	1985
Local Agency Employees		
Collection systems	40,000	66,000
Treatment operations	45,000	62,500
Monitoring and surveillance	3,000	3,500
Engineering and design[1]	2,800	3,000
Research and development	400	500
Planning and report writing	1,000	1,000
Total	92,200	136,500
State Agency Employees	6,420	8,300

[1] Includes private engineering firms.

SOURCE: Panel estimate.

MANPOWER FOR WATER SUPPLIES

In order to consider personnel needs for operational, managerial, and monitoring functions in water supply systems, it is important that the reader have some information on potable water programs.

Concern with the quality of drinking water was entrusted to EPA with the passage of the Safe Drinking Water Act late in 1974. The Act required EPA to publish proposed interim primary drinking water regulations within 90 days and to promulgate revised regulations within 180 days (by June 1975); the revised regulations were to become effective 18 months thereafter. A *primary regulation* is defined as one relating to contaminants which may have an adverse effect on health. EPA was required to promulgate secondary drinking water regulations within 360 days after passage of the Act (by December 1975). A *secondary regulation* relates to contaminants which may adversely affect the odor or appearance of drinking water, or which may adversely affect the public welfare.

The Act also required EPA to publish within 180 days proposed regulations for the states to administer regarding the underground injection of materials which might endanger drinking water sources. Then, EPA was required to promulgate revised regulations within the

TABLE D.14 Employees in Public and Private Water Supply Facilities in 1968

Function	Number of Employees
Production	34,437
Distribution	59,952
Consumer services	14,315
Financing	15,628
Administration	25,751
Management	19,007
Other	30,627
Total	199,717

SOURCE: Adapted from Hudson and Rodriguez (1970) Water utility personnel statistics. Journal of the American Water Works Association 62(8):485–488.

next 180 days. These regulations, published in May, 1975, proposed a permit system for the control of industrial dumping into "conventional wells," "shallow wells," pits, and septic tanks; for the control of municipal dumping into conventional and shallow wells; and for the regulation of subsidence control wells and wells for maintaining salt water barriers.

The Safe Drinking Water Act applies to water supply systems serving as few as 25 persons. In 1975, Deputy EPA Administrator John Quarles advised the American Water Works Association that there were 240,000 water supply systems of this size or larger in the United States.[2]

The magnitude of safe drinking water programs in the nation will depend on hazards found in drinking water supplies and how the nation reacts to them as well as to available technology.

EARLIER STUDIES OF WATERWORKS PERSONNEL

Several cooperative personnel surveys by the U.S. Public Health Service and the American Water Works Association produced some interesting data during the 1960s. These data, published in 1970 (Hudson and Rodriguez), indicate that total water utility employment in 1968 was about 200,000 (see Table D.14). It should be emphasized that the data in

[2]Statement of U.S. EPA Deputy Administrator John Quarles to the 95th Annual Conference of the American Water Works Association, Minneapolis, Minnesota, June 12, 1975.

TABLE D.15 Local Government Employment for Water Supply Functions October 1974

All Employees (Full-time and Part-time)	Full-time Employees	Full-time Equivalent Employment
129,000	115,000	118,000

SOURCE: U.S. Bureau of the Census (1975).

this table represent a reasonable estimate based on a 1968 survey of the entire water supply industry, both public and private. A 1974 report estimated that about 25 percent of the nation's water supply systems might be in private hands.[3] If employment also was in this proportion, there would have been about 50,000 people employed in private water utilities and about 150,000 people working for local governments in water supply facilities in 1968, including a sizable number of persons in managerial, financial, and administrative positions. Census data gathered for 1974 (U.S. Bureau of the Census 1975) show a lower level of overall employment than was reported by the earlier study (see Table D.15).

However, these sets of data are in close enough agreement that they can be examined to determine the rough occupation mix involved in the water supply effort. As shown in Table D.14, there were almost 35,000 production workers, mostly operators, in 1968. In addition, some of the managers and distribution personnel reported in the Hudson and Rodriguez article required special skills associated with water treatment and supply. Altogether the group requiring special training in water treatment technology could be estimated at about 66,000, or one-third the total employment in the field. The remaining water utilities workers are in occupational categories that do not require such training. Application of the same ratio to the full-time equivalent employment in the 1974 Census data produces a local government work force requiring special training of about 39,000.

Finally, the most recent EPA estimate[4] places the number of water supply system operators in government facilities at 51,800 in 1974.

[3]Oklahoma Foundation for Research and Development Utilization, Inc. (1974) Development of Manpower, Planning Criteria for Water Supply Systems. Prepared for the Office of Education, HEW. Oklahoma City, Okla.: Oklahoma Foundation for Research and Development Utilization, Inc. (Unpublished report.)

[4]U.S. Environmental Protection Agency (1975) 1976 Preview on Manpower Development and Training. Washington, D.C.: U.S. Environmental Protection Agency (Unpublished document.)

TABLE D.16 Summary of Actual and Projected Employment for Water Supply Functions, 1974 and 1985

	1974 Estimate	1985 Projection[1]
Total Government and Private Water Utility Employment	180,000	198,000
Treatment Plant and Specialized Distribution Personnel	70,000	77,000
Professional	6,000	6,600
Operator/technician	52,000	57,200
Unskilled	12,000	13,200

[1]Assumes 10 percent increase from 1974 employment.

SOURCE: Panel estimates.

Table D.16 summarizes what is considered to be a conservative estimate of the size of the water supply labor force based on the data presented above. Although the data are approximate, they are close enough for the formulation of national policy alternatives. The employment projections for 1985 are based simply on a 10 percent increase in the 1974 employment to illustrate the effect of such a change on the number of skilled personnel employed.

STATE AGENCY PERSONNEL NEEDS

As is the case for wastewater management, the Safe Drinking Water Act places the primary responsibility for monitoring and enforcement with appropriate state agencies. There can be little doubt that state water supply staffs will increase sharply as a result of this and other new legislation.

The EPA Water Supply Division estimated 1974 employment in state agencies as 400 to 500 professional and technical personnel (McDermott 1975). More recently, EPA completed an analysis of state agency personnel needs similar to the one mentioned earlier for water quality activities. The EPA study included a definition of the legally required functions of state agencies, the development of measures for their anticipated work load, and the estimation of personnel requirements based on these data. Table D.17 provides a summary of the study results.

TABLE D.17 EPA Estimates of Personnel Needs in State Water Supply Agencies to Meet the Requirements of the Safe Drinking Water Act

Function	Full-Time or Shared[a]	Professional			Technical		Other	Total
		Engineers	Scientists	Other	Engineering	Laboratory		
Engineering surveillance &	FT	775		43	452		264	1534
technical assistance[b]	S	18						18
Disease surveillance	FT							0
& investigation	S	56	56					112
Laboratory operations	FT		85			167	44	296
	S		130			4	55	189
Laboratory certification	FT		18				9	28
	S		94				42	136
Enforcement	FT	44		153			211	408

	S			107			87	194
Data management	FT			113			50	163
	S			64			26	90
Administration & program	FT	104		81			60	245
development	S	5		5			5	15
Personnel planning,								
training & operator	FT	128	66	56			65	315
certification	S			98				98
Subtotal	FT	1051	169	446	452	167	703	2988
	S	79	280	274	0	4	215	852
Total		1130	449	720	452	171	918	3840
Estimated work years[a]		1091	309	583	452	169	811	3415[c]

[a]FT=Full-time positions
S=Shared positions
Shared positions counted as ½.
[b]Includes planning and special review.
[c]Totals affected by rounding.

SOURCE: U.S. EPA (1975a).

These figures represent the best effort thus far to project state personnel requirements under the new water supply regulations. Although not indicating that a large number of new workers will be needed, the data strongly suggest that new employees will require highly specialized training in order to be responsible for complex regulatory tasks (U.S. EPA 1975a).

MANPOWER FOR SOLID WASTES MANAGEMENT

Historically, management of solid wastes has been shared at the local level by private enterprise and municipal governments. Sometimes, private enterprise has acted under contract to local governments and often it has been a direct contractor to the producers of solid waste in industry, agriculture, and mining.

Potentially, solid waste management may be one of the most significant areas requiring training of personnel. Surveys in the past decade have indicated that about 4.5 billion tons of municipal, agricultural, industrial, and mining wastes are produced annually in the United States. The trend toward an annual increase in solid waste appears to be leveling off, partly due to recycling and resource recovery efforts which reduce the amount of solid waste that requires disposal. However, the actual production of solid waste is probably controlled by the level of activity of the national economy more than by any other single factor.[5]

It can be expected that continuing environmental programs for air, water, and land-use control will add significantly to the burden of solid waste management. This is already evident with enactment of the Water Pollution Control Act and the Ocean Dumping Act, which preclude disposal of wastewater treatment residuals into our water environment. Implementation of the Clean Air Act and the Safe Drinking Water Act also will produce similar residuals for which there is no apparent means of disposal other than on the land. Land-use control programs, stimulated by concern over contamination of both land and water, undoubtedly will place severe restrictions on future use of land for solid waste disposal. Essentially, this situation eliminates many of the options that have been available to solid waste management, and it leaves the future disposal of toxic and hazardous wastes—including the ever increasing agricultural wastes—subject to conjecture.

[5]Based on unpublished data assembled by the Los Angeles County Sanitation Districts.

Solid waste management legislation has been avoided by Congress except for a token effort toward manpower training and demonstration grants. This seems to have been on the basis that such waste is properly the concern of local and state governments. However, it should be noted that by the process of inverse condemnation, federal preemption of air, water, and land controls has meant that the Congress, in effect, has dictated what may not be done with solid wastes. Meanwhile, state legislation has been enacted by several states as an acknowledgment of the solid waste management problem and to stimulate comprehensive planning at the local level. California, for example, has enacted legislation requiring each county to prepare a comprehensive plan which must be approved by the State Solid Wastes Management Board before its implementation. The law also restricts the implementation of local facilities until the comprehensive plan has been prepared and approved on a county-wide basis.

During the past decade, solid waste management has made a successful transition from open and burning dumps to the modern sanitary landfill. Although sanitary landfills have proved eminently more acceptable than earlier methods of disposal, their use now is being questioned on the basis that landfills are only burial grounds and should be replaced by recycling and other resource recovery. An exception has been the development of energy recovery from methane produced by the decomposition of organics under anaerobic conditions in deep sanitary landfills, such as those in Los Angeles County. In some areas, the availability of acceptable sites already has severely restricted the use of landfills for future consideration and has given rise to recycling programs and resource recovery as a replacement. It is apparent that solid waste management programs in the future will require the use of all forms of technology, including sanitary landfills, but in the foreseeable future, the quantities of wastes requiring disposal in landfills will be only fractionally reduced. Although data are not available and will vary from locality to locality, it seems reasonable to assume that not more than a 25 percent reduction in volume of solid wastes will occur over the next 10 years as a result of the development and implementation of new technology.

The number of people needed to collect municipal solid wastes will not change appreciably, although there may be a slight reduction as collection systems become more automated and the one-man collection vehicle becomes more the rule than the exception. With salvaging and recycling of usable material substantially augmented by separation at the source, future collection systems probably will be designed to maintain this separation until wastes are delivered to the processing station. The processing of solid wastes after collection is likely to become more automated to save labor costs, making resource recovery cost-effective. This will require personnel who are capable of conceiving, designing, constructing, and managing automated systems based on developing technology. The personnel that will be needed for operation of final disposal facilities—largely, sanitary landfills—may decrease slightly as a result of the reduction in materials brought to the site; however, specifically trained manpower will be necessary to select, design, and manage these ultimate disposal sites.

The first thorough study of solid waste management personnel was done in 1972 by Applied Management Sciences for EPA.[6] This study included interviews of managerial and other employees of public and private solid waste organizations. Table D.18 presents the basic personnel inventory of approximately 11,000 private solid waste contractors and 3,000 municipal and county agencies doing collection and disposal of solid wastes in the United States at the time.

Substantial support for the survey results is provided by recently released Census data on solid wastes management expenditures and employment in 1974. Table D.19 covers basic data for state and local governments.

These figures are somewhat larger than the findings in the 1972 study. This is thought to be due to better sampling techniques and normal increases over time. Assuming that the same ratio of public to private personnel and the occupational distribution found in the Applied Management Sciences study is valid, the 1974 base level employment in solid waste management is extrapolated in Table D.20.

Recently, the County Sanitation Districts of Los Angeles County completed a general study of current and future solid waste management problems.[7] In addition to municipal wastes, the Los Angeles study focused on the rapidly increasing problems created by agricultural, industrial, and mining wastes. The personnel aspects of this research, while showing much larger numbers than the studies cited earlier, illustrate how great may be the solid waste problems that must be faced in the future (see Table D.21).

The scope of these problems is also indicated by Table D.22, which shows the volumes of the various solid waste streams that were expected

[6]Applied Management Sciences, Inc. (1972) Solid Waste Management Manpower: Profile and Analysis. Prepared for the Office of Solid Waste Management Programs. Washington, D.C.: U.S. Environmental Protection Agency. (Unpublished report.)

[7]Los Angeles County Sanitation Districts (1976) Study on Manpower Requirements for Solid Waste Management - Municipal, Industrial, Agricultural, and Mining. March. Not published.

TABLE D.18 Distribution of Solid Waste Management Personnel, 1972

	Number Employed		
Job Categories	Total	Local Government	Private
Managerial	19,835	2,723	17,113
General	19,212	2,356	16,856
Other	623	367	257
Clerical	10,914	2,296	8,619
Supervisory	11,470	6,286	5,177
Collection/transportation	9,395	5,078	4,323
Disposal/other	2,075	1,208	854
Skilled Laborers	99,791	36,243	63,591
Maintenance	8,967	2,179	6,788
Collection/transportation	80,046	27,193	52,873
Disposal/other	10,803	6,871	3,930
Unskilled Laborers	84,729	54,344	30,402
Collection/transportation	79,964	51,583	28,385
Disposal/other	4,765	2,761	2,017
Total[1]	226,739	101,892	124,902

[1] Totals are incorrect due to rounding.

SOURCE: Applied Management Sciences, Inc. (1972) Solid Waste Management Manpower: Profile and Analysis. Prepared for the Office of Solid Waste Management Programs. Washington, D.C.: U.S. Environmental Protection Agency. (Unpublished report.)

TABLE D.19 State and Local Government Solid Waste Management Expenditures and Employment, 1974

	Expenditures (1973-74) (thousands of dollars)	Full-time Equivalent Employment (October 1974)
Local Governments	$1,936,354	123,207
State Governments	81,152	733

SOURCE: U.S. Bureau of the Census (1976).

for 1975 and 1985. Further tabulations presenting detailed estimates of current and future personnel requirements for dealing with the many aspects of solid wastes management are shown in Attachment D.I. Table D.23 summarizes these projections.

TABLE D.20 Manpower Distribution in Solid Waste Management, 1974

	Total Number of Workers	Local Government Workers	Private Workers
Managerial	23,925	3,293	20,632
Clerical	13,168	2,776	10,392
Supervisory	13,842	7,601	6,241
Skilled Laborers	120,492	43,825	76,667
Unskilled Laborers	102,366	65,712	36,654
Total	273,793	123,207	150,586

SOURCE: Tables D.18 and D.19.

TABLE D.21 Summary of Manpower Requirements Projected by Los Angeles County Study of Solid Waste Management

Function	1975	1985
Collection and Transportation	340,000	378,000
Processing	96,000	129,000
Disposal	53,000	67,000
Research and Development	8,500	15,000
Design	8,500	16,000
Government Surveillance and Monitoring	10,000	20,000
Total	516,000	625,000

SOURCE: Los Angeles County Sanitation Districts (1975) Study on Manpower Requirements for Solid Waste Management—Municipal, Industrial, Agricultural, and Mining. March. Not published.

MANPOWER FOR AIR POLLUTION CONTROL

The need by state and local governments for personnel to control air pollution is determined basically by two factors: the requirements imposed by the Federal Clean Air Amendments of 1970, plus requirements by other amendments, if and when legislated by Congress; and the schedules imposed by the Act, and as proposed by EPA in administering provisions of the Act not specifically scheduled.

The basic philosophy of the law is that control of air pollution sources

TABLE D.22 Volumes of Solid Waste Generation Expected in 1975 and 1985

Type of Waste	Quantity of Wastes (millions of tons) 1975	1985
Municipal Wastes		
Residential	102	115[a]
Commercial	104	117[a]
Demolition	30	34[a]
Special	14	56[b]
Subtotal	250	322
Agricultural Wastes		
Animal manure	1,750	1,970[a]
Crop residues	650	730[a]
Subtotal	2,400	2,700
Industrial Wastes		
Food processing	32	44
Lumber	59	32[c]
Chemical & petroleum	6	8
Manufacturing	43	56[a]
Subtotal	140	140
Mining & Mineral Wastes		
Slag, culm, and tailings	1,700	2,000
Subtotal	1,700	2,000
Total waste stream	4,490	5,162

[a]Based on an annual population increase of 1.2 per cent.
[b]Projection increase due to upgrading of sewage treatment facilities nationwide.
[c]Increased use of lumber residues should result in a reduction of lumber industry waste by 1985. Projected restrictions on sewered waste should increase manufacturing wastes substantially.

SOURCE: Los Angeles County Sanitation Districts (1975) Study on Manpower Requirements for Solid Waste Management–Municipal, Industrial, Agricultural, and Mining. March. Not published.

TABLE D.23 Summary of Manpower Requirements by Occupation, as Projected by Los Angeles Sanitation Study

	1975	1985
Laborers (refuse collectors, maintenance crews, etc.)	249,000	289,000
Heavy equipment operators (dozers, scrapers, loaders, etc.)	49,500	58,000
Heavy equipment mechanics (dozers, scrapers, loaders, etc.)	1,600	2,300
Truck drivers	135,000	150,000
Equipment operators (incinerators, material handling, etc.)	23,000	34,000
Mechanics	10,500	14,000
Engineers (design and research)	14,400	22,000
Scientists (research)	1,500	2,500
Draftsmen (design)	6,000	12,000
Technicians (operation and development)	2,000	2,500
Surveyors	2,000	2,500
Biologists	500	1,000
Agronomists	2,000	4,000
Animal researchers	1,000	2,000
Sales personnel	8,000	9,000
Administrative (regulatory agencies)	10,000	20,000
Total	516,000	624,800

SOURCE: Los Angeles County Sanitation Districts (1975) Study on Manpower Requirements for Solid Waste Management—Municipal, Industrial, Agricultural, and Mining. March. Not published.

is the primary responsibility of state and local government agencies. The federal role is to administer the provisions of the legislation at the federal level and to assist state and local governments, both technically and through grants, to carry out state and local control programs. Hence, EPA and its predecessor in air pollution control, the Public Health Service (U.S. PHS) of the Department of Health, Education and Welfare, have been involved in the personnel needs of state and local government control agencies. The purpose has been to make certain that adequate personnel is available to carry out the provisions of the legislation and to provide financial help for hiring and training required personnel, a form of assistance that comes within the purview of the annual federal budget process. Hence, EPA data on the federal air pollution control program since its inception are unquestionably the most extensive and comprehensive available; this report cannot be expected to duplicate these efforts. Rather, the role of the National Academy of Sciences is one of review to determine the reasonableness of the projections for personnel that have been made in relation to implementation of the legislation and any anticipated amendments.

STATE AND LOCAL RESPONSIBILITIES

In carrying out their responsibilities for controlling air pollution at its source, state and local governments have undertaken extensive programs. As listed by EPA, their administrative and technical activities in these programs are expected to accomplish the following things:

- develop a comprehensive air resource management plan, including short- and long-range goals;
- select air quality goals and objectives;
- develop plans to implement national ambient air quality standards;
- develop a register of air pollution sources, their emissions, the degree of emission control, and related data;
- measure air quality (this includes operation of a chemical laboratory);
- develop rules and regulations on pollutant emissions, operating practices, design of equipment, fuel composition, etc.;
- evaluate the effects of pollution;
- investigate public complaints;
- initiate detection of violations of emission control and other rules and regulations applicable to stationary sources and motor vehicles;
- negotiate and secure abatement of violations of rules and regulations;
- secure abatement of pollution from sources owned by local governments;
- provide leadership and motivation for development and implementation of plans to reduce motor vehicle use and resulting pollution;
- inspect pollution sources on an annual or other periodic basis;
- issue operating permits;
- develop abatement plans for industry groups;
- measure pollutant emissions from stacks;

• prevent new sources of pollution through review of construction plans;

• provide consultation services to industry and equipment purveyors on the means of emission control;

• establish and operate a fee system;

• conduct informal and formal hearings;

• prosecute chronic and flagrant violators of the law and regulations;

• to the extent possible, prevent (and, as necessary, manage) air pollution episodes and pollution from industrial and other accidents;

• facilitate cooperation among local government agencies, such as those concerned with planning, zoning, transportation, solid waste disposal, water pollution control, and building and boiler inspection, and seek to cooperate with neighboring local governments;

• design and operate systems for data storage and retrieval;

• prepare regular activity reports and special topical reports to the public and to higher levels in the local government;

• review environmental impact statements prepared pursuant to federal, state, or local law for their air quality implications;

• provide on-the-job training, continuing education, and specialized air pollution training to agency staff;

• conduct public information programs;

• maintain liaison with, and provide information to, citizen groups interested in air conservation; and

• maintain a library of technical literature, federal regulations, operational guidelines, and other materials.

EPA and earlier the PHS, have made surveys to identify the public and private air pollution control work force and the critical skill deficiencies which necessitate training if the nation is to achieve its clean air objectives.

In a 1967 survey reported by Cluster (1969), a total of 2521 full-time and part-time budgeted positions were found in 35 state and 136 local air pollution control agencies. Table D.24 provides an occupational breakdown of these positions. Using data such as these in assessing the personnel requirements of the Air Quality Act of 1967, PHS in 1969 projected the total number of positions that would be needed at state and local levels. It was estimated that the requirements would be met by 1974. The results of the projection are given in Table D.25.

After the Federal Clean Air Amendments of 1970 were enacted by Congress, new responsibilities were given state and local agencies and EPA took over from PHS as the coordinating federal agency. In 1971,

TABLE D.24 Positions Budgeted by 35 State and 136 Local Air Pollution Control Agencies, March 1967

Occupational Category	Full-Time	Part-Time
Engineers	490	87
Chemists	150	43
Meteorologists	18	0
Statisticians	17	0
Sanitarians	147	146
Applied Scientists	79	23
Inspectors	480	43
Technicians	196	26
Processing Managers	42	5
Miscellaneous	406	123
Total	2,025	496

SOURCE: Cluster (1969).

TABLE D.25 Personnel Needed by State and Local Agencies, by Occupation, to Meet Requirements of the Air Quality Act of 1967

Occupational Category	Number of Positions
Engineers	2,156
Chemists	539
Meteorologists	121
Sanitarians	459
Other Professionals	381
Inspectors	1,571
Technicians	964
Administrators and Clerks	1,811
Total	8,002

SOURCE: U.S. PHS (1969).

when EPA conducted a personnel survey of state and local agencies, 167 local, 53 state and territorial, and 44 multijurisdictional agencies were included. Tables D.26 and 4.5 of the Committee report show the results. These figures indicate that by April 1971 the state and local agencies were more than halfway toward meeting their personnel requirements under the 1967 legislation (projected in 1967 by PHS as being 8002). However, the occupational profile of actual employment varied somewhat from expectations of the Public Health Service.

TABLE D.26 Budgeted Positions in Air Pollution Control Agencies by Type of Position, April 1971

Full-Time	Part-Time	Vacant	Total
4,205	457	449	5,111

SOURCE: U.S. EPA (1971).

To project personnel requirements under the 1970 legislation, the EPA Office of Air Quality Planning and Standards (OAQPS) continued with the efforts begun earlier to develop a personnel planning model. The most recent model uses two matrices to estimate needs—the number of air pollution sources and the number of monitors (Lynn and Dean 1975). The model is currently undergoing some modifications and improvement (Sherman et al. 1975). In addition, the model is being extended to relate occupational categories to its basic parameters.

A review study has found the OAQPS Manpower Planning Model to be generally indicative of the personnel requirements over large areas, such as states or regions; therefore it should be useful for indicating broad nationwide needs. However, a check on the validity of the model for projecting personnel requirements, which was done by comparing the model's projections with actual numbers of personnel in an EPA region, showed that it is not similarly indicative of needs for local or county agencies. In general, the model tends to underestimate these needs. EPA investigations indicate that underestimates of pollution sources probably are responsible for the model's low projections compared to detailed direct evaluation by surveys of state and local personnel requirements. Usefulness of the model to EPA has been primarily in incremental analyses in which personnel requirements are estimated for the implementation of new strategies. These incremental values are considered to be more valid than the baseline figures used in the model.

As a result of the model's present shortcomings, EPA has based 1980 projections primarily on surveys of state and local agency needs by EPA regional offices. These are shown in Table D.27, which also gives data for 1974.

The estimate of 5400 personnel for state and local control agencies in 1974 is in general agreement with the budgeted and filled positions indicated in Table D.26 and Table 4.5 of the Committee report. It is substantially less than the needs estimated by PHS in 1969, shown in Table D.25, reflecting more substantial operating experience by state and local governments.

TABLE D.27 Air Pollution Manpower Needs for All State and Local Agencies

	1974	1980	1985[a]
State and Local Air Pollution Control Agencies	5,400	8,000	8,000
Other State and Local Agencies	11,000	15,600	15,600
Total	16,400	23,600	23,600

[a]Estimated to be the same as 1980 (see text).

SOURCE: Unpublished EPA estimates.

EPA has estimated personnel needs in 1985 to be the same as those in 1980 unless there are major changes in future federal legislation that would add significant new programs to the contemplated revisions of the Clean Air Act. The consensus in EPA, with which this panel concurs, is that personnel needs for new programs initiated in the 1980 to 1985 period would be provided for by phasing out earlier programs completed during this period. Hence, the estimates for 1980 to 1985 represent, as can be best ascertained at this time, a plateau that probably will be met about 1982, rather than in 1980, due to the lag between actual personnel and authorized positions. Table D.28 has estimates for the occupational categories shown in Table D.27 for state and local air pollution control agencies.

Differences between the 1980 estimate and 1974 experience reflect changes in program needs, principally a possible need for 3000 persons in motor vehicle inspection maintenance programs that are required to implement transportation control strategies in a number of the country's air quality control regions. Other new program areas that were taken into account in arriving at the projections for 1980 and 1985 include: indirect source reviews; transportation control plans; land-use planning; air quality maintenance; nonsignificant deterioration; parking management plans; environmental impact statements; provisions of the Energy Supply and Environmental Coordination Act; quality assurance; ambient air monitoring equivalent methods; and continuous source monitoring. The Table D.28 estimates, like those in the preceding table, show a personnel plateau during 1980 to 1985 and the consequent reprogramming of personnel from program areas that are completed or cut back to new activities. The phasing out of earlier programs accounts for the fact that personnel needs are expected essentially to number 8000 in both years.

In addition to the personnel needs of state and local air pollution

TABLE D.28 Personnel Needs for State and Local Air Pollution Control Agencies, by Occupational Categories

Category	1974	1980	1985[a]
Director	360	527	527
Supervisors	480	710	710
Engineers	1,220	1,820	1,820
Chemists	520	768	768
Meteorologists	70	100	100
Specialists	545	800	800
Technicians	745	1,100	1,100
Inspectors	1,310	1,960	1,960
Aides	150	215	215
Total	5,400	8,000	8,000

[a]Estimated to be same as 1980 (see text).

SOURCE: Unpublished EPA estimates.

control agencies, implementation of the Clean Air Act imposes personnel requirements on other state and local government agencies involved in ancillary activities. Examples include the use of highway police for visible emissions testing and observations; highway engineers to plan, design, construct, and maintain highways with regard to air quality; and agencies involved in regional planning, local zoning, housing, urban development programs, and the like. The overall estimates for these personnel are included in Table D.27.

In considering the personnel requirements indicated in Tables D.27 and D.28, it should be noted that the supply of personnel in the area of air pollution control is generally not restricted by the availability of people who have the required basic education and training. Rather, the attainment of adequate levels of personnel probably will be limited by budget constraints which affect the provision of additional specialized training, authorization of personnel, and the funding of personnel on a long-term basis. The problem of training to develop and maintain specialized skills is of major concern because programs that were established for this purpose during the years 1955 to 1972 have been reduced substantially in the past five years.

In the operation of state and local government air pollution control agencies, the basic professional disciplines required for the most part are those of standard university disciplines—engineering of various types (civil, chemical, mechanical, etc.), physical science, meteorology, and a number of other fields with specialized skills. Professionals comprise about 60 percent of the agencies' staffs, the balance being technicians, inspectors, aides, and clerical support personnel. Experience has shown that the marketplace has been able to supply the basic required qualifications, providing, of course, that adequate personnel ceilings and budgets are made available and that salaries are competitive. These situations do not exist in many states and local communities. However, to provide the diverse specialized skills required to operate an effective and efficient state or local air pollution control program, additional specialized knowledge is required to supplement the basic professional training offered by universities. These skills may be acquired on the job to some extent, particularly in large air pollution control organizations. But for the most part, special air pollution training outside the organization can most effectively fill an agency's needs, especially in small agencies, for new areas of endeavor, or to greatly shorten the period it takes new inexperienced employees to become fully effective.

The Clean Air Act provides for technical and financial assistance to state and local control agencies as a means to assure that the provisions of the legislation are carried out in an effective and efficient manner. To a large extent, these provisions are self-serving to EPA in that failure by states and local agencies to carry out the provisions requires that EPA step in and do the job. Historically, specialized training programs were included in the federal program, to the extent that competitive demands on funds would allow, when responsibility at the federal level rested with the PHS and in the early years of EPA. This continued until about 1972, when an OMB policy decision resulted in a gradual withdrawal by EPA in the provision of direct assistance for specialized training in air pollution control.

When questioned by the Committee for Study of Environmental Manpower, an OMB representative advised that direct assistance for specialized training funds was no longer required because block grants to states would provide adequate funding and because the open market would be sufficiently responsive to meet state and local control agency needs. In the Panel's opinion, that position fails to recognize the hierarchy of control agencies in competition for training funds at state and local government levels or to indicate an understanding of the complexities of the requirements of the Clean Air Act and the time responses demanded. Provision of specialized training funds and programs is more than an inherent segment of an effective federal program;

it is a wise and effective means to husband effort and time in the nation's attainment of its quest for clean air.

Specialized training in air pollution provided by EPA and its predecessor organizations has been in several forms: training of the short-course type conducted by EPA's Air Pollution Training Institute (APTI); training grants to universities; fellowships; as well as specialized training and curriculum development.

Training by APTI has been declining since 1972 when a user fee was imposed on government-sponsored training. Training grant funds and fellowships to universities or university consortia were drastically reduced or eliminated in 1976. This policy is being followed despite studies by EPA operating groups which indicate substantial unmet training needs for air pollution control, with serious impacts on the effectiveness of efforts to carry out the provisions of the Clean Air Act. These critical skill deficiencies occur in areas such as: source compliance and air quality monitoring—critical areas associated with determining whether air quality programs are indeed being carried out on schedule; and management functions to keep programs up-to-date in a rapidly changing technological world. The result of such deficiencies is that state and local agencies will have reduced capabilities to carry out their programs at a time when the work load imposed by the Clean Air Act is increasing.

The result of program failure at the state and local agency level will be to transfer responsibility to EPA for actual source control, source testing, and air monitoring. Keeping in mind that one-half of the funds expended by state and local agencies come from governments at these levels, while the other half comes from the federal government, the nation is faced with the problem of how to continue state and local financial support to air pollution control activities should these state and local efforts fail and the federal government assume full responsibility. Hence, the implications of adequate training are much greater than the degree of proficiency that technicians need to perform their tasks. Adequate training must be provided to optimize the use of monetary and human resources in meeting the requirements of the Clean Air Act.

MANPOWER SUPPLY CONSIDERATIONS

CERTIFICATION

A vital part of the effort to halt the pollution of our environment is sometimes overlooked. Not only are there highly technical equipment and processes involved, but the necessary personnel must be highly trained, technically competent, and sufficiently motivated so that goals set forth in the legislation can be reached. No matter how much money and effort are expended to install facilities, it will be impossible to reach the nation's goals without competent and responsible management and operation of the facilities. Proper personnel planning is necessary to obtain maximum utilization of the existing labor force, although shortages in quality or quantity of personnel are not great at present.

Staffing guides, with numbers and types of personnel with defined work loads, vary greatly because of the multitude of positions attributed to the environmental field. These range from the plant operator who may need only a high school education to the engineer, manager, and other employees who will need a college education to function properly along the lines of work set out for them.

The factor that has done the most to identify the specifics for education and training and to improve employment in the environmental field, particularly in wastewater programs, is the certification of operating personnel. It is an accepted principle that this certification is an appropriate legal mechanism to insure proper operation of facilities in which the nation is making heavy investments. Certification provides a selection process that gives management confidence in its employees. In turn, operators generally have recognized its beneficial results in raising their own technical abilities. The recognition of qualifications that are consistent with responsibilities to the public also lifts the status of operational personnel. One of the biggest incentives for operators to accept the certification program has been the improvement in their salary structure.

A 1974 survey found that all 50 states had some type of certification program for water and wastewater systems employees; 36 had mandatory certification programs for water supply workers, and 38 had mandatory programs for wastewater employees. Nine states reported voluntary programs in each category (Association of Boards of Certification [ABC]

1974). Mandatory certification in all states appears imminent. These programs are definite assets in the skill improvement of operating personnel to meet the challenge presented by new and sophisticated plants now going on the line.

The survey cited above reported that 22,000 operators have been certified for wastewater under all programs—mandatory and voluntary. When allowance is made for turnover, expansion, and further extension of mandatory certification, it seems evident that a substantial training effort will be required.

State certification requirements vary widely with respect to job coverage, education, experience, eligibility, types of certification, and permanence. "Grandfather" clauses have, in some cases, handicapped the attainment of qualified staff as these tend to reduce incentive to achieve full certification. On the other hand, the absence of such provisions in Wisconsin is reported to have led to "quickie" training. Divergent state certification standards result in wide differences in the qualifications of certified workers (ABC 1974). Although it seems unnecessary to have absolute uniformity of standards among the states, which are themselves so divergent, there is room for improvement.

A major step toward alleviating these differences in qualifications for certification was taken in 1972 with the formation of the ABC. This organization has been jointly sponsored and financed by the Water Pollution Control Federation, the American Water Works Association, the Council of State Governments, and EPA. The purpose of ABC is to develop uniform certification guidelines, to upgrade personnel qualifications for operators of water supply and wastewater disposal systems, and to facilitate staffing of operating systems with competent personnel. ABC also has developed a proposed mandatory certification law to be implemented at the state level. Today, ABC is favorably received and it promises to provide much needed cooperation among the several authorities charged with responsibility for operator certification. Moreover, its certification and qualifications guidelines are eventually expected to lead to reciprocity among the individual states for the certification of operators.

INSTITUTIONAL FACTORS

For professional personnel, including engineers, chemists, biologists, and meteorologists, adequate educational facilities seem to be available to accommodate pre-entry personnel training needs.

In the water quality control field, the big influx of personnel to manage the program at the state level under the Water Pollution Control Act appears to be over. For example, the Division of Water Quality of the California Water Resources Control Board retained 62 new professional-type people in calendar year 1975; for the 1977 fiscal year, starting July 1, 1976, it will be allocated 12 additional professional positions. An inquiry to one university indicates that, until now, there has been no problem in placing engineers in the environmental field. The employment situation was not as good for the forthcoming graduating class, but this may be a local problem.[8]

One factor that could increase the number of professional people seeking jobs in wastewater treatment plant operation and other management level positions in the environmental field is a higher salary schedule. As salaries continue to become more competitive, there should be an increase of professional personnel turning toward this field.

TRAINING AND EDUCATION

Professional and engineering staff are usually college trained and may be recruited directly from the campus. To an increasing extent, full professional training for sanitary and other engineers, chemists, biologists, meteorologists, and related disciplines, requires instruction beyond the standard four-year university curriculum.

Training of technicians involves a wide variety of institutions. Technical institutes, junior and community colleges, the armed forces, and private industry are important sources of such personnel. Large numbers of technicians have two or three years of college training but have not completed formal degree requirements. If further training is required, they might attend community and junior colleges which are oriented toward specialized career training, are now located throughout the country, and as a rule are attuned to local needs. However, small class size might be a handicap.

In some areas, state certification and training agencies have been important sponsors of training programs for local environmental pollution control plant operators who have skill deficiencies for jobs or for upgrading. South Carolina funded correspondence courses for operators as early as 1952.[9] These training courses, which vary greatly among states in length and content, have been important in augmenting the supply of trained operators.

Since the inception of a South Carolina-sponsored correspondence

[8]Personal Communication by R.V. Daigh, Chief, Operator Training and Certification Office, California State Water Resources Control Board.

[9]Personal Communication by R.V. Daigh with Dr. John Austin, Clemson University, South Carolina.

course at Clemson University, another correspondence course, "Operation of Wastewater Treatment Plants," was published by the California State University at Sacramento (Kerri 1970) and has been used extensively throughout the nation. In New York state, wastewater treatment plant operators attend either one-week or two-week training courses set up by the Office of Environmental Manpower of the New York State Department of Environmental Conservation. The courses are taught at the Polytechnic Institute of New York, Syracuse University, and the State University of New York College at Buffalo. Other examples of training available in the wastewater treatment field are a program in Neosho, Missouri, and the wastewater treatment program at Charles County Community College in Maryland.

Another kind of training for wastewater treatment plant operators is "hands-on" training, consisting of a treatment plant operated solely for this purpose. The San Marcos Training Center in California is such a facility. It offers a "short course" training program and enrolls each year more than 700 trainees.[10]

An adjunct to the "hands-on" type of training is the mobile classroom-laboratory that travels throughout a state and reaches remote areas where other means of training are not available. Both the in-plant and mobile training have been very successful, each serving a separate need. The mobile program would be the easiest to adapt to meet the needs of new program demands resulting from changes in legislation. Cost figures show it is the less expensive in terms of dollar-cost per trainee.

EMPLOYMENT, SALARIES AND WAGES, AND WORKING CONDITIONS

EMPLOYMENT

As an industry, environmental pollution control by state and local governments is subject to diverse and complex personnel requirements. Solid wastes disposal, for example, has been characterized as a "low skill" sector; in air pollution control, some 60 percent of the workers are in professional, technical, and managerial occupations; and there are wide variations between these extremes. Moreover, this activity, which may involve more than 140 different occupations, is subject to the varying employment conditions of communities in which it operates.

In many small communities, for example, the scale of operations for water supply and wastewater systems makes it necessary to employ only a

[10]Personal Communication by R.V. Daigh.

small staff, who are necessarily generalists. Recruitment of new employees is likely to be restricted to the local community and part-time workers, who have other local responsibilities, are not likely to develop specialized skills, or to perceive clearly the career possibilities in pollution control.

SALARIES AND WAGES

In the past, salaries and wages often have been too low to attract qualified personnel to the field of environmental control. In Michigan, wages were found to be lower in municipal wastewater treatment than for comparable work in federal, state, or private employment, a condition that made it hard to recruit and keep workers (Walters 1974). Municipal water supply utilities consistently seem to pay lower wages than comparable investor-owned utilities. A survey of professional and technical staff in air pollution control showed that, although the salaries of technicians were somewhat higher in the public sector, there was an overall differential of $3000 to $5000 per year favoring private over public sector employment.[11]

On the other hand, salaries of municipal wastewater operators in upstate New York are not as low as these differentials may indicate. In 1973, the average salary for a supervisor of a Type A plant (activated sludge) was $16,700 a year, and the salary of an assistant operator in the same type plant was $8,100 a year (New York [State] 1974). Data for the State of California, in Table D.29, show a definite upward trend in salaries and wages in wastewater treatment jobs.

WORKING CONDITIONS

In the past, working conditions in wastewater treatment were not of the best and the position of the plant operator was held in low esteem. But in the last five years, the picture has completely changed as a result of the emphasis on the environment, the training for water and wastewater treatment plant operators, the plant modernization that has added new technologies to the operation, and, in many cases, a better wage and salary structure. The change in attitude of employees is enlightening. A modern environmental pollution control plant, which may be a commu-

[11]National Society of Professional Engineers (1973) 1972 Salary Analysis of the Private Sector of Air Pollution Control Personnel. Prepared for the U.S. Environmental Protection Agency. Contract No. 68-02-0642. Research Triangle Park, N.C.: U.S. Environmental Protection Agency. (Unpublished)

TABLE D.29 Salaries and Wages in Wastewater Treatment, State of California, January 1976

City-County Public Works Departments (Five plants, maximum size 68 MGD)	
Operator	$1,452/month
Senior operator	1,634/month
Chief operator	1,814/month
Public Utility Districts (Tertiary plant, 7.5 MGD)	
Operator I	$1,162/month
Operator II	1,291/month
Senior operator	1,472/month
Chief operator	1,655/month
Municipal Plants (Activated sludge, 11 MGD)	
Assistant operator	$ 931 - $1,143/month
Water pollution control operator	1,122 - 1,377/month
Supervisor	1,377 - 1,689/month
Superintendent	1,725 - 2,118/month
County Sanitation Districts (20 plants)	
Assistant operator	$ 883 - $1,042/month
Grade I operator	1,083 - 1,194/month
Grade II operator	1,141 - 1,312/month
Grade III operator	1,220 - 1,484/month
Senior operator	1,375 - 1,669/month

SOURCE: Personal communication by R. V. Daigh, Chief, Operator Training and Certification Office, California State Water Resources Control Board.

nity showplace, gives employees a sense of pride and attracts young people seeking work in a challenging field.

Traditionally, public employees have been slow to join unions; those working in small municipalities have been the most reluctant to do so. However, the trend is now in the direction of union membership. A study of Michigan municipal wastewater systems found that, in 1974, labor unions were present in 40 to 50 percent of the plants. As of January 1976, almost all of the large municipal plants in California had union members. Organized labor can be expected to take an increasing role in labor/management relations in large wastewater systems.

The trend toward union organization of public service employees has been stimulated by Executive Order 10988 (1962). Although this provided that "employees of the Federal Government shall have, and shall be protected in the exercise of, the right, freely and without fear of penalty or reprisal, to form, join, and assist any employee organization or to refrain from such activity," the measure has had the effect of encouraging state legislation to permit union representation of public service employees. To date, 12 states have adopted legislation authorizing a closed shop for public employees; 32 states have adopted permissive legislation; and six states remain silent on the issue.

The unionization of public employees and, more specifically, the possibility that services may be withheld, poses a special problem for continued operation of water supply and wastewater treatment systems in such periods. These systems are designed to be dependent on highly specialized and competently trained personnel for satisfactory and continuing operation. Furthermore, the plants are required to operate 24 hours a day, every day, and are constructed with built-in redundancy to avoid shutdown when there is equipment failure or other operating difficulties. The more complex and sophisticated processes necessary to meet the criteria specified by water pollution control and safe drinking water legislation require even greater attention and more highly trained personnel for satisfactory performance.

It is readily apparent and urgently necessary that procedures be developed which will guarantee continued operation of water supply and wastewater treatment systems and at the same time guarantee labor and management rights within the context of collective bargaining procedures. This problem needs to be considered by Congress if federally-mandated standards, as set forth in federal pollution control legislation, are to be met.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

- Recent federal environmental legislation has been characterized by a deliberate and definite shift from ambient quality standards to quantitative emission standards. The emphasis on technology, some of which is not yet available, apparently will continue and of necessity will draw heavily upon the nation's finite resources, including financing, energy, and manpower. The measure of success to be achieved by this legislation will depend largely on the availability of specialized, highly trained, and competent manpower to conceive, design, construct, operate, maintain, and monitor the complex systems needed to meet mandated standards.

• Based on a review of manpower needs and supply problems in air pollution control, manpower supply generally is not restricted by the availability of personnel with the required basic education and training requirements. Rather, it is affected more by the provision of additional specialized training, authorization of personnel, and the funding of personnel on a long-term basis in order to provide for continued evaluation of progress, reappraisal of goals and planning, and continued program operation.

• "Hands-on" training is continuing through state and local training programs. Although available data do not indicate substantial deficiencies in numbers of personnel, the level of competency suggests that marginal operation of systems may be anticipated if existing facilities and those to be constructed to meet federally-mandated criteria are not satisfactorily staffed with competent people.

• Effective environmental control systems must be operated on a continuous basis. One of the most serious obstacles to continuous operation of these control systems is work stoppages in environmental control facilities. Interruption of operations of technology-based environmental protection systems can be particularly disastrous, causing serious damage to the systems as well as degradation of the natural environment and injury to the health of the population far beyond an immediate work stoppage period.

RECOMMENDATIONS

• *To assure that there will be available the specialized professional, technical, and operational personnel needed to conceive, design, construct, operate, and maintain the technology-based systems mandated by federal discharge criteria, it is recommended that the federal government encourage and financially support substantially increased academic and other personnel training programs without further delay.*

• *Because some of the technology required to achieve quantitative emission standards is still in the developmental phase and because existing systems also may benefit from new developments in technology, it is recommended that federal support of research be maintained at a level of funding sufficient to expedite this work and to achieve compatibility with goals and deadlines established by federal legislation.*

• *It is recommended that EPA recognize and study the overriding necessity for continuous and uninterrupted operation of environmental protection systems if these are to be effective, and make appropriate recommendations to Congress.*

• *The subject of training needs to be addressed by Congress and the Administration in order to clarify policy and to assure that manpower development and training programs are consistent with the mandates of the Clean Air Act. Support for this action is provided in reports by concerned organizations at the public meeting sponsored by the Committee for Environmental Manpower in Washington, D.C., on January 16, 1976.*

ATTACHMENT

Tabulations prepared for Los Angeles County Sanitation Districts (1975) Study on Manpower Requirements for Solid Waste Management—Municipal, Industrial, Agricultural, and Mining. March. Not published.

TABLE D.I.1 Municipal Waste Stream Manpower Requirements

	1975	1985
Collection and Transportation[1,2]		
Truck drivers	100,000	115,000
Collectors (laborers)	120,000	135,000
Subtotal	220,000	250,000
Processing[3]		
Recycling by existing secondary materials industry:		
Laborers	40,000	44,000
Mechanics	8,000	9,000
Sales people	8,000	9,000
Engineers	8,000	9,000
Equipment operators	16,000	18,000
Subtotal	80,000	89,000[4]
Resource recovery by advanced technology plants:		
Equipment operators	–	3,000
Maintenance personnel	–	1,500
Engineers	–	1,000
Laborers	–	2,000
Subtotal	–	7,500[5]
Disposal[6]		
Land Disposal:[7]		
Heavy equipment operators	12,500	16,000
Heavy equipment mechanics	1,000	1,300
Surveyors	2,000	2,500
Laborers	12,500	16,000
Engineers	1,000	1,300
Maintenance personnel	6,000	7,900
Subtotal	35,000	45,000
Incineration and other methods:[7]		
Operators	2,000	2,600
Laborers	3,000	3,900
Subtotal	5,000	6,500

TABLE D.I.1 (Continued)

	1975	1985
Research and Development[8]		
Resource recovery:[9]		
Scientists & engineers	500	500
Technicians	500	500
Subtotal	1,000	1,000
Solid Waste Management:[9]	1975	1985
Scientists & engineers	500	500
Technicians	500	500
Subtotal	1,000	1,000
Design of Facilities[10]		
Resource recovery:		
Engineers	600	1,200
Draftsmen	1,200	2,400
Subtotal	1,800	3,600
Total	343,800	403,600

[1] National Commission on Materials Policy (1973). International City Management Association (1975).
[2] Proportional to a 1.2 percent a year population increase.
[3] National Commission of Materials Policy (1973).
[4] Represents expansion of existing recycling plants only.
[5] Of the 250 million tons a day of municipal wastes, about 150 million tons are wastes that can be processed. Assume that about 250 resource recovery plants with a capacity of 500 tons a day will be in operation by 1985. Estimated cost of constructing these initial resource recovery plants is $7.5 billion, based on an estimated construction cost of $30,000 per ton of daily capacity. Total personnel requirements for each plant were estimated at 30 people.
[6] National Association of Counties Research Foundation (1971).
[7] According to the National Commission on Materials Policy, June 1973, 90 percent of collected municipal refuse was still going to land disposal sites. An estimated 8 percent of the urban refuse was being incinerated. The data for incinerator operators and laborers are based on an assumption that 30 persons are required to operate a 500 ton-per-day incinerator plant.
[8] Research and development is assumed to cost 1 percent of the cost of facilities. It is assumed the R&D will be conducted to concentrate effort during the initial three years and remain constant throughout the development.
[9] Includes site investigation and monitoring.
[10] Based on 10 percent of the total cost for construction of resource recovery plants as design emphasis will be greater in 1985. A cost, including overhead, of $30,000 per man year was used to determine personnel requirements.

SOURCE: Los Angeles County Sanitation Districts (1975) Study on Manpower Requirements for Solid Waste Management—Municipal, Industrial, Agricultural, and Mining. March. Not published.

TABLE D.I.2 Agricultural Waste Stream Manpower Requirements

	1975	1985
Collection and Transport[1]		
Equipment operators	25,000	28,000
Laborers	25,000	28,000
Subtotal	50,000	56,000
Processing[2]		
Equipment operators	5,000	10,000
Mechanics	2,500	5,000
Laborers	7,500	15,000
Engineers	1,250	2,500
Subtotal	16,250	32,500
Disposal		
It is assumed that other unprocessed wastes are disposed of on the land or in lagoons. Because this function is performed by farmers and ranchers, it is difficult to determine actual personnel requirements.		
Research and Development[3]		
Engineers & scientists	2,000	4,000
Agronomists	2,000	4,000
Animal researchers	1,000	2,000
Biologists	500	1,000
Subtotal	5,500	11,000
Design of Facilities[4]		
Engineers	2,000	3,000
Draftsmen	3,000	6,000
Subtotal	5,000	9,000
Total	76,750	108,500

[1] Because most collection and transportation will involve manures, these data are for animal wastes stream only. The assumption is made here that an operator of a skip-loader and a laborer will collect about 200 tons of waste per day and transport them to a processing or disposal site.

[2] This assumes that 25 percent of all agricultural wastes now are being processed and that this amount will increase to 50 percent by 1985. Estimated plant size is 1,000 tons per day, requiring about 10 people in each plant. Data are based on total agricultural waste stream.

[3] The authors have estimated that a cost of $10,000 per ton of capacity would be required to construct processing plants. These plants may be simple bagging operations or sophisticated pyrolytic plants and the plants could be incorporated with municipal refuse plants. One percent of the construction cost is allocated for research and development, and cost including overhead of $30,000 per man year, was used to determine the personnel requirements. In addition, much effort must be expended in research in the next 10 years to develop new methods to use agricultural wastes.

[4] Based on 10 percent of the total cost for construction of processing plants. Design emphasis is expected to increase by 1985. A cost including overhead of $30,000 per man year was used to determine personnel requirements.

SOURCE: Los Angeles County Sanitation Districts (1975) Study on Manpower Requirements for Solid Waste Management—Municipal, Industrial, Agricultural, and Mining. March. Not published.

TABLE D.I.3 Industrial Waste Stream Manpower Requirements

	1975	1985
Collection and Transportation[1]		
Truck drivers	25,000	25,000
Laborers	25,000	25,000
Subtotal	50,000	50,000
Processing		
Processing of most industrial solid waste production already has been incorporated into the municipal waste stream data in this report.		
Disposal		
The disposal of most of the industrial solid waste stream also has been incorporated into the municipal disposal data in this report.		
Research and Development[2]		
Engineers	500	1,000
Draftsmen	500	1,000
Subtotal	1,000	2,000
Design[3]		
Engineers	500	1,000
Draftsmen	1,200	2,600
Subtotal	1,700	3,600
Total	52,700	55,600

[1] Personnel requirements are based on an estimated 10 tons per worker day.
[2] Estimated personnel requirements for R&D are based on increased requirements for resource recovery and on restriction of sewered wastes and atmospheric pollution. Increased use of lumber residues is fast becoming a reality; other industries are likely to follow suit.
[3] These data assume that a two-fold increase in treatment processes for industrial wastes will take place.

SOURCE: Los Angeles County Sanitation Districts (1975) Study on Manpower Requirements for Solid Waste Management—Municipal, Industrial, Agricultural, and Mining. March. Not published.

TABLE D.I.4 Mining and Mineral Waste Stream Manpower Requirements[1]

Collection and Transportation[2]	1975	1985
Heavy equipment operators	30,000	35,000
Truck drivers	30,000	35,000
Laborers	40,000	45,000
Subtotal	100,000	115,000
Disposal[3]		
Heavy equipment operators	30,000	35,000
Truck drivers	20,000	23,500
Mechanics	3,000	4,000
Maintenance personnel	10,000	12,500
Engineers and technicians	2,000	2,500
Subtotal	65,000	77,500
Total	165,000	192,500

[1] A limited amount of processing of the solid wastes from mining and mineral extraction is now being done and is not expected to increase. Therefore, the personnel requirements listed are those required to collect, transport, and dispose of slag, culm, and tailings.
[2] Assumes a total of 15 percent of the 1975 solid waste disposal work force engaged in the mining industry. U.S. Bureau of Labor Statistics data show this force at 650,000 people.
[3] Assumes a total of 10 percent of the 1975 work force.

SOURCE: Los Angeles County Sanitation Districts (1975) Study on Manpower Requirements for Solid Waste Management—Municipal, Industrial, Agricultural, and Mining. March. Not published.

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APPENDIX E

Industry and Private Sector Aspects

INTRODUCTION

Past, present, and future requirements of industry and the private sector for environmental personnel can be estimated only with a great deal of uncertainty. Many people involved in environmentally related activities in the industrial and private sector perform these functions on a part-time basis, integrating their environmental work with other duties. Record keeping of such activities has been poor and may continue to be so unless major changes are made. Projections of personnel requirements are tenuous because of the widely varying assumptions that must be incorporated in them, including estimates of personnel use and requirements in the past.

The purpose of this report is to summarize recent data on environmental personnel needs and to discuss a methodology for determining personnel needs resulting from government programs for the control of pollution in the environment. The report also describes shortcomings in the present data base and recommends steps that should be taken to improve the predictions.

Before environmental personnel projections are undertaken, it is essential to define the area of study because the term "environmental personnel" can be narrowly or broadly interpreted. The environmental field covers a wide range of diverse activities, including such subjects as shellfish sanitation, chemical product registration, public relations, industrial and occupational medicine, noise pollution control, waste recovery, air and water pollution control, and pesticide registration.

For the purposes of this report, it is assumed that activities in four major categories will encompass most personnel requirements generated by legislative mandates and by regulations of the Environmental Protection Agency during the next 10 years. These four areas are: air pollution control; water pollution control; pesticide use; and noise pollution control. Solid waste management and radiation protection also involve environmental personnel in the industrial sector; however, these areas are discussed in the report of the panel dealing with state and local manpower requirements and are not treated here. A time span extending through 1985 was established as the study period because longer range projections, based on events that can be predicted only with marginal accuracy, become extremely nebulous.

The private sector of the economy is involved in the four areas covered in this report in various ways, including planning and evaluation; facility design and construction; equipment design, operation, and maintenance; monitoring; research and development; and liaison with regulatory agencies. Since growth trends and the degree of environmental expertise that is needed vary considerably, these activities are examined individually.

Planning activities functions are likely to increase dramatically as control agencies mature and as regulations become more sophisticated. Careful planning and siting of industries and other private businesses will be a major function that will require more environmental personnel and specialized training of people in a number of areas, including scientists and engineers.

Facility design will require personnel with expertise beyond that used in normal civil engineering design, particularly when the purpose of the facility has major environmental consequences. Cost-effective solutions to environmental problems will dictate that people who design control facilities have a good understanding of process operations before design is attempted. The number of individuals who will need this training will be a significant percentage of all of the required environmental personnel in the scientific and engineering fields.

Facility construction for environmental purposes is difficult to separate from general construction. However, it is anticipated that a significant amount of construction of environmental control equipment will occur and will require some expertise normally not available to general contractors. In this area, however, the requirements for personnel with environmental training will be small.

Equipment design and fabrication will be a growing sector as the pollution control industry continues to expand and as sophisticated pollution control equipment—electrostatic precipitators, flue gas scrubbers, chemical-physical water treatment units, and the like—are used on a larger scale. To best use advanced technology, personnel with training and experience in the environmental control area will be needed in the manufacturing, distribution, and installation of pollution control equipment. However, although a large number of people will be required, the extent of training in environmental fields will not be great for most of these people.

Perhaps the largest personnel requirement in the private sector will be for the operation and maintenance of pollution control equipment. As the inventory of control devices increases, personnel requirements also will increase. Unlike design engineers, who can accomplish one design function and then direct their efforts to a new project, equipment operators and maintenance crews are needed for the life of the equipment. To insure maximum effectiveness of control facilities, their operators and, to a lesser degree, their maintenance crews should be properly trained. This training function will have to be large scale and continuous and, for the most part, it will be at or below the two-year college level.

Environmental monitoring is just beginning to reach an accelerated growth phase. All new environmental regulations probably will result in increased activity in this field. Research and development on techniques for siting, operating, analyzing, and using environmental monitoring networks will require a significant number of highly trained environmental specialists.

Environmental control R&D is an ongoing commitment that will continue and, perhaps, accelerate in the private sector. It is expected that the present proportion of environmental personnel dollars that are spent in the research and development area is a reasonable measure of future needs, with the proportion gradually increasing as standards and criteria become more restrictive and technologies more complex.

The liaison role is a relatively new function created by the need for the private sector to communicate with control agencies as regulatory activities have increased. Personnel requirements for this function are expected to continue to grow. The training that individuals need to carry out liaison with government agencies will vary from industry to industry, but it is anticipated that they will require a good technical base in the environmental area as well as good management and communications skills.

SPECIAL PROBLEMS OF SMALL BUSINESS

Whereas government and large industry can respond directly to the increased demand for trained personnel as reflected by federal or state laws and regulations for the control of environmental pollution, special problems are created for small business and farmers. Such problems may result from new requirements in air pollution control as, for example, prohibitions against the burning of trash; water pollution control, in which the runoff from farms and feedlots is of concern; wastes management; and use of pesticides. Due to the difficulties in responding to these environmental concerns, there appears to be a sense of frustration—a feeling of being overwhelmed by bureaucratic regulations and encroachment—in small industry and in the agricultural sector.

The greatest unmet personnel needs for farmers and small business are for adequate technical assistance—for information and advice on the nature of the new regulations and the options that are provided for response. In the agricultural sector, the need for technical assistance is being partially supplied by the Cooperative Extension Service, the land-grant universities, and the U.S. Soil Conservation Service. For small business and industry outside agriculture, there is no organized system at present to provide technical assistance and advice. Most regulatory agencies do not provide much guidance or help for environmental corrective measures.

The Panel does not anticipate that small business, farmers, and ranchers will employ any more scientific or technical environmental personnel than they now have available, although the need exists. The response to this need must come, if it is supplied, from government.

METHODOLOGY AND DATA FOR PREDICTING FUTURE ENVIRONMENTAL PERSONNEL NEEDS

METHODOLOGY

Projections of future environmental personnel needs must be based on at least two considerations. First, some indications of these needs can be obtained by carefully analyzing available data on needs and trends in the past. Second, some judgments must be made about the rapidly changing environmental arena and the resulting personnel shifts that will occur. As environmental control becomes more sophisticated and as the upgrading of existing facilities is completed, activities will shift from improving existing facilities to the planning, siting, and development of modern, low-polluting production units. In addition, great emphasis will be placed on impact analysis, pollutant effects, economic analysis, and research and development activities. This will place new demands on environmental personnel that must be incorporated into any long-range projections of the numbers of people and the kinds of training that will be required.

A number of studies have been undertaken to determine the relationship between environmental activities and personnel requirements. Some information on scientific personnel requirements is available in special studies done by the Bureau of Labor Statistics (BLS) in the U.S. Department of Labor (1975), and by nonprofit research organizations for the National Science Foundation (NSF) (Lecht et al. 1974). The first of these studies used a version of the input–output approach to estimate the scientific personnel requirements generated by expenditures for plant and equipment, operation and maintenance, monitoring, and research and development in the area of pollution control. A number of assumptions about the future must be built into this framework, although several important considerations, especially labor market developments, are difficult to predict. Basic to these assumptions is the definition of direct and indirect environmental activity and of what can be considered an environmental expenditure.

Other studies (Lecht et al. 1974) have developed a methodology for the projection of future personnel needs based on levels of expenditures for capital purposes, operation and maintenance, and research and development. Although projections in the Lecht study were based on legislation existing before the 1972 Water Pollution Control Act was enacted, the results are valuable because a methodology is presented that can be used to estimate personnel requirements generated by varying expenditure levels. The basic assumption of the report is that, in the environmental area, the ratio of environmental personnel requirements to operating and maintenance expenditures will not change significantly during the projection period. The assumption is also made that the ratio of environmental personnel employed for research and development activities to environmental research and development expenditures will remain constant. In addition, the study implies that there is a direct relationship between capital expenditures for environmental control and environmental personnel employed. However, this ratio may be subject to major shifts as a result of inflation, equipment sophistication, and regulatory pressures.

It becomes even more difficult to employ this concept in developing projections of personnel requirements for new facilities than it is for the upgrading of existing facilities. In the future, many environmental problems associated with manufacturing may well be handled through process change, raw material controls, proper plant siting and, in some instances, product elimination. The decision process will require environmental expertise among personnel responsible for these activities. Even though major shifts will occur as new facilities are built, the total number of persons employed in environmentally-related jobs in connection with these facilities will be relatively small, particularly when compared to the number who will be employed by upgrading programs for existing facilities. Future environmental activities also are expected to rely more heavily on planning, monitoring, research and development, and regulatory liaison than has been the case in the past. Thus, some adjustments must be made in the present ratios of personnel requirements and dollars spent if such ratios are to be used to project future personnel needs.

DATA

Projections of personnel requirements by BLS—the foundation for many personnel projections in the environmental field—are based on a series of assumptions about the economy, government policy, pace of research and development growth, and the level of research and development funding. Presumably, the greater the disparity between assumed and actual conditions, the more likely it is that employment requirements and actual levels will vary from projected levels.

Daniel Bell (1973) suggests that predictions usually deal with events: who will win an election, the specifics of a new invention, and other matters that center on decisions. Yet such predictions, while possible, cannot be formalized and made subject to rules, Bell says. The prediction of events is inherently difficult and, more aptly, is related to statistical probability. Whereas Lecht et al. relate certain events to national goals, Bell asserts that events are created by the intersection of social vectors (interests, forces, pressures, and the like). While to some extent it is possible to assess the strength of individual vectors, one would need a "social psychic" to predict exact crosspoints where decisions and forces combine not only to create an event but, more importantly, its outcome.

Lecht et al. (1974) have pointed to the significant influence of national goals on personnel requirements. As examples they cite the impact of Medicare and Medicaid legislation in enlarging personnel needs in the health occupations, and the role of the space program in the early sixties in increasing the demand for engineers and scientists. Of more recent origin is the changing outlook brought about by the "energy crisis," an example of a dramatic and relatively sudden change in needs, requirements, and perceptions that has affected our national goals. Thus, although some people perceived the need for a comprehensive energy policy for the United States long before the 1973 fuel crisis, it was not until then that a large part of the general population and a large number of experts agreed upon this national goal.

"Goals research," which is designed to help in the development of criteria to use in judging actual and evolving events, could be an important adjunct in the process of evolving manpower policy and projections. However, the attainment of goals inherent in our national commitment to a quality environment is based upon a number of assumptions that appear quite disparate when viewed by different people. For example, Moeller (1974) states:

> An assessment of manpower development activities within EPA has caused the committee to conclude that far too little effort is being directed to career developmental opportunities for EPA employees, that short-term technical training is being hampered by policies such as the assessment of user charges, and that the need for qualified technicians, such as those who maintain air pollution control equipment on automobiles, is being almost totally neglected. Suffering from a similar lack of attention are air pollution manpower and training needs of state highway departments and planning agencies. Because of cutbacks in training grant funds for colleges and universities, much of the momentum and enthusiasm formerly common to those working in such programs has been lost. As a result, there has been a deterioration in the quality of graduate air pollution educational programs and this decline is accelerating.

Conversely, Alden[1] believes that the present pool of engineers and scientists, though not specifically or exclusively educated for careers in environmental control, will be capable of meeting most of the needs. Alden further believes that relatively minor changes in curriculum will be sufficient for the task.

For many years, information and statistics related to environmental personnel needs have been collected by many organizations. This information has been valuable in developing a data base and, to some extent, a methodology for the projection of personnel needs. However, there has not been a comprehensive and comparable data system developed for all types of environmental personnel needs. This is especially true in industry and the private sector, where the functions of environmental control may be assigned to persons who are not

[1]Personal communication from John D. Alden, Engineering Manpower Commission to P.R. Atkins, Aluminum Company of America.

exclusively involved in these activities. The result is a wide variety of definitions, coverage, timing, and data collection methods, and this gives rise to problems of statistics that are not comparable and to weaknesses in much of the data. The Panel recognized these problems and has made an effort to minimize the more glaring inconsistencies among various projections—as, for example, an absence of common reference periods—to make possible a more consistent and manageable basis for analysis.

In a review of environmental personnel projections, it is not always clear what is included within the rubric of environmental measures, and it is often assumed that this is a clearly defined and agreed upon series of events. In practice, environmental measures embrace activities ranging from noise abatement to recycling of wastes, and environmental considerations are often only one element among many. On the one hand, a business firm may invest in equipment specifically intended to neutralize water chemically prior to its discharge into a lake or stream, or to eliminate toxic gases from industrial emissions. On the other hand, a plant may be replaced before it is obsolete primarily because the new facility, along with other advantages, generates less pollution.

Concern with environmental considerations may hasten the introduction of new technologies that have been available for some time and now become practicable because they are less likely to produce pollutants. There are reports, for example, that environmental considerations have accelerated the use of the pelletizing process in the iron and steel industry and the hydrogen process in petroleum refining. These actions raise questions of whether changeovers in processes and the more rapid introduction of new plants should be included in measurements of environmental activities. Clearly, a common definition of what constitutes environmental activities is necessary if various cost estimates and personnel projections are to be compatible with one another.

ENVIRONMENTAL MANPOWER STUDIES

In the diverse literature on environmental control personnel, one can discern that a unified approach seems to be evolving. However, there is a great range in the quality and objectives of this literature. Some people look at the problem and analyze supply from the viewpoint of producing personnel with needed skills, and their use by industrial categories and the consultants who serve these categories. Other people establish demand norms based upon existing employment, usually by category, per million dollars spent. Thus, the problems involved in an attempt to develop national demand and supply information on personnel for pollution control are legion and most of the literature is replete with caveats about the "data sets" or the large problems of the economic outlook, energy needs and supply, and technological developments.

An important aspect of the whole environmental personnel problem is the fact that the literature reveals several different perceptions of its relation to national goals and priorities. For example, we are reminded by Lecht et al. (1974) how rising expenditures for national defense and space exploration goals increased requirements for scientific manpower (and skilled and semi-skilled labor) in the early 1960s, and of the effects in terms of diminishing requirements when research and development outlays leveled off in the early 1970s. At the same time, others complain that during a period of rising expenditures for pollution control activities to correct existing problems and to plan for future amelioration of pollution, the training programs developed in the 1950s and 1960s were being cut, degraded, or completely abandoned.

It is true that, to a degree, environmental pollution control and environmental engineering are being introduced into the specialties at the undergraduate level, and therefore a larger pool of environmental specialists will be available in the future. But when viewed from the vantage point of needs—in the steel industry alone, $32.3 billion (in terms of 1975 dollars) may be needed to meet 1980 capital requirements for pollution control, replacement, and expansion costs, and $48.9 billion may be needed to meet 1983 requirements (A.D. Little 1975)—it is clear that the sheer magnitude of the expenditures demands a high degree of expertise. Moreover, such calculations do not take into account the newly discovered need to deal with environmental pollution control and planning in an energy conserving manner. This new element which hitherto, even when acknowledged, was met only in the breach, must now be included in all calculations.

The inherent difficulty of approaching the problem in a highly specific manner is illustrated by the following quotation. The quote, which is not directly related to the manpower problem, is from a recent analysis by Luken et al. (1976) of the generation, discharge, cost of control, and regional distribution of liquid wastes to be expected in meeting the requirements of the Water Pollution Control Act. The discussion concerns the analysis of industrial activity and the need to reduce the number of relevant variables to what is usable and available:

> It would be highly desirable to analyze in more detail the range of available options for achieving reduction in residuals discharge and the costs of achieving

that reduction. The type of information would obviously be subcategories of four-digit (SIC) which could achieve higher levels of residuals discharge reduction at lower costs than other activities. But many such options are plant and site specific, so that it is impossible to consider them in a national analysis.

For similar reasons, the data set available to use as a basis for environmental personnel projections for industry and the private sector is meager. However, there is considerable literature on these requirements. In a general sense, it can be divided into two major segnents: one deals with reporting current manpower use (numbers and kind); the other is devoted to one of several aspects of future demand and supply projections.

It is important to recognize that this literature, although it consists primarily of study reports, some professional and technical journal articles, and a few books, has a measurable social impact of its own. University career counselors and professors inevitably read articles and papers related to personnel needs, and it is their perception of the data presented, the conclusions drawn, and the projections made that is transmitted to students. The importance of this information increases as government support of training in environmental control curricula decreases. Its importance is enhanced because of the increased investment students must make in heeding advice and counsel on a possible professional career in the field of environmental control.

Even before the formation of EPA, serious questions were being raised about how to predict future personnel needs for environmental control. The following quotes are from a 1970 HEW report to Congress (U.S. Congress, Senate 1970) which drew heavily from a report (Faith 1969) prepared for the National Air Pollution Control Administration. Although the data are several years old, the material is quoted for its intrinsic value and to show the views at the time:

Industrial Plants. Air pollution research and control activities in industry involve a broad spectrum of personnel, ranging from top management to equipment operators and maintenance men. In nearly every department of a manufacturing organization, there is an interaction between the specific departmental activity and air pollution control.

One function of corporate management is to be aware of regulations and trends that affect company operations. In this report, environmental control represents an area of rapidly increasing importance. Most large companies with multiplant operations assign at least one man to the field of air and water pollution. In many cases, it is not uncommon for an equivalent of 1.5 man-years to be devoted to air pollution control. In addition to personnel at corporate headquarters, one employee, usually an engineer or chemist, is assigned full time to air and water pollution problems in each of the larger plants of the organization. At the plant level, aid is given to the plant manager on matters pertaining to local regulations,

TABLE E.1 General Manpower Matrix by Industry in 1969 and Estimates for 1974 (Man-Years for Air Pollution Control)

Industry	Professional and Executive		Technician		Operation and Maintenance		Total	
	1969	1974	1969	1974	1969	1974	1969	1974
Rock product processing:								
Cement (portland)	75	135	0	175	300	450	375	760
Other (lime, glass & ceramic, gypsum)	71	91	7	7	75	110	153	208
Chemical[1]	950	1,700	150	1,200	1,400	1,750	2,500	4,650
Food and kindred products[2]	214[3]	306[3]	0	0	15	15	229	321
Steel and related manufacturing:								
Integrated steel mills	400	790	175	200	1,400	1,800	1,975	2,790
Electric steel operations	20	35	0	0	75	150	95	185
Gray-iron foundry	40	40	0	0	50	1,800	90	1,840
Nonferrous metals:								
Copper (primary smelting)	69	162	38	90	230	600	337	852
Lead & zinc (primary & secondary smelting)	121	152	28	38	750	1,140	899	1,330
Aluminum reduction	70	144	30	72	140	144	240	360
Nonferrous foundries	20	20	0	0	50	750	70	770
Petroleum:								
Petroleum refining	650	740	200	260	2,000	2,600	2,850	3,600
Other (hot paving mix, asphalt-saturated felt)	0	0	0	0	0	140	0	140
Steam-electric powerplant	200	2,080	50	870	60	150	310	3,100
Pulp and paper	240	550	150	220	210	330	600	1,100
Rubber	20	60	0	40	0	0	20	100

[1] Includes alkalis and chlorine, intermediate coal-tar products, pharmaceutical preparations, paints and allied products, fertilizers, agricultural chemicals, soaps and detergents, synthetic rubber and fibers, plastics, other inorganic and organic chemicals.
[2] Includes meat, fish, canned and frozen foods, flours and cereals, other milling and allied operations, fats and oils.
[3] Includes 150 man-years for rendering operations.

SOURCE: U.S. Congress, Senate (1970).

public complaints, effectiveness of controls, and liaison with local authorities.

Process and equipment design is important in any operation where either the process must be modified to prevent pollutant formation or pollutants must be captured before discharge into the atmosphere. Where collection equipment is required, this function is often shifted to the manufacturer of the equipment.

Research and development is particularly important in industries with the greatest air and water pollution problems. Research and development time is required for solution of specific problems. In the chemical industry especially, new process developments need evaluation as to their impact on air and water quality.

Process control is a necessity even after air pollution control equipment is designed and installed, because the equipment can seldom be operated continually at the desired efficiency without monitoring. Technical manpower, usually engineers, chemists, and technicians, are required to monitor operating procedures, equipment efficiency, stack emissions, and ambient air concentrations.

Use of air pollution control equipment results in additional manpower for operation and maintenance. The additional manpower is similar to that already employed in industry; the required increase is variable, depending on equipment size and type.

For performance of the functions described above, industry prefers professional and subprofessional personnel to be well trained in their basic disciplines, have suitable experience in the specific industry, and obtain expertise in air pollution control by post-job entry study, practice in the field, and attendance at meetings. Industry does not express a need for manpower highly trained in air pollution control technology. Manpower requirements for specific industries were estimated by using current data on manufacturing establishments. Air pollution control manpower was estimated for a typical plant for each industry; these estimates were then extrapolated to a national figure. The industries chosen and the estimates made are summarized [in Table E.1]. Three manpower categories are shown in each industry: executive and professional; technician; and operation and maintenance.

As shown in [Table E.1], the estimates indicate that the manpower needs of industry will be doubled, as a minimum, by air pollution control requirements arising from implementation of the Air Quality Act. The actual number of employees will be at least twice the indicated man-years.

A factor not considered in [Table E.1] is the manpower required for industry compliance with permit systems. Assuming the man-years required for the preparation of permit application amount to three times the man-years required for review, and using the predictive model output for State and local agencies, it is estimated that 3,500 engineering man-years will be required in addition to the estimates in [Table E.1].

The amount of inspection of air pollution control facilities is another factor of importance. If annual inspection is assumed, and because it is common practice for industry to have available a person qualified to accompany the inspector on his rounds, it is estimated that an additional 1,000 man-years would be required based on the predictive model output for state and local agencies in addition to the estimates in [Table E.1].

A third factor not considered in [Table E.1] is the effect of regulations for the control of sulfur oxides emissions from power plants. If emissions are controlled by using low sulfur fuel, no additional manpower would be required. If control is effected by removing sulfur oxides from stack gases, then additional manpower will be needed.

The difficulties inherent in trying to arrive at an accurate census of environmental personnel currently employed are illustrated by two sets of data on the subject. The Third National Environmental Engineering Education Conference[2] reported that the engineering and scientific manpower employed by industry was 3700 in 1974 and was projected to be 12,100 in 1976, and that the employment of consulting engineers was 7600 in 1971 and would be 11,800 in 1975. This can be contrasted with a 1976 statement by Isaiah Gelman[3] on behalf on the National Council of the Paper Industry for Air and Stream Improvement, Inc., that,

> based on an estimated (projected) capital outlay of $650 million for environmental protection capital projects in 1975 and $250 million in operating expenses, current manpower involvement within the industry can be estimated at 5500 to 6000 man years per year. Of these perhaps 1300 to 1400 can be classed as scientific and engineering professionals, 1200 to 1300 as technicians, 2400 to 2600 as facilities operators, and 600 to 700 as in the management and administrative area.

Furthermore, Gelman says, "External to the industry one can estimate that detailed scientific and engineering services require consultant supply of 500 to 750 man years per year." It is difficult to conceive that, of the 12,100 scientific and engineering man years per year projected in industry for 1976, 1300 to 1400, or approximately 11 percent, were subsumed in 1975 under one category, the paper industry. Obviously, the independent projections made in these two studies incorporated different assumptions and used different base points.

GENERAL ECONOMIC PERSPECTIVE

Most studies suggest a recognizable relationship between total expenditures for pollution control and personnel requirements. This figure is difficult to develop accurately because of the varying nature of pollution control activities from industry to industry and from media to media. For example, water pollution control activities appear to be more labor intensive than air pollution control activities. Also, research and development in pollution control are changing rapidly, as are the

[2]Roberts, J.B. (1973) Summary of the 3rd National Environmental Engineering Education Conference. Proceedings of the Third National Environmental Engineering Conference. Philadelphia: Drexel University.

[3]Gelman, I. (1976) Environmental Manpower Needs—As Viewed from a Paper Industry Perspective. New York: National Council of the Paper Industry for Air and Stream Improvement, Inc. (Unpublished.)

financial commitments necessary to maintain a man-year of research effort.

Nevertheless, the concept of the demand for environmental manpower is meaningful in terms of the employment generated by private and public spending on pollution control. It is possible to determine the parameters of environmental manpower demand by examining past and present expenditure patterns by government and industry. While such parameters lack much of the fine detail needed for proper policy assessment, they do provide a realistic frame of reference within which to examine the many fragmentary bits of demand information that have been developed.

The Panel employs 1974 as the base year because reasonably comprehensive and complete data are available for that period. For example, the Bureau of the Census has reported that total government spending on selected environmental quality control activities during FY 1973–74 amounted to approximately $7 billion (U.S. Bureau of the Census 1976). This appears to be a fairly conservative figure as it includes only activities related to water quality control ($4.6 billion), air quality control ($297 million), and solid waste management ($2 billion). Fairly substantial activity in water supply, noise, radiation, and pesticide control is excluded. Therefore, actual government spending on all forms of pollution control certainly exceeded $7 billion in 1974.

The Bureau of Economic Analysis (BEA) in the Department of Commerce has recently begun to compile capital spending data for pollution control by industry (Cremeans et al. 1975, Segel and Rutledge 1976). These data also are limited to water quality, air quality, and solid waste management expenditures and show that in 1974 a total of $5.6 billion were invested in new pollution control plants and equipment. That represents only 5 percent of total new plant and equipment purchases by industry during 1974 but is still a substantial investment. Total industry spending during the year was clearly higher than these data indicate because the survey did not cover operation and maintenance costs or abatement costs incurred in noise. radiation, and pesticides programs (see Table E.2).

There is a wide variety of other estimates of past and future pollution control costs. For example, the Seventh Annual Report of the Council on Environmental Quality (1976) estimates that private industry spent approximately $14.7 billion in capital and operating and maintenance costs in 1975 for pollution abatement and will spend approximately $38.4 billion for these purposes in 1984 (in 1975 dollars). Most of the 1984 expenditures were expected to be for air and water pollution control. Table E.3 summarizes these projections.

TABLE E.2 New Plant and Equipment Expenditures by U.S. Business for the Abatement of Air, Water, and Solid Waste Pollution,[1] 1974-76

[millions of dollars]

	1974					1975					Planned 1976				
	Pollution abatement					Pollution abatement					Pollution abatement				
	Total	Air	Water	Solid waste	Total[2]	Total	Air	Water	Solid waste	Total[2]	Total	Air	Water	Solid waste	Total[2]
Manufacturing	3,656	2,153	1,251	252	45,795	4,475	2,494	1,736	245	48,314	4,488	2,157	2,074	257	50,710
Durable goods	1,648	1,115	437	95	22,669	1,775	1,161	529	85	22,046	1,762	1,020	668	73	22,225
Primary metals[3]	798	620	143	35	4,805	1,012	750	221	41	5,892	1,007	675	300	31	5,831
Blast furnaces, steel works	245	160	70	15	2,030	396	261	135	1	2,926	540	340	197	3	2,866
Nonferrous metals	500	409	71	19	2,292	546	425	82	39	2,267	396	272	98	26	2,112
Electrical machinery	207	68	128	11	3,060	136	34	93	9	2,327	158	32	116	11	2,391
Machinery, except electrical	77	37	27	13	4,264	83	40	37	6	4,736	106	42	61	2	4,867
Transportation equipment[3]	140	67	50	24	3,826	116	51	50	15	3,387	137	51	68	17	3,308
Motor vehicles	115	55	38	23	2,812	86	35	38	13	2,206	114	39	59	16	2,374
Aircraft	22	10	11	1	766	26	14	11	1	915	20	11	8	1	713
Stone, clay, and glass	191	174	14	3	1,483	198	164	31	3	1,389	164	118	42	4	1,427
Other durables[3]	235	150	76	9	5,231	229	122	97	10	4,315	191	102	81	8	4,401

Nondurable goods	2,008	1,037	814	157	23,126	2,700	1,333	1,208	160	26,268	2,726	1,137	1,405	184	28,485
Food including beverage	150	56	85	10	3,206	175	71	92	12	3,383	203	90	93	20	3,754
Textiles	28	10	15	3	849	31	15	15	1	680	46	14	32	1	787
Paper	491	308	158	25	2,546	489	273	189	27	2,908	502	213	274	15	3,347
Chemicals	469	192	246	30	5,628	684	250	394	40	6,300	786	247	478	61	6,844
Petroleum	796	416	296	84	7,868	1,239	684	483	72	10,497	1,100	530	490	81	11,245
Rubber	47	33	11	2	1,475	41	25	14	2	1,037	54	28	22	4	1,178
Other nondurables[3]	28	21	4	3	1,554	41	14	22	6	1,463	34	15	16	3	1,330
Nonmanufacturing	1,961	1,190	624	147	66,124	2,074	1,296	626	152	65,175	2,859	1,703	968	187	68,975
Mining	57	24	25	9	3,097	73	32	31	10	3,823	99	44	44	11	3,666
Railroad	29	12	14	2	2,484	35	11	21	3	2,539	35	8	24	3	2,287
Air transportation	7	4	2	1	1,970	11	6	4	1	1,841	14	7	5	2	1,262
Other transportation	46	11	28	6	2,034	41	12	19	10	2,901	58	14	28	15	2,821
Public utilities	1,622	1,031	499	92	20,597	1,700	1,138	466	96	20,313	2,431	1,557	747	128	23,993
Electric	1,578	1,011	477	90	17,649	1,650	1,123	438	89	17,030	2,386	1,547	715	124	20,052
Gas and other	44	20	22	2	2,948	50	16	28	6	3,283	45	10	32	3	3,941
Communication, commercial and other[4]	201	108	56	37	35,942	214	97	84	33	33,758	221	74	119	28	34,946
All industries	5,617	3,343	1,876	398	111,919	6,549	3,790	2,362	396	113,489	7,346	3,860	3,042	444	119,685

[1] Excludes agricultural business; real estate operators; medical, legal, educational, and cultural services; and nonprofit organizations. Excludes outlays charged to current account.

[2] Estimates of total plant and equipment (P. & E.) expenditures (1974, 1975, and planned 1976) are as of the survey date, to allow comparison with estimates of pollution abatement expenditures. Updated estimates of total P. & E. expenditures can be found in "Plant and Equipment Expenditure Programs," Survey of Current Business, March 1976, pp. 14-19.

[3] Includes industries not shown separately.

[4] Consists of trade, service, construction, finance, and insurance.

NOTE: Details may not add to totals because of rounding.

SOURCE: Segel and Rutledge (1976).

TABLE E.3 Estimated Total Pollution Control Expenditures in the Private Sector, 1975 and 1984[1]

Pollutant/Source	1975 O & M Costs	1975 Capital Costs[2]	1975 Total Annual Costs[3]	1984 O & M Costs	1984 Capital Costs[2]	1984 Total Annual Costs[3]	Cumulative (1975-1984) Capital Invest-ment	Cumulative (1975-1984) O & M Costs	Cumulative (1975-1984) Capital Costs[2]	Cumulative (1975-1984) Total Annual Costs[3]
				(in billions of 1975 dollars)						
Air Pollution										
Industry	2.1	2.4	4.5	4.9	5.6	10.5	24.0	34.8	39.5	74.3
Utilities	1.0	1.0	2.0	3.5	3.5	7.0	19.0	21.0	21.0	42.0
Water Pollution										
Industry	1.9	1.7	3.6	7.4	5.7	13.1	41.4	40.6	33.0	73.6
Utilities	0.6	0.4	1.0	1.4	0.8	2.2	3.8	10.5	6.3	16.8
Solid Wastes	2.9	0.7	3.6	3.9	1.1	5.0	5.6	28.4	8.8	37.2
Noise	NA	NA	NA	0.3	0.3	0.6	1.7	1.8	1.6	3.4
Total	8.5	6.2	14.7	21.4	17.0	38.4	95.5	137.1	110.2	247.3

[1] Original table included public expenditures as well.
[2] Interest and depreciation.
[3] Operation and maintenance plus capital costs.
NA Not available

SOURCE: Council on Environmental Quality (1976).

Chase Econometrics Associates (1975) reported to the Council on Environmental Quality that incremental pollution control expenditures for private industry for 1973 to 1977 would be $25.6 billion—54 percent for air pollution control and the rest for water pollution control. For 1978 to 1982, capital expenditures would be $4.8 billion (in 1973 dollars)—30 percent for air pollution control and 70 percent for water pollution control.

McGraw-Hill (1976) recently reported the results of a survey citing U.S. industry plans to spend $9.46 billion for pollution control in 1976 and, eventually, to invest $30.6 billion (in 1976 dollars) to bring existing facilities into compliance with current environmental standards. The preliminary plans of industry indicated that pollution control spending may peak in 1977 or 1978 and that expenditures in 1979 would be $8.67 billion. Air pollution control is approximately 60 percent of the total; water pollution control, approximately 30 percent; and solid waste control, approximately 10 percent.

EPA (1976) has estimated that total capital investment for industrial pollution control between 1975 and 1985 will be $100.14 billion, with the rate of capital expenditure beginning at about $16 billion a year, peaking in 1979, and falling to approximately $3 billion a year in 1985 (in 1975 dollars). Annual operating and maintenance costs were estimated at $158 billion in the same period, as shown in Table E.4.

MANPOWER FACTORS

In 1973, Bezdek and Hannon (1974) estimated that $1 billion (1975 dollars) allocated to the construction of wastewater treatment facilities would employ a total of 82,000 people. However, much of this employment would be related to construction rather than to pollution control. The Bureau of Labor Statistics estimates that only 53,600 (in 1972 dollars) jobs would be generated for each billion dollars spent on construction of wastewater treatment systems, but that 78,000 jobs would result from a billion dollars spent for research and administration of pollution control programs (U.S. Department of Labor 1975). Ch'uan-K'ai Leung and Klein (1975) report that approximately 70,000 jobs were generated, on the average, by the expenditure of a billion dollars for pollution abatement in 1975. In each of these cases it should be emphasized that both direct and indirect employment impacts were estimated. Direct employment, the concern of this panel, represents about half of total employment.

To be more specific, the BLS found that an average of 31,700 jobs were generated directly in 1970 by each billion dollars of federal spending on

TABLE E.4 Estimated Annual Cost to Industry of Pollution Control, 1975 through 1985

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Total
	(in billions of 1975 dollars)											
Air Pollution												
Capital Investment	7.90	3.30	5.50	6.00	4.20	1.73	1.42	0.95	0.50	0.60	0.62	32.72
Operation and Maintenance	3.01	4.15	4.67	5.07	5.42	5.67	5.70	5.72	5.74	5.76	5.78	56.69
Water Pollution												
Capital Investment	6.70	5.00	6.00	4.90	6.90	7.90	7.50	6.80	4.91	2.00	2.26	60.87
Operation and Maintenance	3.00	4.00	4.99	6.00	7.10	8.20	9.20	10.20	11.20	10.38	10.38	84.65
Solid Wastes[1]												
Capital Investment	1.00	0.65	0.79	0.75	0.72	0.69	0.65	0.54	0.38	0.18	0.20	6.55
Operation and Maintenance	0.72	0.98	1.16	1.33	1.50	1.67	1.76	1.88	2.00	1.91	1.79	16.70

[1] Solid wastes data added to EPA data by assuming solid wastes capital investment at 7 percent of air and water investment, and solid wastes operation and maintenance at 12 percent of air and water operation and maintenance.

SOURCE: U.S. EPA (1976).

pollution control activities (1975). Allowing for a 20 percent reduction in the job generating power of such spending due to inflation during the intervening years, a billion dollars in 1974 would support direct employment of about 25,400 persons. This should be compared with the results of the 1974 Census study of government spending and employment for pollution control (U.S. Bureau of the Census 1976). The Census study showed that total spending of nearly $7 billion in 1974 created over 225,000 jobs, or a direct employment ratio of 32,400 per billion dollars in government alone. Allowing for some nongovernmental direct employment as a result of this spending would easily put the ratio to at least 36,000 jobs per billion dollars or higher.

It is reasonable that the BLS study indicated lower direct employment impacts than the Census report. Federal spending tends to be concentrated in technology-intensive areas and on relatively highly-paid scientists and engineers. Fully 88 percent of federally generated employment was at professional, technical, or managerial levels, according to the BLS study. Conversely, local government environmental spending includes substantial amounts for solid waste management and other purposes where larger numbers of lower-skilled personnel are employed.

Data developed by the Manufacturing Chemists Assocation (MCA 1975) indicate that the employment impact per million dollars is diminishing rapidly. In 1962, $1 million spent on pollution control operation, maintenance, and research generated an average of 43 jobs in the chemicals industry. Due to a combination of inflation and higher capital investments, that ratio dropped to an industry average of only 15 jobs per million dollars in 1975. Table 4.11 of the Committee report presents the MCA data.

The Aluminum Company of America (ALCOA) recently analyzed Bureau of the Census data from various operating locations and found that environmentally-related personnel, exclusive of corporate staff, amounted to 18.2 full-time workers per million dollars of expenditure for operating and maintaining environmental management facilities.[4] This may or may not be typical of the nonferrous metals industry, but nevertheless it is of interest for comparative purposes.

ESTIMATING OVERALL EMPLOYMENT IN INDUSTRY

The wide differences in pollution control cost estimates from different sources indicate the difficulty in determining future capital costs or

[4]Personal communication from J.B. Whitchurch to P.R. Atkins, Aluminum Company of America, April 1976.

requirements for environmental personnel. On the one hand the very proliferation of cost estimates reveals the uncertainty that surrounds the entire environmental effort. While this is understandable and is perhaps inevitable in a new program of this type, it does complicate manpower planning. On the other hand, the manpower factors themselves are uncertain and changing both with the value of money and with technological innovation.

In a situation like this it was necessary for the Panel to exercise judgment and select cost and manpower figures which seemed most reasonable. For purposes of this section, the results of the Bureau of Economics Analysis (BEA) survey of capital costs for pollution control in 1974 are used (Segel and Rutledge 1976). The BEA survey shows that in 1974 industry spent $5.6 billion on capital equipment for pollution control (water, air, solid waste). This would add some $2.2 billion to industry expenditures during 1974. Economic studies done for EPA suggest that during early stages of development, industrial operation and maintenance costs for pollution control are about 40 percent of capital costs.

The range of manpower factors described above extended from a low of 15,100 jobs per billion dollars for operational personnel in industry to a high of 36,000 jobs per billion dollars for local government. The effect of applying a range of these factors to industry spending in 1974 is shown below. A much lower direct employment estimate is placed on operation and maintenance than on capital investment.

	1974 Expenditures ($ billions)	1974 Direct Employment (per $ billion)	1974 Direct Employment
Capital Investment	$5.6	30-36,000	168,000-201,600
Operation and Maintenance	$2.2	15-19,000	33,000- 41,800

Some environmental spending is certainly omitted from spending totals and for that reason the employment ranges may underestimate actual 1974 employment. On the other hand, a very substantial number of those employed directly on pollution control projects do not constitute part of the specialized labor forces that are the focus of this Panel's concern. The figures do, however, suggest an order of magnitude for overall employment created by industry spending on pollution control in 1974.

OTHER STUDIES OF ENVIRONMENTAL MANPOWER DEMAND IN THE PRIVATE SECTOR

For the private sector, more data are available on projections of personnel requirements in water pollution control than there are in air pollution control, but the estimates vary widely owing to the use of different methodologies and scenarios. In the main, most of the data generated before passage of the 1972 Water Pollution Control Act missed the mark because of the rapid acceleration of expenditures by the private sector resulting from the mandates of that Act.

In 1972, EPA submitted a report to Congress using data from the 1968 Census of Water Use in Manufacturing and an inventory of all wastewater treatment plants to estimate 1976 personnel requirements (U.S. Congress, House 1972). It concluded that the most critical need is for operators and operator training, and that environmental engineers will be needed, largely because of the increased technological sophistication of control processes. In the main, the report emphasized that higher training will be needed at all levels and that technological developments will continue to affect this need for additional training. The results of the studies are shown in Tables E.5 and E.6.

Using essentially the same data base as the 1972 EPA report to Congress, Middlebrooks (1974a) concluded that there would be a 300 to 400 percent increase in total personnel employment in industrial water pollution control from 1974 to 1979. In addition, he concluded that process control technicians and operators probably would be in the greatest demand and that the need for intensive educational and training activities would be heightened.

TABLE E.5 Labor Force Growth in Water Pollution Control by Personnel Category, 1971 and 1976

Personnel Category	1971 Personnel Employed	1976 Personnel Requirements	Percentage Increase
Professional	25,400	42,220	66%
Operator	49,300	92,900	88%
Technician	26,900	47,300	76%
Other	47,800	71,800	50%
Total	149,400	254,220	70%

SOURCE: U.S. Congress, House (1972).

TABLE E.6 Additional Water Pollution Control Personnel Required by 1976, by Personnel Category

Personnel Category	Employment Sector: Nongovernmental	Local	State	Federal (Non-EPA)	EPA	Total
Professional	10,200	1,300	3,400	1,300	600	16,800
Operator	33,300	8,900		1,400		43,600
Technician	18,400	1,200	400	200	200	20,400
Other	10,400	11,700	800	400	600	23,900
Total	72,300	23,100	4,600	3,300	1,400	104,700

SOURCE: U.S. Congress House (1972).

Middlebrooks (1975) published another statement in which he concluded that in 1976 approximately 920,000 people would be involved in industrial water pollution control activities. This is approximately 6 percent of the entire U.S. work force in the manufacturing category. The chemical industry was expected to have 20 percent of its total work force in water pollution control.

The Middlebrooks report states that similar predictions of total personnel requirements, using an EPA model and another model, suggest that from 1.8 to 3.7 million persons would be involved in water pollution control in 1976. In the same report, Middlebrooks estimated that in 1976 the number of people employed in all pollution control activities (including those working in the air, water, and solid waste sectors) would total 3.5 million.

These estimates appear to include both direct and indirect employment and count all persons having a cursory or part-time involvement with pollution control along with those employed on a full-time basis. As such, the limitations on these data should be recognized. While substantially overstating pollution control employment in the sense it has been used by this Panel, the data do suggest the large numbers of workers who are affected in some way by environmental programs.

Middlebrooks (1974b), in a report to EPA, concluded that personnel needs in the specialized equipment industries would more than double by 1978 and that there was a significant demand for well-organized, short-term educational programs. The projection was made that professional staff for these industries would increase to more than 5000 persons and that technical staff would increase to 16,000 persons. Engineering was the largest professional category, with about 80 percent of the total professional work force; operating and maintenance personnel made up about 90 percent of the technician group. Middlebrooks noted that only 19 percent of all professionals were licensed in these industries and that there was little incentive for licensing or certification.

In a report to the National Science Foundation (Lecht et al. 1974), the National Planning Association found that the overall increase in the projected demand for scientists and engineers in five major private sectors of the economy—food, paper, chemicals, primary metals, and petroleum refining—varied considerably according to the policy scenario chosen. If the pollution control mandates existing at that time were carried out on schedule, the report showed, a projected increase of 58 percent would occur in the demand for scientists and engineers between 1970 and 1980, and there would be a 70 percent increase between 1970 and 1985. The total demand in 1985 in this situation was estimated to be 307,000, a large increase over the employment level of 180,600 in 1970. Table E.7 summarizes the numerical projections.

The National Planning Association report also stated that there is a need for a federal manpower budget to act as an advance warning system for indicating the expected consequences of federal government expenditures in all segments of the manpower pool involved.

In 1973, J.B. Roberts concluded from the "Proceedings of the Third National Environmental Engineering Education Conference" that the role of environmental engineers will expand and increase in complexity as population increases and environmental constraints become more sophisticated.[5] In addition, a 100 percent increase was projected in the number of nongovernmental environmental engineering positions during the next five years. The conference decided that it was necessary to have an undergraduate environmental engineering curriculum, a flexible graduate curriculum, more emphasis on interdisciplinary education, a stronger continuing education program, and increased financial support by the government for both graduate and undergraduate environmental education.

The best and most recent data on scientific and engineering employment for pollution control by industry are provided by the 1974 National Survey of Scientists and Engineers.[6] This survey, sponsored by the

[5]See note 2 above.

[6]Data from the 1974 National Survey of Scientists and Engineers was obtained from the Bureau of the Census and tabulated by the Committee. See Appendix B for additional background material.

TABLE E.7 Projected Needs for Scientists and Engineers in 1980 and 1985 in All Fields, Including Pollution Control

	1970	1980			1985	
Category	Employment	Baseline Scenario	Present Policy Scenario	Environmental Goals Scenario	Present Policy Scenario	Environmental Goals Scenario
Scientists	80,400	113,322	127,620	143,767	136,481	150,913
Engineers	100,200	138,403	158,190	174,042	171,180	180,739
Total	180,600	251,735	285,810	317,809	307,661	331,652

SOURCE: Lecht et al. (1974).

National Science Foundation, showed that in 1974 about 80,000 industry scientists and engineers claimed to devote a significant amount of their professional time to pollution control or environmental protection. A more complete presentation of these national data can be found in Appendix B, Methodology and National Data Aspects of Environmental Pollution Control Manpower, and in the Committee report. The summary shown below indicates the overall distribution of environmental scientists and engineers by type of employer in 1974:

Private Industry	79,926
Government	41,730
Other	12,894
Total	134,550

PRESENT AND FUTURE PERSONNEL NEEDS IN THE ENVIRONMENTAL CONSULTING FIELD

Middlebrooks et al. (1972) conducted a survey of consulting firms in water pollution control as part of an overall evaluation of personnel needs. He concluded that at present levels of federal aid for pollution control construction projects, the water pollution consulting industry would grow from 14,777 professionals in 1972 to 20,116 in 1976. Technician support staff would increase from 11,900 to 16,600 in the same period.

In a more recent survey,[7] estimates were made of the current population of environmental consultants based on listings in the World Environmental Directory (Gough 1975). Particular attention was given to the distribution of employees by pollutant category (air, water, solid wastes) and by job function (management, professional, technician). The results are shown below:

[7]Personal communication from R. David DiJulio, Environmental Research and Technology, Inc., to P.R. Atkins, Aluminum Company of America.

Estimated Number of Environmental Consultants in the U.S. in 1975 and Distribution by Environmental Sector (in thousands)

	Pollutant Category			
Job Functions	Air	Water	Solid Wastes	Total
Management	2-3	2-6	1-3	5-12
Professional	4-12	7-20	2-5	13-37
Technician	3-9	6-17	1-4	10-30

These data have been used to project needs for environmental consultants in 1985. The projections are based upon a 200 percent growth from 1975 to 1985, anticipated increases in the percentage of professionals, and anticipated increases in the solid wastes and noise categories as needs grow in those areas. Estimates of the distribution of consultants by pollutant category were based on the growth in expenditures by category from 1975 to 1985 and are shown below:

Estimated Number of Environmental Consultants in the U.S., 1985 (in thousands)

	Pollutant Category				
Job Functions	Air	Water	Solid Wastes	Other	Total
Management	3-8	3-8	2-5	1-2	9-23
Professional	12-33	12-33	6-17	3-9	33-92
Technician	4-13	5-13	3-8	2-5	14-39

The World Environmental Directory also lists 3580 U.S. firms that offer environmental professional, consulting, or laboratory services. According to the editor, the publication has a capture rate of 80 to 90 percent; it is at least that because firms not listed are generally the smaller firms. Thus, it can be estimated that there are 4000 to 4500 environmental consulting firms in the United States. With 10 to 25 persons employed by the average firm—an estimate derived from experience in this field—there are 40,000 to 112,500 employees of such firms. In one large, full-service environmental consulting firm, the employees are distributed in this way: there are about 20 percent in management; 33 percent working as professional engineers and scientists; 28 percent are technicians; and 19 percent are clerical workers. The personnel estimates below were made by applying the same distribution to the estimates of all consulting firm employees first cited:

Estimated Number of Employees of Environmental Consulting Firms, 1975

Job Functions	Lower Estimate	Upper Estimate
Management	8,000	22,500
Professional	13,200	37,125
Technician	11,200	31,500
Clerical	7,600	21,375
Total	40,000	112,500

The growth rate in environmental consulting was rapid in the late sixties and early seventies as needs for new technology and enterprises exploded during the rapid clean-up period. As environmental control activities mature, the growth rate for consultants is expected to slow but it still will exceed other components of the environmental field. This will be particularly true during the 1980–1985 period, as the focus of environmental activities shifts from control of existing facilities to the design of new facilities and as the need is created for new expertise and technologies.

It is important to note, however, that consulting work is by its very nature cyclical and subject to wide swings in demand. Unless new funding is committed to pollution control after the present programs finish, or unless government and economic incentives exist for extensive process changes, demand for specialized consultants could easily fall off rapidly after the middle 1980s.

SUMMARY OF PROJECTED PERSONNEL REQUIREMENTS

Personnel requirements for operational maintenance of pollution control equipment in the industrial and private sector through the study period are expected to be substantially greater than at present. Not only will the number of individuals in the engineering, science, and technician categories increase, but the degree of training and experience in relatively narrow specialty fields also can be expected to increase for some of the engineers and scientists. Much of the increase in expertise and experience will come from in-house training by employers, but even in these cases, a basic education in the environmental sciences will be needed. In addition, people will be needed from the fields of biology, botany, geology, water chemistry, atmospheric chemistry, economics, planning, and health, although the number of persons who will be needed from each of these fields will be relatively small.

It has been assumed in this report that environmental personnel requirements in the industrial and private sector will increase according to the amount expended to comply with environmental regulations. The expected requirements for personnel as a result of expenditures to operate and maintain existing facilities are:

Number of Full-Time Equivalent Environmental Personnel in Industry and the Private Sector (per Million 1975 Dollars of Environmental Expenditures)

Occupational Categories	1975	1980	1985
Engineers	5.0	4.7	4.6
Scientists	4.0	4.2	4.3
Technicians	9.1	8.5	7.5
Total	18.1	17.4	16.4

The base point for the projection is the ALCOA study cited earlier in this report.[8] The reduction in manpower per million dollars could very well be much greater than that shown if inflation remains high and productivity increases in the operation of pollution control facilities.

While industry operation and maintenance employment will increase over time, there is considerable evidence that capital spending and the direct employment it generates will be cut back sharply by 1985 (see Table E.4). There is widespread consensus that most industries will be in substantial compliance with air and water standards by that time and will have completed their major construction and equipment purchase programs. This probably will lead to a reduction in consulting and

[8]See note 6 above.

specialized equipment production employment, at least from peak levels that may not yet have been reached.

Thus, while demand by the private sector for specialized scientists, engineers, and technicians for pollution control is likely to remain strong over the next decade, the shifting emphasis from capital programs to operation and maintenance may very well keep total industry employment stable. Another factor tending to keep overall demand for evironmental manpower from rising is the continuous search by industry for economical process changes that reduce waste and thereby restrain the need for ever more complex and costly end-of-pipe treatment technologies. Still, it should be noted that industry is by far the largest employer of scientific and technical environmental manpower, and the simple maintenance of that high quality work force may require close cooperation with government and educational institutions.

EDUCATION AND TRAINING NEEDS FOR ENVIRONMENTAL PERSONNEL IN THE INDUSTRIAL AND PRIVATE SECTOR

It is generally assumed that environmental legislation and EPA regulations already on the books or anticipated in the next few years will generate requirements for substantial numbers of engineers, technologists, and technicians with specialized knowledge in fields under consideration by the Committee for Study of Environmental Manpower. While such specialists will be needed in greater numbers than in the past, it also will be necessary for many personnel in other disciplines to have a general knowledge and understanding of environmental requirements and constraints affecting their professional work. Judging by past experience with the introduction of new technologies and new design criteria and constraints, it seems likely that much environmental work in the future will be done by persons in traditional disciplines as a normal part of their jobs. Thus, although specialists will be needed in many areas, a significant portion of future environmental personnel requirements will be filled from the existing pool of scientists and engineers and by new graduates. Some of these persons will be released from other areas by the shift of national priorities and funds from "old" areas, such as the design of energy-consuming products, to areas reflecting new environmental concerns.

Environmental concerns in industry and the private sector are, and will continue to be, reflected in six general work areas: research and development; the production of equipment for pollution control; the operation, monitoring, maintenance, and repair of pollution control equipment; administrative duties resulting from environmental regulations; plant and facility construction; and instruction and training.

RESEARCH AND DEVELOPMENT

There is a need for research and development of processes, techniques, and equipment to perform functions not now within the state of the art in pollution control, such as the detection and removal of pollutants that at present are not adequately treated. This is "pure" environmental work and obviously will require competent and experienced specialists, although in relatively small numbers.

PRODUCTION OF EQUIPMENT FOR POLLUTION CONTROL

The manufacture of equipment developed by specialists, and its incorporation in new or existing plants to achieve process controls mandated by environmental regulations, will be performed by persons normally engaged in the design and production of the type of machinery or equipment that is involved. These persons will not need to be environmental specialists, but they will have to be knowledgeable about environmental factors. This knowledge probably can be gained in short refresher courses, on-the-job instruction, and in college courses. The personnel requirements generated by the added complexity of the new products will be only slightly greater than would normally be needed for equipment production.

OPERATION, MONITORING, MAINTENANCE, AND REPAIR OF POLLUTION CONTROL EQUIPMENT

Additional people will be required to carry out these functions, but the number of these people and their environmental expertise probably need not be high. For example, the addition of a few monitoring instruments to existing control panels may not require additional operators, and the maintenance and repair of instruments and machinery should not require new skills on the part of technicians. Existing technical curricula should provide the kinds of technicians needed and there should be on-the-job training to familiarize them with new equipment as it is developed and installed.

ADMINISTRATIVE DUTIES RESULTING FROM ENVIRONMENTAL REGULATIONS

The imposition and enforcement of new environmental regulations will create a need for people in the regulated industries to write impact statements, do inspections, monitor, keep records, and conduct some on-the-job training and indoctrination. The main requirements in such jobs will be an understanding of the regulations and standards involved, and the administration of production personnel. Presumably, most of these positions could be filled by people with a general education in engineering, technology, applied science, social science, or economics.

PLANT AND FACILITY CONSTRUCTION

Unquestionably, there will be requirements for the construction of new plants or the modification of existing plants. Design specifications will be developed by engineers, architects, and other technicians who have an expert knowledge of environmental requirements, but relatively few of these persons will be needed because of the already specialized nature of plant design. In any highly technical area (such as off-shore oil rigs, petrochemical plant design, tunneling), the number of specialized design firms is small. For actual supervision of construction, a general civil engineering education normally is sufficient. If large numbers of pollution control projects are placed under construction at one time, there obviously will be a need for more construction workers, but this will be a one-time operation. Once the necessary plants are built, these needs will diminish. It is therefore preferable that the personnel needs be met by diverting construction workers from lower priority jobs so that the nation will not be faced with large numbers of unemployed mechanics and technicians when pollution control facilities are in place. Operation of the plants, most notably wastewater treatment and water purification facilities, will require additional technically-trained personnel, but most of them can be trained in a relatively short time in existing schools or by apprenticeship and on-the-job training programs.

EDUCATION AND TRAINING

Experts will be needed to conduct educational and training programs, but their numbers will be relatively small. Most college departments of engineering and technology have experts in areas of environmental concern; by enlarging the classes of these experts, the number of graduates with some background in environmental sciences can be increased to some extent. These expert teachers also can be used as visiting consultants to conduct on-site courses. Postgraduate programs in highly specialized fields should receive special consideration. Establishing centers of excellence in various environmental fields could provide a corps of specialists to maintain ongoing research and training programs.

AN ASSESSMENT OF PERSONNEL REQUIREMENTS

In general, the Panel believes that environmental personnel needs for industry and the private sector will be met primarily from the existing and expected future stock of science, engineering, and technology graduates. In respect to the people who will be needed to operate and maintain pollution control equipment, to perform administrative duties resulting from pollution controls, and to build plants and other facilities, the technology is not so complicated that it prevents personnel needs from being met on a local basis as they arise. The requirement for people to manufacture and install control equipment will generate needs for some additional personnel. However, these people will be in fields where the personnel pool is already large and where new graduates are being produced in reasonable numbers. The requirements for research and development and for experts to conduct education and training could warrant programs to train additional specialists at the graduate degree level. Because of the time it takes to develop these competencies, some advance planning should be done; however, the time period can be shortened by providing further education to people already at the bachelor's or master's level in a related field of engineering or science. If such a program is undertaken, it should be kept small and personnel needs should be carefully and continuously monitored to avoid either shortages or overproduction of the kind that has taken place in years past in high energy physics, aerospace science and technology, and teaching.

Since most environmental activities in industry and the private sector probably will be done as a regular part of an employee's everyday work, it would be desirable to include environmental courses in general engineering and other technology curricula as soon as possible. This could be stimulated by competitive grants for the development of model courses or of modules and textbooks suitable for general adoption.

In addition, much of the environmental talent that will be needed by industry and the private sector will be developed through in-service training and orientation. Many industries, and perhaps trade organizations, will develop their own formal in-service training programs, while others will rely heavily on short courses, seminars, and symposia offered by universities and pollution control agencies. A rapidly increasing data base for environmental decision making suggests that continuing education will play a major role in ongoing training programs. It is anticipated that 50 percent of the professionals involved in environmental activities should attend at least one training session every three to five years. Thus, the requirements for training courses could be 150,000 man-week units each year through 1985 for the private sector alone.

The matter of meeting requirements for technicians should not be overlooked. Although training time for technicians is probably not longer than two years, the technician labor market is quite localized and few specialized courses exist. Although some technician training will occur through in-service programs, additional emphasis will be placed on outside training as the operation of facilities becomes more stringent than at present. It would be desirable, therefore, to stimulate the development of high quality curricula and environmental modules, textbooks, and training aids suitable for adoption in general technician programs. It is anticipated that most operators should receive additional external training every five years, which creates a requirement for 55,000 man-week units of additional outside training for technician and operating personnel in the private and industrial sector.

Outside training programs can be conducted by universities, EPA contractors, or by EPA. There are advantages to all of these approaches. Perhaps a mix of the three types of programs would be the best way to provide the external training that will be required by the private sector. But whatever the mode of training, it is imperative that industrial participation be present in the training programs to ensure that the material presented will upgrade the professional and technical workers in industry. Towards that end, formal liaison programs between major industrial categories and training administrators should be established.

NEEDS FOR MORE SPECIFICALLY TRAINED INDIVIDUALS AND ENVIRONMENTAL TRAINING FOR GENERAL TECHNICAL PERSONNEL

As environmental activities become a more normal part of industrial operations, the amount of expertise and specialized training required for a relatively small number of persons will increase. Industry will rely heavily upon planners, economists, biologists, ichthyologists, foresters, geologists, water chemists, atmospheric chemists, mathematicians knowledgeable about dispersion modeling, health experts, and the like, to provide answers to the complex questions associated with environmental control programs. These individuals not only will assist industrial clients, but will work to increase the data bank upon which future environmental decisions and regulations will be based.

Thus, there will be an ongoing need for highly specialized environmental training programs to produce the personnel needed to fill these positions. Normal growth and interest in these fields will provide an adequate supply of trained persons. It is not anticipated that major alterations in the present educational system will be required to accomplish this task, nor will economic assistance from government be necessary over and above the normal economic stimulus offered for graduate programs in highly specialized fields.

Since it appears that environmental activities will become a part of almost all future decision making, it is recommended that general environmental training be incorporated into curricula for all technically trained individuals who are planning a career in the industrial and private sectors. This training would provide decision makers with the basic knowledge of the critical nature of environmental problems and an understanding of the potential impacts of certain decisions. Although such programs would not require major modifications of existing university structures, it is recommended that efforts be made to stimulate development of general environmental courses at all major universities.

CERTIFICATION REQUIREMENTS

At present, there is little incentive for people working in environmental fields in the private sector to be registered or certified, with the exception of consulting engineers. Several states now require that wastewater treatment plant operators have some level of certification based on treatment plant size and the type of wastes being handled. However, these requirements usually are minimal.

With growing sophistication of treatment processes and the operation of control equipment, the need for skilled, well-motivated operators will intensify. For this reason, a certification program probably will prove beneficial to the proper operation of in-place equipment. There is little motivation in the private sector to develop certification programs and this development may have to come from the government and from professional societies. Since the turnover rate for environmental personnel in industry is large and since a number of people become involved in pollution control activities on a less than full-time basis, certification programs should not be so complicated that people cannot complete the requirements in a reasonably short time, with periodic reexamination and upgrading through the use of short courses and continuing education.

Certification programs should be developed on a state basis because requirements vary significantly from state to state, particularly in areas such as solid wastes management, community noise control, and pesticide applications management. Full participation of the private sector should be encouraged in the development of certification programs and the conduct of certification procedures. In the past, certification programs have emphasized municipal wastewater treatment; such programs should be expanded to all industrial wastewater, air pollution control, and solid wastes management programs.

The development of a comprehensive certification program will accelerate the demand for effective, concise, continuing education courses to give technicians, operators, and professionals the basic information needed to use environmental control equipment properly. Since the industrial sector relies heavily on internally trained personnel to handle not only environmental control functions but other services and production-related activities, short-term environmentally-related training activities will be attractive.

NEEDS FOR IMPROVED DATA COLLECTION AND USE IN INDUSTRIAL MANPOWER PROJECTIONS

A substantial amount of literature deals with the impact of environmental legislation and regulations on future requirements for engineers, scientists, technicians, and others. Although this literature can provide many significant indications of future problems and developments, it also presents serious data base problems, conceptual and methodological problems, and problems of interpretation. To improve the making of projections, these steps might be taken:

- make periodic surveys of the supply of engineering, scientific, and technical personnel to determine who is involved in environmental protection work, what they are doing, and what specialized knowledge they require;
- develop common definitions of what constitutes environmental protection activities for more reliable and stable estimates of expenditures for pollution abatement;
- use the U.S. Department of Labor's newly revised economic growth model to indicate the personnel impacts of environmental measures in the coming decade on an industry-by-industry basis;
- prepare scientific personnel impact statements (this would be done by appropriate government agencies) to show anticipated changes in requirements for scientists, engineers, and others as a result of changes in government regulations or legislation receiving serious consideration; and
- improve projection methods to take account of the impact of changes in earnings of scientific personnel, as well as changes in expenditures for the employment of scientists and engineers.

Information on scientific personnel requirements is available in special studies by the BLS in the U.S. Department of Labor or by universities or nonprofit research organizations for the NSF. Most of these studies make use of some version of the input–output approach to estimate scientific personnel requirements generated in pollution control by expenditures for plant and equipment, operations and maintenance, monitoring, and research and development. The personnel estimates typically refer to "direct" employment in industries producing the end product or carrying on the pollution control activity, and to "indirect" employment in the major industries supplying goods and services to the end product firms. BLS projections usually are "spinoffs" from the basic personnel matrix derived from its economic growth model.

Expenditure estimates for environmental measures are the takeoff point for personnel projections; each revision of expenditure estimates by EPA or other government agencies carries with it an implied change in personnel requirements. In the past, there have been frequent and major changes in estimates of future outlays for pollution abatement from EPA and other sources. While it is understandable that program changes, new legislation, and lack of experience can create significant changes in expenditure projections, more reliable and less frequent changes in the outlay figure constitute an important step in improving the data base for personnel projections.

In the private sector, changes in environmental personnel needs are largely due to changes in legislation and regulations. Discussions and hearings on proposed changes in standards or in legislation often are concerned with the costs these changes imply but, so far, too little concern has been given to the effects of expenditures in generating personnel requirements. To encourage awareness of the consequences of its own actions in the environmental area in terms of personnel use, the federal government should report regularly on effects that major changes in legislation or regulations and that future pollution abatement expenditures are likely to have on personnel requirements. In addition, government reports should review the consequences of state and local mandates on personnel needs.

Much of the basic economic framework for scientific personnel projections, and many of the projections themselves, are derived from the economic growth model of the U.S. Department of Labor. This model has been revised to allow for higher unemployment rates than those assumed in earlier versions, and to take account of the effects of higher energy costs in increasing or decreasing employment in over 100 industries. It would be desirable for the Department to undertake an application of the model to show the effects of higher costs resulting from environmental measures on personnel use on an industry-by-industry basis.

At present, scientific personnel projections are largely "requirements" projections that deal with the demand side of the scientific and technical manpower labor market. More knowledge of the demand side, by itself, is unlikely to show where bottlenecks are likely to appear and the kinds and the number of specialists that should be trained. There is considerably less knowledge about the supply side of the problem. Even though there is a significant amount of information on new graduates, there is little systematic information on how many or what kinds of scientists and engineers are involved in designing, operating, and maintaining pollution abatement equipment; in environmental research and development; in monitoring; or in the construction of plants or production of control equipment. It may well be that, in many areas, much of this work can be done by persons with the present scientific and technical skills, or with minor additional training. However, other aspects of environmental protection, such as designing new types of equipment, doing research, or providing technical advice on pollution control, may require different and highly specialized skills. A high priority should be given to surveys of who is doing what in the environmental area and of the kinds of training required. These surveys should be repeated every two or three years by joint action of the NSF, EPA, and/or the Department of Labor. An example of a survey of this type that deals with water pollution is described in an article by Middlebrooks (1975). Together with projections of degrees in relevant fields and of personnel requirements, such surveys could provide a basis for anticipating bottlenecks and training needs.

There has been considerable controversy among economists about the use of the input–output approach as a basis for personnel projections. The projections have been questioned because they usually assume a fixed relationship—that is, a constant manpower coefficient—between expenditures and employment. In practice, expenditure-employment relationships change as technology or as salaries and other elements of jobs change. It is apparent that technicians can be substituted for more highly paid professionals if there are serious shortages of professionals, and that instruments and automated processes sometimes can be substituted for both groups. It would be desirable to develop econometric projection models which give heavier weight to changes in salaries or to the possibilities of substituting one type of skill or expertise for another or of equipment for personnel. However, econometric manpower models probably would be no more able to anticipate changes on the demand side arising from shifts in government policy, or the effects of technology changes, than are the less sophisticated projection techniques.

Present techniques are least useful in anticipating the effects of major technological changes upon engineering, scientific, and technical personnel. Typically, projections assume that, over the next 5 or 10 years, technological changes will represent continuous modifications of technology or that there will be further introductions of new technology. Often, this is a reasonable expectation, but insofar as there are major discontinuous changes in environmental technology—as, for example, changes facilitated by implementation of the Best Available Technology standard—the projections probably will become outmoded. For this reason, long-term projections covering 20 or 30 years are more open to question than those covering 5 or 10 years. Improvements in the difficult art of technology forecasting probably are the prerequisite for significant progress in anticipating the personnel dimensions of technological change in environmental or other areas. More frequent monitoring of personnel changes in pollution abatement, as they relate to the technology in use, can increase the likelihood of producing "surprise-free" projections.

As a final step, greater recognition should be given by the producers and users of the scientific personnel projections to the capabilities and limitations of the projections. The projections essentially are based on a series of assumptions about the growth of the Gross National Product (GNP), technological and productivity changes, population changes, and future pollution programs and expenditures. What appear to be reasonable assumptions about the future often change and, when they do, the personnel implications also change. While the presently available projections might be greatly improved, their value as predictions will continue to be limited by the fact that they represent attempts to anticipate what is inherently an uncertain future.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSION 1

The presently available environmental personnel data base and predictive tools are severely limited in usefulness. Because a number of the persons involved in environmental activities also are involved in other areas of industrial and consultant work and because the spectrum of environmental activities is broad and changing rapidly, past personnel assessments are useful only as crude indicators.

RECOMMENDATION 1

- *The Panel recommends the design and conduct of a long-term personnel study to produce the data necessary to make possible an accurate assessment of present and future personnel and training needs.*

CONCLUSION 2

There is a quantifiable relationship between operating and maintenance costs associated with environmental control and ongoing personnel requirements for environmental programs in the private sector. There is also a relationship between capital requirements and environmental personnel, but this relationship may be more variable than that involved in operation and maintenance.

RECOMMENDATION 2

- *Environmental expenditure projections should be used as a basis for estimating the number of environmental personnel needed by the private sector.*

CONCLUSION 3

As the environmental disciplines mature, there will be a shift in personnel requirements as a function of expenditure. More emphasis will be placed on planners, impact analysis specialists, highly specialized consultants, and environmental managers. However, there still will be a continuing need for well-trained technicians and operators as well as qualified environmental engineers.

RECOMMENDATION 3

- *Education and training programs should be established to ensure comprehensive training of personnel.*

CONCLUSION 4

Based on projections of expenditures to achieve the goals of the Clean Air Act, the Federal Water Pollution Control Act Amendments (including solid waste disposal), and the Safe Drinking Water Act, the full-time equivalent personnel required for the industrial and private sector in 1975 to 1985, is estimated to increase slightly. The need to maintain and improve the quality of these workers, however, will create a sustained demand for new entrants with specialized skills.

RECOMMENDATION 4

• *Steps should be taken to ensure that the necessary personnel and training mechanisms are available to satisfy environmental personnel requirements of industry and the private sector.*

CONCLUSION 5

Environmental personnel needed for achievement of the goals and objectives of existing environmental regulations will be involved in more sophisticated design, operation, and planning programs as the requirements of the legislation impose more and more restrictive limitations on emissions and discharges.

RECOMMENDATION 5

• *The Panel recommends development of well-structured educational curricula to incorporate environmental concerns in a variety of degree and non-degree programs so that consideration will be given to the environmental aspects of projects at an early stage.*

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